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***Fibre Channel Interface***  
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***Product Manual***  
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August 2000

Publication number: 77767496, Rev. B

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Printed in the United States of America

# Revision status summary sheet

<b>Revision</b>	<b>Date</b>	<b>Writer/Engineer</b>	<b>Sheets Affected</b>
A	03/21/97	L. Newman/J. Coomes and W. Whittington	All
B	08/01/2000	L. Newman/J. Coomes	All



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## 1.0 Publication overview

This publication provides some general information about Fibre Channel as well as detailed information about how Seagate disc drives implement Fibre Channel Arbitrated Loop technology.

This publication will continue to be revised as Fibre Channel technology advances and as Seagate Fibre Channel drives change to meet data storage needs.

You will observe that many references are made to SCSI throughout this publication. This is because Fibre Channel transports the SCSI command set. This concept is discussed in more detail throughout this publication beginning in Chapter 2.

### 1.1 Acknowledgements

The information contained in this publication was gathered from many sources. Portions of the text used to explain general Fibre Channel concepts were adapted in various forms, with permission, from Ancot Corporation's *Fibre Channel, Volume 1: The Basics* written by Gary R. Stephens and Jan V. Dedek. Additional information was contributed by Canadian Valley Vocational-Technical instructor Chuck Chalupa.

### 1.2 How to use this manual

This publication provides a universal detailed description of the Fibre Channel interface for Seagate disc drives. You may read it from front-to-back, or turn directly to the sections that interest you the most. A glossary is provided in the back (see Appendix A) which you may find useful as you read this manual.

**Note.** Volume 1 Product Manuals have tables that specify which SCSI features are implemented in each specific drive model, what the default parameters are for the various features they implement, and which parameters are changeable and which are not.

No method exists at present to inform an initiator if a target supports SCSI-3 features as opposed to only SCSI-2 features. A few SCSI-3 features are supported by Seagate drives, but no attempt has been made herein to differentiate between SCSI-2 and SCSI-3 features. Therefore, when an Inquiry command reports what the ANSI-approved version of the drive is, it reports SCSI-2, where SCSI-2 means SCSI-2 features plus some SCSI-3 features.

No attempt is made in this universal specification to specify which descriptions or tables apply to SCSI-2 or SCSI-3. The combination of this general specification with the details in the individual drive's Product Manual, Volume 1, provides a description of the individual drive implementation of the SCSI interface.

This interface manual is not intended to be a stand-alone publication about Fibre Channel's features. You should reference the individual drive's Product Manual to determine the specific features supported by each drive model.

This specification is Volume 2 of a set of manuals that is made up of a separate drive Product Manual, Volume 1, and this manual. This Volume 2 manual is referenced by the Volume 1 Product Manual for Seagate Fibre Channel disc drives.

### 1.3 General interface description

This manual describes the Seagate Technology, LLC Fibre Channel/SCSI (Small Computer Systems Interface) as implemented on Seagate Fibre Channel (FC) disc drives.

The disc drives covered by this manual are classified as intelligent peripherals.

The interface supports multiple initiators, self-configuring host software, automatic features that relieve the host from the necessity of knowing the physical architecture of the target (logical block addressing is used), and some other miscellaneous features.

The physical interface uses differential drivers and receivers for the Fibre Channel serial connections. The single channel transfer rate is 106 MB/second (commonly called 1 gigabit/sec) or 212 MB/second (commonly called 2 gigabit/sec). See the Volume 1 Product Manual for a definition of the electrical characteristics of the interface.



## 2.0 Introduction to Fibre Channel

Fibre Channel is an American National Standards Institute (ANSI) interface that acts as a general transport vehicle to simultaneously deliver the command sets of several existing interface protocols including SCSI-3, IPI-3, HIPPI-FP, IP, and ATM/AAL5. Proprietary and other command sets may also use and share the Fibre Channel, but these are not yet defined as part of the Fibre Channel standard.

Fibre Channel Arbitrated Loop (FC-AL) is one topology used to connect two or more devices within the guidelines set by the ANSI standards. This topology is discussed in detail throughout this manual. Other topologies do exist and are discussed briefly in this manual to give you some idea of how these topologies can coexist and interact.

### 2.1 General information

Fibre Channel supports both large and small data transfers. This makes it effective in transferring a wide variety of data and can be used in systems ranging from supercomputers to individual workstations. Fibre Channel peripherals can include devices such as, but not limited to, disc drives, tape units, high-bandwidth graphics terminals, and laser printers.

To accommodate all of these device types with various command sets, Fibre Channel separates the physical I/O interface from the I/O operations. This makes it possible to use the multiple command sets simultaneously. This also allows new speeds and new functions to be added without making all previous investment in existing components obsolete.

Another benefit of Fibre Channel is that it supports both channel and network peripheral protocols for device communication. This means that channel and network protocols can share the same physical medium.

Fibre Channel does not have its own native I/O command set protocol. It simply lets other protocols superimpose their command sets onto itself and then transports this information. Fibre Channel has a command set that it uses to manage the links between the various participating devices using Fibre Channel. Fibre Channel calls these link level functions "link services."

Since multiple command sets may use Fibre Channel, it identifies the information by command set type. This allows the receiving port to distinguish among the protocols and make processing decisions. Each Fibre Channel frame has a field in the frame header to identify the protocol associated with that frame. Additional information about frames is available in Section 6.0 beginning on page 19.

### 2.2 Channels vs networks

As mentioned above, Fibre Channel supports both channel and network communications.

#### Channels

Traditional disc drive communications occur in a channel environment where the host controls the devices attached to it. The primary requirement for channel environments is to provide error-free delivery, with transfer delays being a secondary consideration.

#### Networks

Networks allow many devices to communicate with each other at will. This is usually accompanied by software support to route transactions to the correct provider and to verify access permission. Networks are used for transferring data with "error-free delivery" and voice and video where "delivery on time" is the primary requirement with error-free delivery being a secondary consideration. For example, when transferring video, it is more important to provide on-time delivery of data to prevent loss of video frames than to lose one or two pixels in a video frame.

### 2.3 The advantages of Fibre Channel

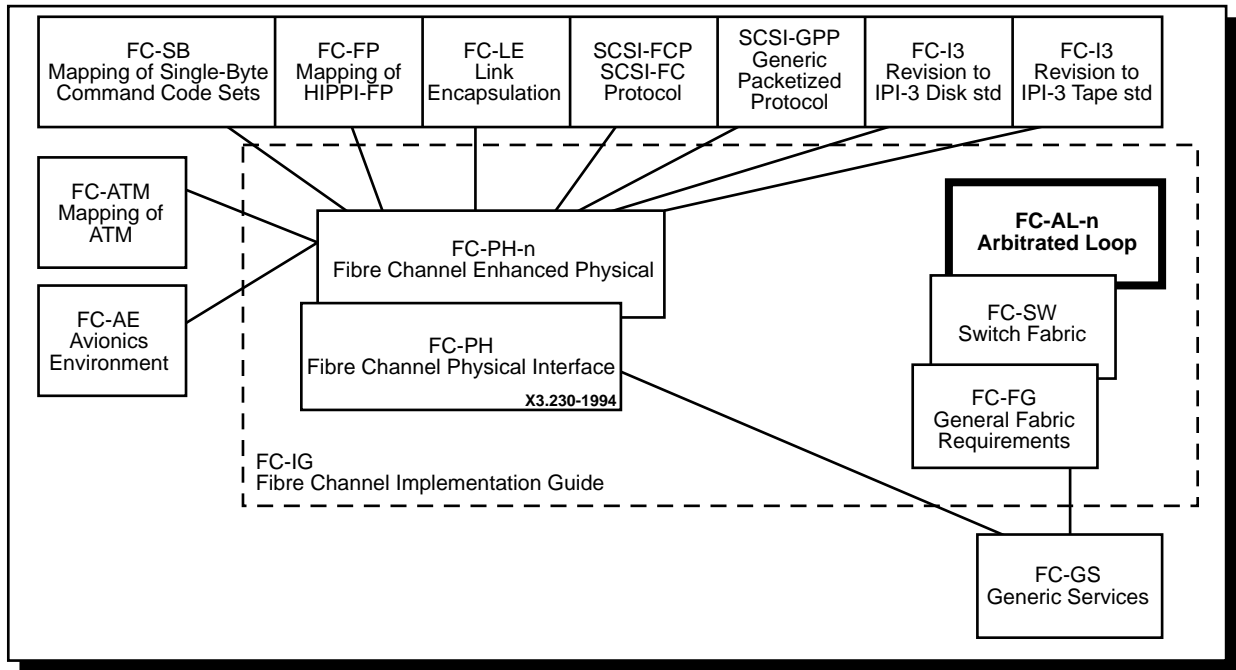
In addition to the channel/network support, Fibre Channel:

- Supports multiple physical interface types.
- Provides a means to interconnect physical interface types.
- Provides high-speed data transfer rates much faster than parallel SCSI.
- Separates the logical protocol being transported from the physical interface—this allows multiple protocols to be transported over a common physical interface.
- Allows increased cable lengths. You can have 30 meters between each device when using twisted pair copper media. Note that this 30 meters is between each device, not the total length (multiply the number of devices by 30m to obtain total allowable length). Fiber optic media extended this even further by allowing distances of 10km between each device.
- Increases the potential number of devices connected. Just one private arbitrated loop can have up to 125 devices attached. Even more can be attached in non-participating mode. Also, multiple loops can be attached to fabrics to significantly increase the number of devices attached.
- Uses asynchronous transmission to fully utilize the available bandwidth.
- Allows flexibility in transfer rates, distances, media types, and protocols.



### 3.0 Fibre Channel standards

Figure 1 shows the various documents involved in the ANSI set of standards relating to Fibre Channel. This model is not static—it is growing as others areas of interest are developed.



**Figure 1. Fibre Channel standards**

The interface is compatible with a subset of the ANSI standards listed below:

- SCSI-2 Standard and the Common Command Set (CCS) document, Revision 4.B
- SCSI Parallel Interface-3 (SPI-3)
- SCSI Enclosure Services (SES) Command Set, X3T10 NCITS, 305-199x
- Fibre Channel Physical and Signaling, Revision 4.3 (FC-PH)
- Fibre Channel Physical and Signaling, Revision 7.4 (FC-PH-2)
- Fibre Channel Physical and Signaling, Revision 9.4 (FC-PH-3)
- SCSI Fibre Channel Protocol, Revision 12 (SCSI-FCP)
- Fibre Channel Arbitrated Loop, Revision 4.5 (FC-AL)
- Fibre Channel Arbitrated Loop Direct Attach SCSI Technical Report
- Fibre Channel Fabric Loop Attach Technical Report

Copies of ANSI documents relating to Fibre Channel can be purchased from:

Global Engineering  
 15 Inverness Way East  
 Englewood, CO 80112-5704  
 (800) 854-7179 or  
 (303) 792-2181  
 Fax: (303) 792-2192

#### 3.1 General information

The FC-PH standard is the foundation upon which all others are based. Each topology, command set, and protocol has its own standard. These are all separate to allow future growth and to allow designers to more easily use only those parts that affect their products. It is important for system designers to consider the requirements of the set of protocols to be supported because different protocols require different subsets of the functions permitted in a Fibre Channel port.

### 3.1.1 Description of Fibre Channel levels

The Fibre Channel levels are listed below:

- Physical (FC-0)
- 8B/10B encoding/decoding (FC-1)
- FC-AL (FC-1.5)
- Framing protocol (FC-2)
- Common services (FC-3)
- Interface mapping (FC-4)

#### 3.1.1.1 FC-0

FC-0 defines the physical portions of the Fibre Channel. This includes the fibre, connectors, and optical and electrical parameters for a variety of data rates and physical media. Coax, twinax, and twisted pair versions are defined for limited distance applications. FC-0 also provides the point-to-point physical portion of the Fibre Channel.

#### 3.1.1.2 FC-1

FC-1 defines the transmission protocol which includes the serial encoding, decoding, and error control.

#### 3.1.1.3 FC-1.5

FC-1.5 defines the topology involved with Fibre Channel Arbitrated Loop (FC-AL) configurations.

#### 3.1.1.4 FC-2

FC-2 defines the signaling protocol which includes the frame structure and byte sequences.

#### 3.1.1.5 FC-3

FC-3 defines a set of services which are common across multiple ports of a node.

#### 3.1.1.6 FC-4

FC-4 defines the interface mapping between the lower levels of the Fibre Channel and the various command sets. These various command sets are known as upper layer protocols (ULPs). Examples of upper layer protocols include SCSI, IPI, HIPPI, and IP.

### 3.1.2 Relationship between the levels

FC-0, FC-1, and FC-2 are integrated into the FC-PH document. The other documents are separate so that each implementation may use the technology best suited to the environment in which it will be used.

### 3.1.3 Topology standards

Each topology has its own standard. This is done so that designers can concentrate on documents that apply to the technology suited to their specific area of interest.

The following topology standards are available:

- FC-FG (Fibre Channel Fabric Generic)
- FC-SW (Fibre Channel Cross-point switch)
- FC-AL (Fibre Channel Arbitrated Loop)

The FC-FG and FC-AL documents are of the most interest for Seagate disc drive interconnection.

### 3.1.4 FC Implementation Guide (FC-IG)

FC-IG provides some implementation guidance for all Fibre Channel systems.

## 4.0 Introduction to topologies

Topologies include all the elements necessary to successfully connect two or more nodes (also known as devices). See Section 4.1. There are several topologies available with Fibre Channel, but all of them have certain common components: nodes, ports, and links. These components are discussed in this section.

The ANSI Fibre Channel standard defines three topologies:

1. Arbitrated loop (Fibre Channel Arbitrated Loop, FC-AL)
2. Fabric
3. Point-to-point

Seagate supports arbitrated loop and fabric as the primary topologies for disc drive connections.

**Note.** Some brief discussions about items not directly associated with arbitrated loop and fabric topologies are included to make you aware that other topologies exist within the constructs of the ANSI Fibre Channel standard.

The fabric topology permits dynamic interconnections between nodes through ports connected to a fabric. This fabric is similar to a switch or router and is often compared to a telephone system because of its redundant rerouting capabilities. The fabric topology also allows multiple connections simultaneously, unlike FC-AL which results in a single circuit being established between only two ports at any one particular time. Fabric and arbitrated loop topologies may be combined in one system to provide a wide variety of services and performance levels to the nodes.

Point-to-point topologies are used only to connect two ports without any routing capabilities.

### 4.1 Nodes

Fibre Channel devices are called nodes. This is a generic term describing any device (workstation, printer, disc drive, scanner, etc.) connected to a Fibre Channel topology. Each node has at least one port, called an N\_Port to provide access to other nodes. The “N” in N\_Port stands for node. As you will see later, ports used in a Fibre Channel Arbitrated Loop topology are called NL\_Ports where the “NL” stands for node loop.

The components that connect two or more node ports together are what are collectively called a topology. Nodes work within the provided topology to communicate with all other nodes.

### 4.2 Ports

Ports are the link to the outside world for a Fibre Channel node. See Figure 2. As stated above, each node has at least one port to provide access to other nodes. Each Seagate Fibre Channel drive has two ports.

Each port uses a pair of fibers—one to carry information into the port and one to carry information out of the port. This pair of fibers (actually copper wire) is called a “link” and is part of each topology. The Fibre Channel ANSI specification also supports fibers made of optical strands as a medium for data transfer.

As stated above, ports used in a FC-AL topology are called node loop ports (NL\_Ports). Other port types exist as documented in the following table.

**Table 1. Fibre Channel port types**

Port type	Location	Associated topology
N_Port	Node	Point-to-point or Fabric
NL_Port	Node	in N_Port mode—Point-to-point or Fabric in NL_Port mode—Arbitrated Loop
F_Port	Fabric	Fabric
FL_Port	Fabric	in F_Port mode—Fabric in FL_Port mode—Arbitrated Loop
E_Port	Fabric	Internal Fabric Expansion
G_Port	Fabric	in F_Port mode—Fabric in E_Port mode—Internal fabric expansion
GL_Port	Fabric	in F_Port mode—Fabric in FL_Port mode—Arbitrated Loop in E_Port mode—Internal fabric expansion

NL\_Ports and FL\_Ports discover their mode of operation dynamically during the initialization procedure.

**Note.** You may hear the term “L\_Port” when discussing Fibre Channel. This term is often used as a “catch-all” term meaning NL\_Port or FL\_Port when it is not important to specifically distinguish between the two. Therefore, when you read the term L\_Port, you should think of NL\_Port when the discussion is about Arbitrated Loop or Point-to-Point topologies, and you should think of FL\_Port when the discussion is about the Fabric topology.

An L\_Port discovers its environment and works properly, without outside intervention, with an F\_Port, N\_Port, or with other L\_Ports.

Arbitrated loops can have up to 126 active NL\_Ports, but only one active FL\_Port attached to the same arbitrated loop. The NL\_Ports discover whether there is a fabric present by discovering whether there is an FL\_Port present. If there isn't an FL\_Port present, the loop is called a private loop. If there is an FL\_Port present, the loop is called a public loop and the FL\_Port is considered the manager of the loop.

The most commonly used ports are the NL\_Port and FL\_Port. With these two types, you can easily migrate nodes from one topology to another.

Each NL\_Port is attached to one link. Information flows in one direction only.

### 4.3 Links

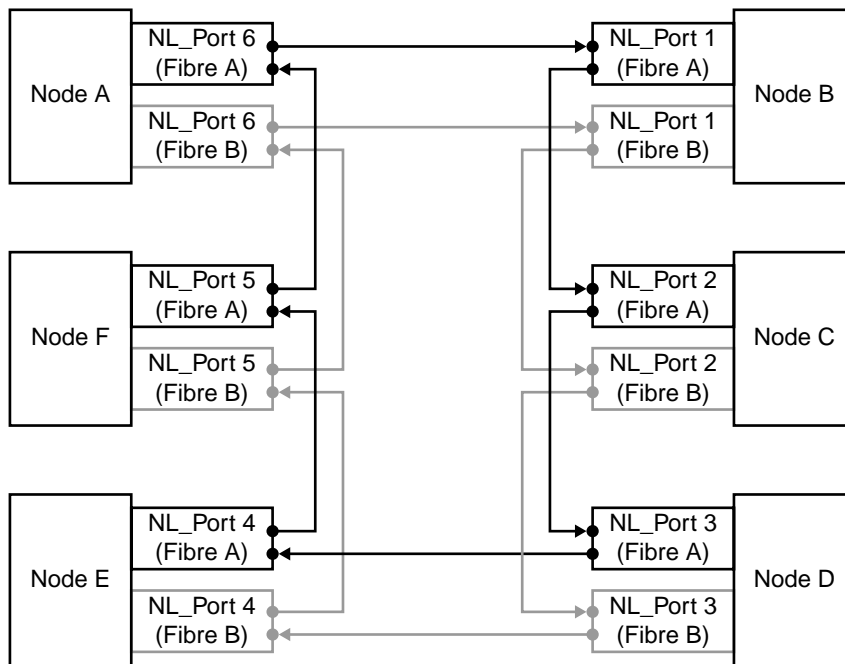
Each port is comprised of two fibers, one carries information into the port and is called a receiver. The other carries information out of the port and is appropriately called a transmitter. Fibre Channel supports two types of fibers—electrical wires (most commonly copper) and optical strands. This pair of wires is called a link. See Figure 2.

Links carry the data frames between nodes. Each link can handle multiple frame types; therefore, frame multiplexing is possible. For example, a frame containing SCSI information may be followed by a frame containing TCP/IP followed by a frame containing yet another protocol's information.

### 4.4 Arbitrated loop topology

Fibre Channel Arbitrated Loops (FC-AL) attach multiple nodes in a loop without hubs and switches. The node ports use arbitration to establish a point-to-point circuit. FC-AL is a distributed topology where each L\_Port includes the minimum necessary function to establish the circuit.

The arbitrated loop topology is used to connect from two to 126 node ports. See Figure 2.



**Figure 2. Arbitrated loop topology (dual port private loop)**

The ports in an arbitrated loop topology are called NL\_Ports (Node Loop Ports). Each of the NL\_Ports has an input and output connection. Seagate Fibre Channel drives support dual ports (specified with a “1” in byte 6, bit 4 of the disc drive inquiry data). The actual ports are located on the host’s backpanel, not on the disc drive. Dual ports are provided for redundancy so that if one loop fails, the other one can fulfill the loop duties. Each drive has one FC SCA (single connector attachment) connector.

The arbitrated loop protocol is a token acquisition protocol. This means each port on the same arbitrated loop sees all messages, but passes all messages that are addressed to other ports.

**4.5 Topology and port login**

Each NL\_Port must sign in with the other ports on the loop. Each port first attempts to locate an FL\_Port. If it finds an FL\_Port, it knows it is a part of a public loop connected to a fabric. If the port does not locate an FL\_Port, it knows it is a part of a private loop with other NL\_Ports only.

There can be up to 126 active NL\_Ports and up to one active FL\_Port attached to the same arbitrated loop. If an NL\_Port does not attempt to discover an FL\_Port and there is an FL\_Port present, the NL\_Port is only allowed to access other NL\_Ports on the same loop.

**4.6 Port bypass circuits**

So far, we’ve discussed links, ports, nodes, and topology logins. All’s fine with this model as long as the loop is intact. What happens, then, if a device is disconnected from the loop. Doesn’t this break the loop? The answer is no. Fibre Channel provides port bypass circuitry which bypasses the drive if it is removed, incapable of providing loop services, unable to obtain a valid address, or otherwise incapable of providing loop services. These port bypass circuits (PBCs) are located external to the drive or other FC-AL device. Figure 3 shows the relationship between the PBC and drive.

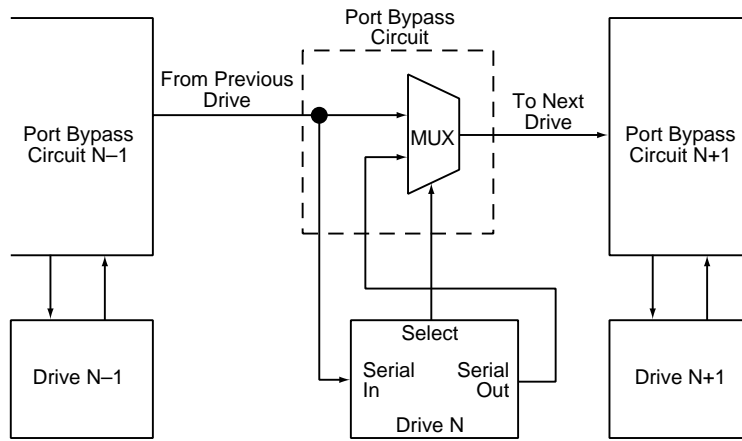


Figure 3. Port bypass circuit physical interconnect

## 5.0 Data encoding (FC-1)

Fibre Channel devices don't transmit 8-bit bytes. If this were to occur, the receiving node would not understand the transmitter's intentions. To fix this situation, the data is encoded prior to transmission. Encoding allows the creation of special transmission code characters with unique bit patterns for data management and word alignment so the receiving node will know what to do with the bytes. Encoding also improves the transmission characteristics across a fibre and increases the likelihood of detecting errors.

### 5.1 Encoding and decoding

An unencoded data byte is represented in FC-1 as HGFEDCBA where H is the most significant bit. The hex to FC-1 decimal value translation is accomplished as shown below:

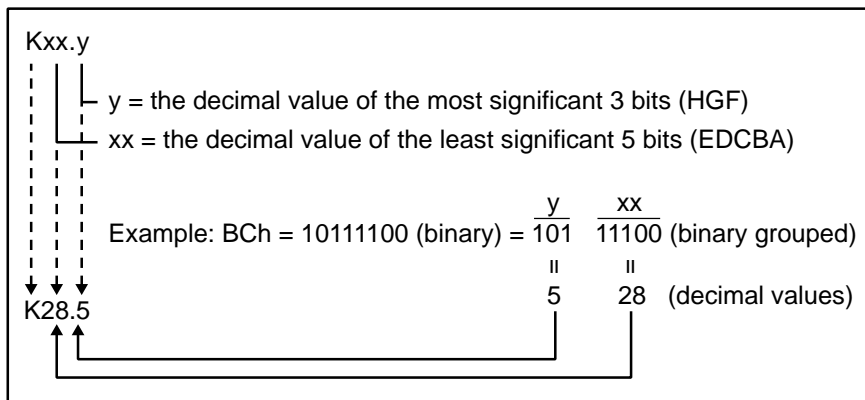


Figure 4. Decimal value translation

A decimal value is assigned to each bit combination with the range of 0 to 31 for xx and 0 to 7 for y. This means the range of valid data characters using the FC-1 naming convention is D00.0 through D31.7.

FC serial transmission delivers 10-bit characters which represent encoded data. Of the 1,024 characters possible with the 10-bit space, 256 8-bit byte data characters are mapped, along with 1 control character. This mapping process is called 8B/10B encoding. This encoding method involves selecting encoded 10-bit characters to maintain a run-length-limited serial stream of bits. To prevent too many ones or zeros on the serial interface from causing a DC electrical shift of the serial media, the encoder monitors the number of ones in the encoded character and selects the option of the 10-bit encode character that will shift to balance the total number of zeros and ones. This balancing is called running disparity.

A 10-bit character is actually made up of 6- and 4-bit sub-blocks. The 6-bit sub-block shifts out first followed by the 4-bit sub-block. Running disparity is set positive at the end of the sub-block as follows:

- If the number of ones in a sub-block is greater than the number of zeros, the 6-bit sub-block is 000111b, or the 4-bit sub-block is 0011b. Running disparity is set positive at the end of the sub-block.
- If the number of zeros in a sub-block is greater than the number of ones, the 6-bit sub-block is 111000b, or the 4-bit sub-block is 1100b. Running disparity is set negative at the end of the sub-block.
- If the number of ones and zeros in a sub-block are equal, running disparity is neutral and the value of running disparity at the end of the sub-block remains the same as the preceding character even if it is separated by neutral characters.

**Note.** The rules of running disparity prohibit consecutive positive or consecutive negative characters even if they are separated by neutral disparity characters. In other words, the negative and positive disparity characters must alternate, even if separated by a neutral disparity character. See Table 2.

Table 2. Running disparity examples

Sub-blocks					Valid?
1	2	3	4	5	
+	N	-	+	-	Yes
+	N	+			No
+	+				No
-	-				No

5.2 Buffer-to-buffer data transfers

Fibre Channel devices transfer information from an output buffer in the transmitting node to an input buffer of the receiving node. This is called a buffer-to-buffer transfer. Each node may have from 1 to n buffers. The number of buffers in each node does not have to be equal. Each buffer is the size a frame may transfer in its payload. The Fibre Channel standard does not define the actual length of the buffer or the method used to store the bytes in the buffer. Figure 5 shows how data is sent from the transmit buffer and received by the receive buffer.

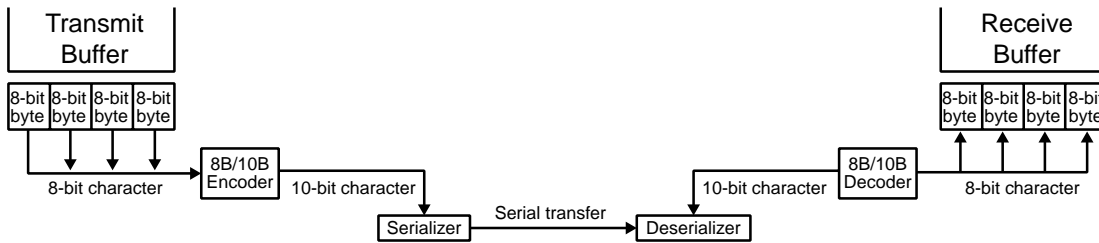


Figure 5. Serialization process

The bytes being transmitted are sent in increasing displacement.<sup>1</sup>

The basic unit of transfer for the contents of a buffer-to-buffer data transfer is the frame.

5.3 Data hierarchy

A hierarchy of data types is presented in Figure 6.

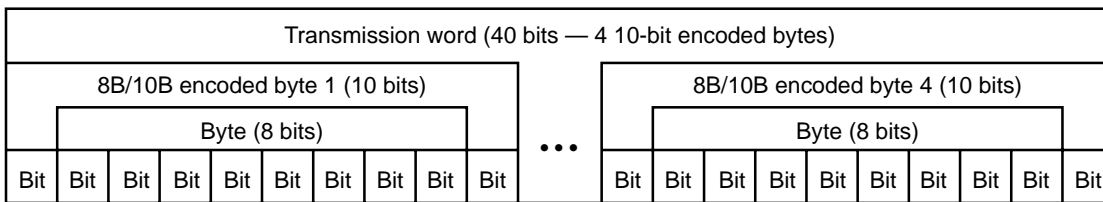


Figure 6. FC data hierarchy

5.3.1 Transmission words

Transmission words are the lowest level of control on Fibre Channel other than the control character used to provide character synchronization.

A transmission word is defined as four contiguous 8B/10B encoded transmission characters (10 bits each) treated as a unit. This unit is 40 bits in length (4 characters x 10 bits each) and is the smallest unit of transmission in Fibre Channel.

1. This means that if byte 0 is sent first, bytes 1, 2, 3, and 4 are then transmitted in that order. If byte 100 is sent first, bytes 101, 102, 103, and 104 are then transmitted in that order.



### 5.3.1.1 Data characters

A data character is a 8B/10B encoded transmission character with a data byte equated by the transmission code as one of the 256 possible data characters.

### 5.3.1.2 Special characters

The 8B/10B encoding scheme allows for all 256 data byte values, plus several others that can be used for special signaling. These other values are called special characters. Special characters include any transmission character considered valid by the transmission code but not equated to a valid data byte.

## 5.4 Ordered sets

An ordered set is a four-character combination of data and special transmissions characters. There are three primary categories of ordered sets:

- Primitive signals
- Primitive sequences
- Frame delimiters

The K28.5 special character is the first character of all ordered sets.

### 5.4.1 Primitive signals

Primitive signals are ordered sets that perform a control function. Primitive signals are recognized when one ordered set is detected. Table 3 lists the defined primitive signals. There must be a minimum of six primitive signals (Idles and R\_RDYs) at the N\_Port transmitter between frames to properly maintain clock skew.

**Table 3. Primitive signals**

Primitive signal	Signal	Beginning running disparity	Ordered set (FC-1)	Ordered set (hex)
Idle	IDLE	Negative	K28.5 D21.4 D21.5 D21.5	BC 95 B5 B5
Receiver_Ready	R_RDY	Negative	K28.5 D21.4 D10.2 D10.2	BC 95 4A 4A

#### Idle (IDLE)

An Idle is transmitted on the loop to indicate the node is operational and ready for frame transmission and reception. Idles are transmitted when frames, R\_RDY, or primitive sequences are not being transmitted. This maintains word synchronization and minimum spacing between frames.

#### Receiver ready (R\_RDY)

R\_RDY indicates that a frame was received and that the interface buffer that received the frame is ready for another frame. R\_RDY is preceded and followed by a minimum of two Idles. R\_RDY establishes buffer-to-buffer credit during data transmissions between an initiator and target.

#### 5.4.1.1 Primitive signals used as frame delimiters

Primitive signals can also be frame delimiters. A frame is an indivisible information unit that may contain data to record on disc or control information such as a SCSI command.

**Note.** All ordered sets (except for the End-of-frame delimiter, EOF) require the running disparity from the previous word to be negative. The second character of an ordered set (except EOF) will be positive and the third and fourth characters are neutral.

Frame delimiters mark the beginning and end of frames. There are several frame delimiters available in Fibre Channel. There are nine Start-of-frame (SOF) delimiters and six End-of-frame (EOF) delimiters as listed in Table 4.

Start-of-frame (SOF) delimiters:

- mark the beginning of a frame,
- indicate whether this is the first frame of the sequence, and
- indicate the class of service for the frame.

End-of-frame (EOF) delimiters:

- mark the end of a frame, and
- indicate whether this frame is the last frame of the sequence.

The second character of EOF delimiters differentiates between normal and invalid frames. The EOF delimiter also ensures that negative running disparity results after processing the set by assigning the appropriate second character.

The third and fourth characters of the delimiter functions (SOF and EOF) are repeated to ensure that an error affecting a single character will not result in the recognition of an ordered set other than the one transmitted. See Table 4 below.

Seagate disc drives use only those listed in **bold type** (Seagate Fibre Channel disc drives are Class 3 devices and use only Class 3 delimiters).

**Table 4. Frame delimiters**

Delimiter function	Delimiter	Beginning running disparity	Ordered set (FC-1)	Ordered set (hex)
SOF Connect Class 1	SOFc1	Negative	K28.5 D21.5 D23.0 D23.0	BC B5 17 17
SOF Initiate Class 1	SOFi1	Negative	K28.5 D21.5 D23.2 D23.2	BC B5 57 57
SOF Normal Class 1	SOFn1	Negative	K28.5 D21.5 D23.1 D23.1	BC B5 37 37
SOF Initiate Class 2	SOFi2	Negative	K28.5 D21.5 D21.2 D21.2	BC B5 55 55
SOF Normal Class 2	SOFn2	Negative	K28.5 D21.5 D21.1 D21.1	BC B5 35 35
<b>SOF Initiate Class 3</b>	<b>SOFi3</b>	<b>Negative</b>	<b>K28.5 D21.5 D22.2 D22.2</b>	<b>BC B5 56 56</b>
<b>SOF Normal Class 3</b>	<b>SOFn3</b>	<b>Negative</b>	<b>K28.5 D21.5 D22.1 D22.1</b>	<b>BC B5 36 36</b>
<b>SOF Initialize Loop</b>	<b>SOFil</b>	<b>Negative</b>	<b>K28.5 D21.5 D22.2 D22.2</b>	<b>BC B5 56 56</b>
SOF Activate Class 4	SOFc4	Negative	K28.5 D21.5 D25.0 D25.0	BC B5 19 19
SOF Initiate Class 4	SOFi4	Negative	K28.5 D21.5 D25.2 D25.2	BC B5 59 59
SOF Normal Class 4	SOFn4	Negative	K28.5 D21.5 D25.1 D25.1	BC B5 39 39
SOF Fabric	SOFf	Negative	K28.5 D21.5 D24.2 D24.2	BC B5 58 58
<b>EOF Terminate</b>	<b>EOFt</b>	<b>Negative</b> <b>Positive</b>	<b>K28.5 D21.4 D21.3 D21.3</b> <b>K28.5 D21.5 D21.3 D21.3</b>	<b>BC 95 75 75</b> <b>BC B5 75 75</b>
EOF Disconnect-Terminate	EOFdt	Negative Positive	K28.5 D21.4 D21.4 D21.4 K28.5 D21.5 D21.4 D21.4	BC 95 95 95 BC B5 95 95
EOF Abort	EOFa	Negative Positive	K28.5 D21.4 D21.7 D21.7 K28.5 D21.5 D21.7 D21.7	BC 95 F5 F5 BC B5 F5 F5
<b>EOF Normal</b>	<b>EOFn</b>	<b>Negative</b> <b>Positive</b>	<b>K28.5 D21.4 D21.6 D21.6</b> <b>K28.5 D21.5 D21.6 D21.6</b>	<b>BC 95 D5 D5</b> <b>BC B5 D5 D5</b>
EOF Disconnect-Terminate-Invalid	EOFdti	Negative Positive	K28.5 D10.4 D21.4 D21.4 K28.5 D10.5 D21.4 D21.4	BC 8A 95 95 BC AA 95 95
EOF Normal-Invalid	EOFni	Negative Positive	K28.5 D10.4 D21.6 D21.6 K28.5 D10.5 D21.6 D21.6	BC 8A D5 D5 BC AA D5 D5

**Notes.**

1. EOF primitives come in two forms—one is used when the beginning running disparity is positive and the other is used if the beginning running disparity is negative. Regardless of which form is used, each EOF delimiter is defined so that negative current running disparity results after processing the final (rightmost) character of the ordered set.
2. Ordered sets associated with SOF delimiters, primitive signals, and primitive sequences are always transmitted with negative beginning running disparity. As a result, primitive signals, primitive sequences, and SOF delimiters are only defined for the negative beginning running disparity case.
3. Frames that end with any other EOF type are discarded by the drive.

**Start-of-frame Initiate Class 3 (SOFi3)**

SOFi3 indicates the beginning of the first frame of a sequence of frames (an exchange). (This includes all single frame sequences, commands, link services, transfer readys, and response frames.) SOFi3 is also used in the first data frame of a sequence.

**Start-of-frame Normal Class 3 (SOFn3)**

SOFn3 indicates the beginning of any frame other than the first frame of an exchange (see SOFi3 above).

**Start-of-frame Initialize Loop (SOFil)**

SOFil is the same as SOFi3, but is renamed for use in Loop Initialization to remove the class of service distinction from the initialization process.

**End-of-frame Normal (EOFn)**

EOFn indicates the end of any frame other than the last frame of an exchange or sequence.

**End-of-frame Terminate (EOFt)**

EOFt marks the end of the last frame of all sequences. It can also indicate the end of the last frame of an exchange. For example, the single frame sequences, commands, link services, transfer readys, and response frames.

**5.4.1.2 Primitive signals custom made for arbitrated loop topologies**

There are eight primitive signals used exclusively within arbitrated loop (FC-AL) topologies. These primitives are listed in Table 5 and defined in text following the table.

**Table 5. FC-AL primitive signals**

FC-AL primitive signal	Signal	Beginning running disparity	Ordered set (FC-1)	Ordered set (hex)
Arbitrate	ARBx	Negative	K28.5 D20.4 AL_PA AL_PA	BC 94 AL_PA AL_PA
Arbitrate (F0)	ARB(F0)	Negative	K28.5 D20.4 D16.7 D16.7	BC 94 F0 F0
Open full-duplex	OPNyx	Negative	K28.5 D17.4 AL_PD AL_PS	BC 91 AL_PD AL_PS
Open half-duplex	OPNyy	Negative	K28.5 D17.4 AL_PD AL_PD	BC 91 AL_PD AL_PD
Open broadcast replicate	OPNfr	Negative	K28.5 D17.4 D31.7 D31.7	BC 91 FF FF
Open selective replicate	OPNyr	Negative	K28.5 D17.4 AL_PD D31.7	BC 91 AL_PD FF
Close	CLS	Negative	K28.5 D5.4 D21.5 D21.5	BC 85 B5 B5
Dynamic Half Duplex	DHD	Negative	K28.5 D10.4 D21.5 D21.5	BC 8A B5 B5
Mark	MRKtx	Negative	K28.5 D31.2 MK_TP AL_PS	BC 5F MK_TP AL_PS

**Arbitrate (ARBx)**

ARBx is transmitted to request access to the loop. Each ARBx contains the Physical (port) Address (AL\_PA) of the requestor.

**Arbitrate (ARB(F0))**

ARB(F0) is transmitted to manage access fairness (see Section 8.3.1 on page 43). It is also used to assign a loop master during initialization.

**Open full-duplex (OPNyx)**

After successful arbitration, the transmitting port (x) opens the receiving port (y) for control and data frame transmission and reception. Any FC port can transmit or receive an OPN.

**Open half-duplex (OPNyy)**

After successful arbitration, the initiator opens the target (y) for control and data frame transmission and reception of control frames. Data frame transmission from the target is not allowed.

**Open broadcast replicate (OPNfr)—Not supported by Seagate drives**

OPNfr is used by the open port to communicate with all ports in the loop. When received by the targets (the opened ports), they are not allowed to generate any transmission words (except fill words). They must replicate and retransmit all received words until a CLS is detected. Both 'f' and 'r' are FFh (D31.7 in FC-1 transmission code).

**Open selective replicate (OPNyr)—Not supported by Seagate drives**

Similar to OPNfr (see definition above), with the exception that the initiator can communicate with a subset of the targets on the loop. The target at AL\_PA 'y' is a member of the subset.

**Close (CLS)**

Close indicates that the CLS originator is prepared to or has ended the current loop circuit.

**Dynamic Half Duplex (DHD)**

DHD indicates the open L\_Port is relinquishing control of when the current loop circuit is closed. Support of DHD is discovered during Port Login.

**Mark (MRKtx)—Not supported by Seagate drives**

Mark may be used for synchronization within the loop (for example, spindle sync in a RAID application). The third character of the ordered set 't' (MK\_TP) is a vendor-unique sync code. Seagate drives pass through this primitive signal without responding to it.

**5.4.2 Primitive sequences**

Primitive sequences are ordered sets that perform control functions. These primitive sequences are listed in Table 6. Primitive sequences differ from primitive signals in the requirement for detection. Primitive sequences must have at least three consecutive ordered sets to be detected. Primitive sequences are transmitted repeatedly.

All of these primitive sequences are defined in Fibre Channel, but are not recognized by the drive. The Loop Initialization Primitive (LIP) sequence is used in arbitrated loop configurations to reset all attached ports to a known state. Refer to Section 8.2 on page 32 for additional information about LIPs.

Table 6. Primitive sequences

Primitive sequences	Sequence	Beginning running disparity	Ordered set (FC-1)	Ordered set (hex)
Offline	OLS	Negative	K28.5 D21.1 D10.4 D21.2	BC 35 8A 55
Not_Operational	NOS	Negative	K28.5 D21.2 D31.5 D5.2	BC 55 BF 45
Link_Reset	LR	Negative	K28.5 D9.2 D31.5 D9.2	BC 49 BF 49
Link_Reset_Response	LRR	Negative	K28.5 D21.1 D31.5 D9.2	BC 35 BF 49

**Offline (OLS)**

Offline is transmitted to indicate that the port is initiating the initialization protocol prior to going offline. The sequence will be transmitted for a minimum of 5 msec before further action is taken.

**Not\_Operational (NOS)**

Not\_Operational is transmitted to indicate that the port has detected a loop failure or is offline.

**Link\_Reset (LR)**

Link\_Reset is transmitted by a port to initiate the Link Reset protocol following a Link Timeout. This brings the port back to a stable synchronized state.

**Link\_Reset\_Response (LRR)**

Link\_Reset\_Response is transmitted to indicate that the port is receiving and recognizes the Link\_Reset (LR) primitive sequence.

**5.4.2.1 Primitive sequences custom made for Arbitrated Loop topologies**

There are eight primitive sequences used exclusively within arbitrated loop (FC-AL) topologies. These primitives are listed in Table 7 and defined in text following the table.

Table 7. FC-AL primitive sequences

FC-AL primitive sequence	Sequence	Beginning running disparity	Ordered set (FC-1)	Ordered set (hex)
Loop initialization, no valid AL_PA	LIP	Negative	K28.5 D21.0 D23.7 D23.7	BC 15 F7 F7
Loop initialization, loop failure, no valid AL_PA	LIP	Negative	K28.5 D21.0 D24.7 D23.7	BC 15 F8 F7
Loop initialization, valid AL_PA	LIP	Negative	K28.5 D21.0 D23.7 AL_PS	BC 15 F7 AL_PS
Loop initialization, loop failure, valid AL_PA	LIP	Negative	K28.5 D21.0 D24.7 AL_PS	BC 15 F8 AL_PS
Loop initialization reset	LIP	Negative	K28.5 D21.0 AL_PD AL_PS	BC 15 AL_PD AL_PS
Loop initialization reset all	LIP	Negative	K28.5 D21.0 D31.7 AL_PS	BC 15 FF AL_PS
Loop port enable	LPEyx	Negative	K28.5 D5.0 AL_PD AL_PS	BC 05 AL_PD AL_PS
Loop port enable all	LPEfx	Negative	K28.5 D5.0 D31.7 AL_PS	BC 05 FF AL_PS
Loop port bypass	LPByx	Negative	K28.5 D9.0 AL_PD AL_PS	BC 09 AL_PD AL_PS
Loop port bypass all	LPBfx	Negative	K28.5 D9.0 D31.7 AL_PS	BC 09 FF AL_PS

**Note.** There are six sequences that invoke loop initialization. There is no operational difference between them except that bytes 3 and 4 identify the reason for the loop initialization.

**Loop initialization, no valid AL\_PA (LIP)**

The L\_Port is attempting to acquire an AL\_PA.

**Loop initialization, loop failure, no valid AL\_PA (LIP)**

The transmitting L\_Port detects a loop failure at its receiver. Since it has not completed initialization, it uses 'F7' (D23.7) rather than a valid AL\_PA.

**Loop initialization, valid AL\_PA (LIP)**

The L\_Port is attempting to reinitialize the loop to a known state after recognizing a problem (performance degradation).

**Loop initialization, loop failure, valid AL\_PA (LIP)**

The transmitting L\_Port detects a loop failure at its receiver.

**Loop initialization reset (LIP)**

If the rightmost two bytes consist of a valid destination and source address, the source is requesting the target to perform a device reset.

**Loop initialization reset all (LIP)**

If byte 3 is FFh and byte 4 is a valid source address, the source is requesting all receiving targets to perform a device reset.

**Loop port enable (LPEyx)**

LPEyx resets the bypass circuit and enables a previously-bypassed L\_Port.

**Loop port enable all (LPEfx)**

LPEfx resets the bypass circuits on all L\_Ports on the loop.

**Loop port bypass (LPByx)**

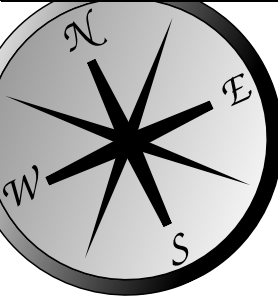
LPByx activates the port bypass circuit and prevents the L\_Port from actively participating on the loop.

**Loop port bypass all (LPBfx)**

LPBfx activates the port bypass circuit for all L\_Ports on the loop with bypass circuits except for the source of the LPBfx.

## 6.0 Framing protocol (FC-2)

The entire responsibility of moving frames between N\_Ports is assigned to the Fibre Channel layer called the framing protocol (FC-2). This protocol is primarily concerned with constructing and managing frames, sequences, and exchanges.



**Navigation assistance**

The field descriptions that are provided for most tables have sidebar labels which identify the table they are associated with. This helps orient you when nested tables occur within a section.

*Sidebar example*

Table number	Field definitions (listed alphabetically)
1	<b>Field name</b>
	The sidebar (black background with reversed text) identifies this field as being associated with Table 1.

### 6.1 Frames

Frames transfer all information between nodes. The frames are normally constructed by the transmitting node's N\_Port. A frame is the smallest unit of information transfer across a link. A sequence is one or more frames. An exchange is one or more sequences. See Figure 7 below.

It is possible, but not common, for a sequence to have only one frame and for an exchange to have only one sequence. Again, this isn't common, but possible. Most sequences have more than one frame, and most exchanges have more than one sequence.

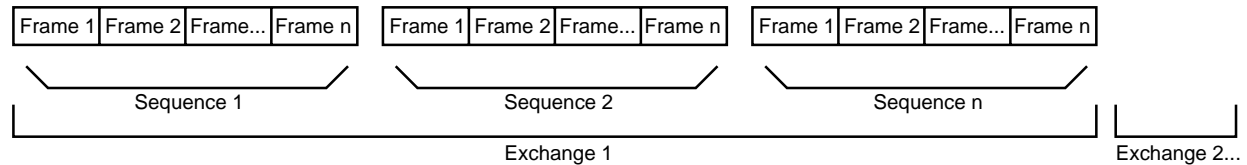


Figure 7. Relationship between frames, sequences, and exchanges

#### 6.1.1 Frame structure

A frame is a string of transmission words containing data bytes. Every frame is prefixed by a start-of-field (SOF) delimiter and suffixed by an end-of-field (EOF) delimiter. There are never any primitive signals or primitive sequences in a frame.

All frames also have a header and a Cyclic Redundancy Check (CRC) field. The payload data field is optional (but normally present) with the size and contents determined by the type of frame.

Bytes	4	24	0 to 2112	4	4	24	
	Fill Words	SOF	Frame Header	Fill Bytes	CRC	EOF	Fill Words
Transmission Words	1	6	0 to 528	1	1	6	

Figure 8. Frame structure

##### 6.1.1.1 Start-of-frame (SOF) delimiter

Start-of-frame (SOF) delimiters signal the beginning of a frame. See "Frame delimiters" on page 14. This referenced page contains a list of the various types of SOF delimiters.

### 6.1.1.2 Frame header

The frame header is 24 bytes long and is present in all frames. It is used to control link operation, control device protocol transfers, and to detect missing frames or frames that are out of order.

**Table 8. Frame header format**

Byte Word	0 (bits 31 - 24)	1 (bits 23 - 16)	2 (bits 15 - 08)	3 (bits 07 - 00)
0	R_CTL	D_ID		
1	Reserved	S_ID		
2	Type	F_CTL		
3	SEQ_ID	DF_CTL	SEQ_CNT	
4	OX_ID		RX_ID	
5	Offset			

**Table number** **Field definitions (listed alphabetically)**

**8 DF\_CTL (Data Field Control)**

Specifies the presence of optional headers in the payload of the frame. The drive does not support optional headers.

00h The drive sets this field to 00h for all frames it originates (sends), and should also be 00h for all frames sent to the drive.

**8 D\_ID (Destination Identifier)**

The 3-byte N\_Port address to which the frame is being sent.



**8 F\_CTL (Frame Control)**

This 3-byte (24-bit) field contains control information relating to the frame content as defined below.

**Table 9. Frame Control (F\_CTL) bit definitions**

Bit	Definition	Description
23	Exchange context	0 = Frame is from the exchange originator. 1 = Frame is from the exchange responder.
22	Sequence context	0 = Initiator 1 = Recipient
21	First sequence	0 = Not the first sequence of the exchange. 1 = First sequence of the exchange.
20	Last sequence	0 = Not the last sequence of the exchange. 1 = Last sequence of the exchange.
19	End of sequence	0 = Not the last frame of the sequence. 1 = Last frame of the sequence.
18	End connection	Not supported.
17	Chained sequence	Not supported.
16	Sequence initiative	0 = Hold sequence initiative. 1 = Transfer sequence initiative.
15	X_ID reassigned	Not supported.
14	Invalid X_ID	Not supported.
13 12 11 10	Reserved	
9	Retransmitted sequence	Not supported.
8	Unidirectional transmit	Not supported.
7 6	Continue sequence condition	Not supported.
5 4	Abort sequence condition	Not supported.
3	Relative offset present	0 = Parameter field not meaningful. 1 = Parameter field equals relative offset.
2	Reserved	
1 0	Fill data bytes	End of data field fill bytes 00 = 0 bytes of fill. 01 = 1 byte of fill (last byte of data field). 02 = 2 bytes of fill (last 2 bytes of data field). 03 = 3 bytes of fill (last 3 bytes of data field).

**8 Offset**

This 4-byte field is used in data frames to define the relative offset (displacement) of the first byte of the payload from the base address of the command. When the relative offset is present, bit 3 of F\_CTL is set to indicate that relative offset is valid.

The drive uses the SEQ\_CNT value to verify that frames are being received in order. The drive does not use relative offset in frames it receives. The drive sends relative offset information in data frames it originates.

**8 OX\_ID (Originator Exchange Identifier)**

This 2-byte field is assigned by the originator of an exchange. For SCSI FCP frames, this value is analogous to the Queue Tag used in Parallel SCSI and must be unique for an initiator/drive pair.

**8 R\_CTL (Routing Control)**

This one-byte field provides routing bits and information bits to categorize the frame function.

The high order bits (bits 31-28) indicate the frame type as indicated below:

0000	=	FC-4 Device_Data frame
0010	=	Extended Link_Data frame
0011	=	FC-4 Link_Data frame
0100	=	Video_Data frame
1000	=	Basic Link_Data frame
1100	=	Link_Control frame
Others	=	Reserved

The low order bits (bits 27-24) contain the Information field values. This is dependent on the value of the high order bits (31-28). If the high order bit value = 1000, the Information field contains a basic link service. For all other high order bit values, the Information field specifies the Common Information Categories specified in the table below.

**Table 10. Routing Control values**

High order bits	Low order bits	Use	
Type 08h, SCSI FCP, Device Data frames			
0000	0000	Uncategorized	Not supported
	0001	Solicited Data	Read and write data
	0010	Unsolicited Control	Not supported
	0011	Solicited control	Not supported
	0100	Unsolicited data	Not supported
	0101	Data descriptor	Transfer ready
	0110	Unsolicited command	Command
	0111	Command status	Response
Type 01h, Extended link service			
0010	0000	Uncategorized	Not supported
	0001	Solicited data	Not supported
	0010	Unsolicited control	Request
	0011	Solicited control	Reply
	0100	Unsolicited data	Not supported
	0101	Data descriptor	Not supported
	0110	Unsolicited command	Not supported
	0111	Command status	Not supported
Type 00h, Basic link service			
1000	0000	No operation	Not supported
	0001	Abort sequence (ABTS)	Request
	0010	Remove connection	Not supported
	0011	Reserved	Not supported
	0100	Basic_Accept (BA_ACC)	Reply
	0101	Basic_Reject (BA_RJT)	Reply
	0110-0111	Reserved	Not supported

**8 RX\_ID (Responder Exchange Identifier)**

This 2-byte identifier is a unique identifier generated by the responder for an exchange established by an originator and identified by an OX\_ID.

With Class 3 devices such as this drive, the responder of the exchange assigns a unique value for RX\_ID other than FFFFh if RX\_ID is being used in an ACK to a data frame in the first sequence transmitted as a sequence initiator.

The drive returns FFFFh in this field to indicate the RX\_ID is not being used.

**8 SEQ\_CNT (Sequence Count)**

This 2-byte field identifies the sequential order of frames within a sequence or multiple sequences of the same exchange. The SEQ\_CNT value for each frame of a sequence has to be unique. The field range limits the number of frames per sequence to a maximum of 65,536.

For SCSI FCP write data transfers that require more than one sequence to transfer the data, the first frame of each sequence starts with a SEQ\_CNT of 0000h. The transfer of sequence initiative between write data sequences and the XFR\_RDY sent by the drive give the sequence originator (the SCSI Initiator) verification that the previous sequence is closed.

For SCSI FCP read data transfers that require more than one sequence to transfer the data, the SEQ\_CNT does not reset to 0000h for each new sequence. The SEQ\_CNT increments sequentially across the sequence boundaries. The SEQ\_CNT is still allowed to increment through all 65,536 possible values for each sequence. This is required as there is no verification in Class 3 that all the frames of previous sequences have been delivered.

**8 SEQ\_ID (Sequence Identifier)**

This field uniquely identifies frames in a non-streamed sequence or when only one sequence is open.

**8 S\_ID (Source Identifier)**

The 3-byte address of the N\_Port or F\_Port originating the frame.

**8 Type (Data Structure Type)**

This 1-byte field identifies the protocol of the frame contents as described below:

**Table 11. Data type codes**

R_CTL (4 highest order bits)	Type code	Description
1000	00	Basic Link Service
0010	01	Extended Link Service
0000	08	SCSI FCP

**6.1.1.3 Data field (payload)**

The data field, also known as the payload, is aligned on word boundaries. The payload length must be an integer multiple of four bytes and is limited to 2,112 bytes. If the data field is not an integer multiple of four bytes, valid fill bytes are inserted to meet the requirement. F\_CTL bits 0 and 1 indicate how many fill bytes are used. Fill bytes are only permitted in the last frame of a sequence. These fill bytes can be any valid byte value.

The contents of the frame payload is specified by the type of frame. Refer to Section 9.0 for link service information.

**6.1.1.4 CRC field**

The Cyclic Redundancy Check (CRC) is a 4-byte field that follows the payload field. The CRC is used to verify the integrity of the frame header and payload fields. This helps detect errors in a frame. The SOF and EOF frame delimiters are not included in the CRC calculation.

The algorithm used to calculate the CRC field value is the same as that used in the Fiber Distributed Data Interface (FDDI) standard. The polynomial for the CRC is:

$$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$$

### 6.1.1.5 End-of-frame (EOF) delimiter

End-of-frame (EOF) delimiters signal the end of a frame. See “Frame delimiters” on page 14. This page contains a list of the various types of EOF delimiters.

## 6.2 Frame sequences

Since the data field has a maximum length of 2,112 bytes (528 transmission words), larger amounts of data must be split into several frames.

Frame sequences always contain at least one frame. The frame header subfields in the F\_CTL field are used to identify the beginning, middle, and end of a frame sequence. The SEQ\_ID and SEQ\_CNT fields are used to identify the order of the frames for reassembly in the event they arrive out of order at the destination when participating in a fabric topology.

The OX\_ID and RX\_ID fields identify the larger context (the exchange) of which this frame sequence is a part.

The frame sequence itself may be part of an exchange and is identified by the SEQ\_ID field in the frame header. The R\_CTL field of the frame header identifies the category of information in all the frames of the sequence. All of the frames within the same sequence are required to have the same category.

## 6.3 Exchanges

Exchanges are an additional layer that controls operations across Fibre Channel. An exchange provides a control environment for the transfer of information between two N\_Ports. You can think of exchanges as an operating system that controls communications between nodes when two or more sequences are required to transmit data or commands. Exchanges even keep track of operations that occur in opposite directions (sender to receiver and receiver to sender). Here's a short explanation of how this occurs:

One of the N\_Ports establishes an exchange by sending a sequence to the other N\_Port with at least one frame in it. The originator names its resources using the OX\_ID field in the frame header of each frame of the exchange.

The responder of the exchange also allocates resources after it receives the first frame of the first sequence. It names its resources using the RX\_ID field.

These two independent fields (OX\_ID and RX\_ID) allow each N\_Port to identify the resources needed to manage a frame or sequence as it arrives. Each N\_Port involved with the exchange can use a link service request to view the contents of the control information in the other port in the exchange; however, no other N\_Ports are allowed to request information for the exchange since they are not involved with that particular exchange.

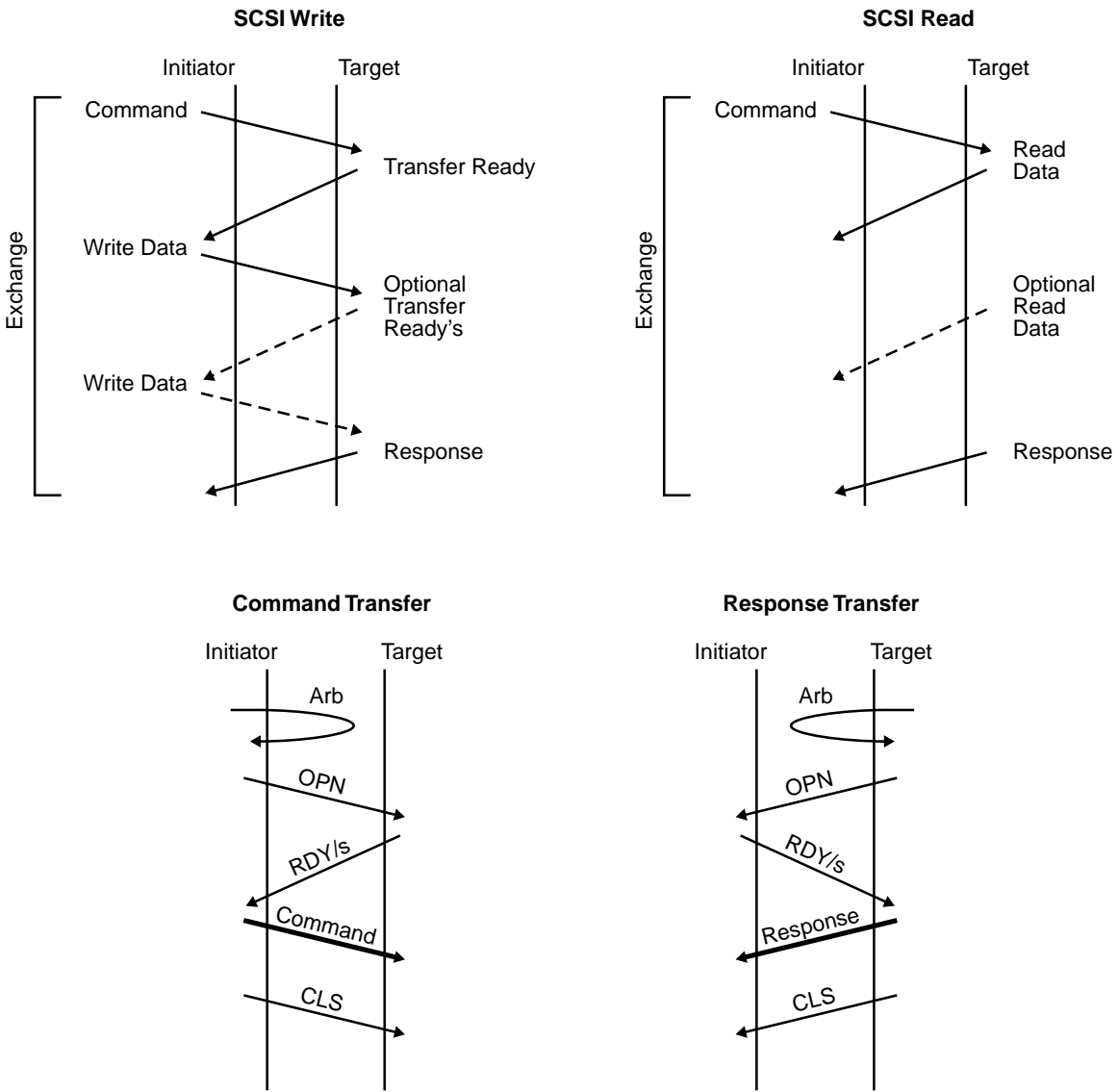


Figure 9. FC-SCSI exchanges, command and response transfers

### 6.4 Credit

The framing protocol must be concerned about how many frames one source N\_Port can send to another without overflowing the buffers in the receiving N\_Port. To address this problem, there are two types of credit:

1. Buffer-to-buffer credit (BB\_Credit). This type of credit is associated only with the immediate fiber exiting the transmitter to the next receiver (F\_Port or N\_Port). This credit is managed by the R\_RDY primitive signal on a link.
2. End-to-end credit (EE\_Credit). This type of credit is negotiated between a source N\_Port and a destination N\_Port. This credit is managed using an acknowledgment (ACK) frame sent from the destination back to the source N\_Port. This type of credit is not used in Class 3 therefore it is not applicable to Seagate drives.



## 7.0 Classes of service (FC-2)

There are five classes of service currently available or being defined. Classes of service are simply different communication methods used between nodes. Seagate drives use only Class 3; however, brief explanations of the other classes are provided as well.

### 7.1 Class 1

Class 1 is like a direct face-to-face meeting with no interruptions or delays. It is a dedicated full-bandwidth connection between two nodes.

#### Other Class 1 attributes

- Guaranteed delivery
- Frames are received in the order they are transmitted
- Usually uses the least overall bandwidth
- Very little software interaction

### 7.2 Class 2

Class 2 is like an electronic mail transaction where each message has an acknowledgment message sent from the receiver to signal that the message was received successfully. This class of service allows one N\_Port to transmit consecutive frames to multiple destinations without establishing a dedicated connection with any specific N\_Port and also allows one N\_Port to receive consecutive frames from one or more N\_Ports without having established dedicated connections with any of them.

#### Other Class 2 attributes

- Confirmed delivery (the receiver sends an acknowledgment on receipt)
- Frames are not always guaranteed to be received in the order they are transmitted
- Can potentially use more bandwidth than Class 1 and latency may increase by waiting for acknowledgments

### 7.3 Class 3

Class 3 service multiplexes frames at frame boundaries to or from one or more N\_Ports without acknowledgment of receipt.

Seagate drives use Class 3 exclusively. Class 3 reduces the complexity of the ports and provides better performance for disc applications.

#### Other Class 3 attributes

- Full duplex transfers may be used between two ports using Class 3; however, Class 3 operation does not require half duplex operation.
- Acknowledge (ACK) buffer not required (no waiting for ACKs)
- EE\_Credit not required
- Busy and Reject not needed due to alternate credit model
- Errors are recovered at the exchange level

#### 7.3.1 Class 3 flow control

Class 3 flow control is a simple model which does not require EE\_Credits. With Class 3, there is only buffer-to-buffer flow control in one direction and there are no link level responses to Class 3 frames.

### 7.4 Classes 4 and 5

Classes 4 and 5 are being defined by Fibre Channel committees to aid audio and video applications.

Class 4 is similar to Class 1 in that a dedicated connection is established; however, with Class 4, the full bandwidth is not available. Connections for other nodes connected may be assigned portions of the bandwidth.

Class 5 provides isochronous service through a fabric. A Class 5 node is guaranteed access through a fabric at established time intervals.





## 8.0 FC Arbitrated Loop concepts

This section describes some basic Fibre Channel Arbitrated Loop (FC-AL) concepts. Seagate disc drives support FC-AL as the topology for connectivity in Fibre Channel environments.

Fibre Channel is a serial data channel that provides *logical* point-to-point service to two communicating devices. With FC-AL, you can have a maximum of one point-to-point circuit at any one time. When this circuit is active, only two L\_Ports are communicating, but up to 127 devices may be attached to and participating on the same loop. All of the L\_Ports that are on the loop but that are not one of the two communicating L\_Ports “see” all data transferred across the loop and retransmit this information so that the data reaches its intended destination.

### 8.1 Arbitrated Loop physical address (AL\_PA)

Each device communicating on an arbitrated loop must have an Arbitrated Loop Physical Address (AL\_PA). The AL\_PA is an 8-bit (1-byte) 8B/10B encoded value that is a valid data character. This 8-bit character, when encoded to 10 bits, must have an equal number of 1's and 0's in the address to maintain neutral running disparity. Neutral running disparity is required so that the AL\_PA data character does not change the current running disparity of the current transmission word. There are 134 characters that result in neutral disparity. See Table 12. Seven of the 134 neutral disparity characters are reserved (see Table 13 on page 31). This leaves 127 valid addresses.

Table 12. 8B/10B characters with neutral disparity

D xx.y	y								Hex value
	0	1	2	3	4	5	6	7	
00	*				*			*	00, 80, E0
01	*				*			*	01, 81, E1
02	*				*			*	02, 82, E2
03		*	*	*		*	*		23, 43, 63, A3, C3
04	*				*			*	04, 84, E4
05		*	*	*		*	*		25, 45, 65, A5, C5
06		*	*	*		*	*		26, 46, 66, A6, C6
07		*	*	*		*	*		27, 47, 67, A7, C7
08	*				*			*	08, 88, E8
09		*	*	*		*	*		29, 49, 69, A9, C9
10		*	*	*		*	*		2A, 4A, 6A, AA, CA
11		*	*	*		*	*		2B, 4B, 6B, AB, CB
12		*	*	*		*	*		2C, 4C, 6C, AC, CC
13		*	*	*		*	*		2E, 4E, 6E, AE, CE
14		*	*	*		*	*		2E, 4E, 6E, AE, CE
15	*				*			*	0F, 8F, EF
16	*				*			*	10, 90, F0 <sup>R</sup>
17		*	*	*		*	*		31, 51, 71, B1, D1
18		*	*	*		*	*		32, 52, 72, B2, D2
19		*	*	*		*	*		33, 53, 73, B3, D3
20		*	*	*		*	*		34, 54, 74, B4, D4
21		*	*	*		*	*		35, 55, 75, B5, D5
22		*	*	*		*	*		36, 56, 76, B6, D6
23	*				*			*	17, 97, F7 <sup>R</sup>
24	*				*			*	18, 98, F8 <sup>R</sup>
25		*	*	*		*	*		39, 59, 79, B9, D9
26		*	*	*		*	*		3A, 5A, 7A, BA, DA
27	*				*			*	1B, 9B, FB <sup>R</sup>
28		*	*	*		*	*		3C, 5C, 7C, BC, DC
29	*				*			*	1D, 9D, FD <sup>R</sup>
30	*				*			*	1E, 9E, FE <sup>R</sup>
31	*				*			*	1F, 9F, FF <sup>R</sup>
Total 134	13	19	19	19	13	19	19	13	

\* character with neutral disparity.

<sup>R</sup> Reserved (see Table 13 on page 31).

Of the 134 neutral disparity characters, seven are reserved. This leaves 127 valid non-reserved addresses. 126 of these addresses may be used by NL\_Ports and one (00) may be used by a FL\_Port (if present).

**Table 13. AL\_PA addressing**

Values (hex)	Use
00	Reserved for the FL_Port (if present)
01-EF	Contains 127 valid addresses
F0	Reserved for fairness
F1-F6	These values do not have neutral running disparity
F7-F8	Reserved for loop initialization
FB, FD, and FE	Reserved for future use
FF	Reserved to address all ports in broadcast mode

In the parallel SCSI world, the higher the bus address, the higher the priority the device has. The opposite is true with FC-AL. See Table 14.

**Table 14. AL\_PA value priorities**

AL_PA value	Priority
00	Highest priority (assigned to the FL_Port if present)
01	Highest priority NL_Port (on a public loop)
EF	Lowest priority NL_Port address
F0	Used only by the fairness algorithm and has no priority

During loop initialization, each NL\_Port interested in participating on the loop is assigned one of the 126 AL\_PA values. If an NL\_Port is offline because its node is powered off, the port is considered a non-participating NL\_Port.

One more reason exists for an L\_Port being in non-participating mode; you can place more than 127 L\_Ports on a loop, and, if this occurs, loop initialization permits only the first 126 NL\_Ports and the first FL\_Port to acquire a valid AL\_PA. The remaining L\_Ports must wait for a position to open up to obtain a valid AL\_PA.

An L\_Port can get a valid AL\_PA in four ways:

1. Assigned by the fabric (if present)
2. Use the previously-assigned address
3. Hard assigned by the backpanel
4. Soft assigned and acquired through the loop initialization process

The most common method that disc drives use is to have the backpanel provide a hard assigned address. This is similar to setting a SCSI ID on a drive, but with Fibre Channel, the ID is set on the backpanel rather than the drive. If, for some reason, a duplicate address is encountered when hard-assigned addresses are processed, the drive will revert to acquiring a soft-assigned AL\_PA during initialization. This insures that every node gets a unique AL\_PA.

A more detailed explanation of loop initialization is provided in the following section.

## 8.2 Loop initialization

Loop initialization is the process used to obtain or verify AL\_PAs. Loop initialization occurs at power-up, when a new node is inserted in the loop, or for error recovery.

During loop initialization, each NL\_Port discovers that it is connected in an arbitrated loop topology and that there may be multiple NL\_Ports on the arbitrated loop. The procedure used for this discovery is called the loop port state machine (LPSM). The FC-2 protocol is also used.

A buffer on the drive receives each of the following loop initialization frames: LISM, LIFA, LIPA, LIHA, LISA, LIRP, and LILP. All other frames may be discarded if the L\_Port's buffer is full.

If the NL\_Ports finds that there are not any more NL\_Ports attached, but that there is only an F\_Port or N\_Port attached, the NL\_Port configures itself to operate as an N\_Port by going into N\_Port mode.

An L\_Port begins the loop initialization procedure in the initializing state at the request of the node. In most cases, the backpanel will be set to provide a hard assigned physical address which will not be changed by the initialization process, unless duplicate hard assigned physical addresses are found. The AL\_PA of the one FL\_Port (if present) is always 00h. All other AL\_PA values will range from 01h - EFh.

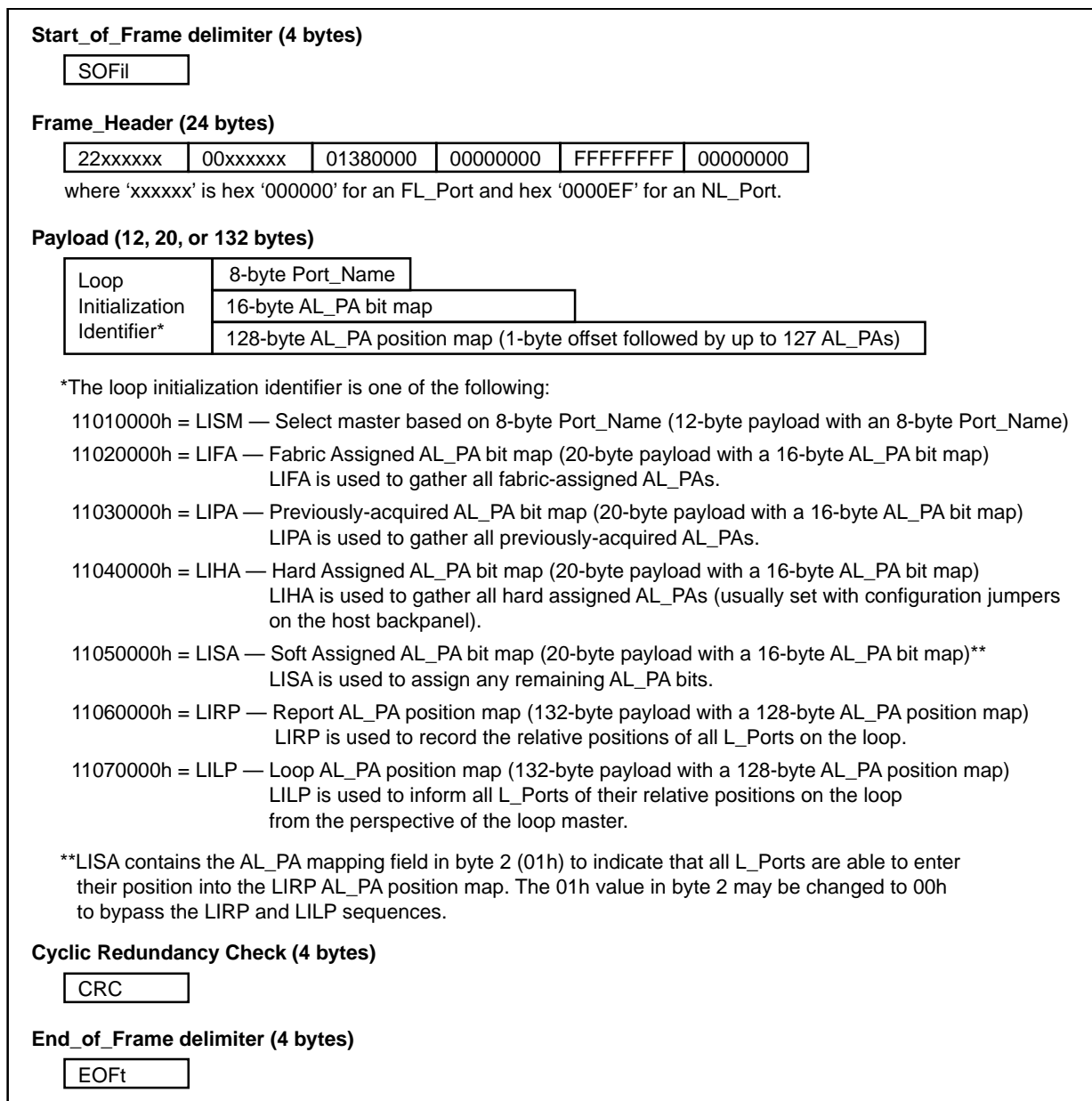


Figure 10. Loop initialization sequences

The loop initialization process begins when any NL\_Port forces the loop into the INITIALIZING state. See Figure 11. This initializing port begins transmitting loop initialization primitive sequences (LIPs). Any NL\_Port can cause this by sending any of the LIPs listed in Table 15. All LIPs cause the 4-step initialization process to occur. A loss of signal will also force the loop to initialize.

There are five Loop Initialization Primitive (LIP) sequences:

**Table 15. Loop Initialization Primitive (LIP) sequences**

LIP Reason Code	Use	Description
F7, F7	Initializing LIP	Used when an L_Port wants to acquire an AL_PA.
F8, AL_PS	Loop failure	The originating L_Port has detected an input failure. The AL_PS is the AL_PA of the L_Port.
F8, F7	Loop failure	The originating L_Port has detected an input failure but the L_Port does not have an AL_PA.
F7, AL_PS	Performance degradation	The originating L_Port has detected poor loop performance. Example: The L_Port is unable to win arbitration.
AL_PD, AL_PS	Selective reset	The source L_Port (AL_PS) wants to reset the destination port (AL_PD). All L_Ports complete loop initialization. The selected L_Port performs a reset after loop initialization.
FF, AL_PS	Reset all	The source L_Port (AL_PS) wants to reset all other L_Ports supporting LIP reset on the loop. All L_Ports complete initialization. The L_Ports supporting LIP reset all (generally only the targets in a storage implementation) perform a reset after loop initialization.

The next L\_Port in the loop receives the LIPs and transitions to the OPEN\_INIT state and transmits LIPs to the next L\_Port on the loop. This cycle continues until the port that started the initialization process receives the LIPs. It then also transitions to the OPEN\_INIT state. This means all L\_Ports on the loop are in the OPEN\_INIT state at this point.

Each port transmits a minimum of 12 LIPs and then transmits Idles for the AL\_TIME (15 msec). The L\_Port then transmits Loop Initialization Select Master (LISM) frames to select a loop master who will then control the initialization process.

### Loop initialization steps

There are four primary steps involved in initializing the loop.

1. Select a loop master based on the 8-byte port name (Loop Initialization Select Master—LISM).
2. Assign each port an arbitrated loop physical address (AL\_PA). There are four ways a port can acquire an AL\_PA. These are listed below.
  - Fabric assigned (Loop Initialization Fabric Assigned—LIFA)
  - Previously acquired (Loop Initialization Previously Acquired—LIPA)
  - Hard assigned (Loop Initialization Hardware Assigned—LIHA)
  - Soft assigned (Loop Initialization Soft Assigned—LISA)
3. Generate AL\_PA position map (Loop Initialization Report Position—LIRP).
4. Transmit completed AL\_PA position map around the loop (Loop Initialization Loop Position—LILP).

### Loop Initialization Select Master (LISM)

#### 12-byte payload

<b>11010000</b>	<b>8-byte port name</b>
-----------------	-------------------------

The loop master is determined as follows:

- Each NL\_Port selects an initial AL\_PA of 'EF'. The FL\_Port (if present) selects an AL\_PA of '0'.
- Each port transmits LISM with the D\_ID and S\_ID fields of the header set to its AL\_PA. The payload is set to the port name which includes the world wide name (WWN).
- Each port examines the payload in the inbound LISM. If it is greater than its own, the port transmits a new LISM with its own port name in the payload. If it is less than its own, the port retransmits the received LISM. If it is the same as its own, it becomes the loop master.
- The loop master sends ARB(F0) to purge the loop and to inform all other ports that a master has been selected. When the master receives ARB(F0) on the inbound fibre, initialization proceeds to LIFA.

### Loop Initialization Fabric Assigned (LIFA)

#### 20-byte payload

<b>11020000</b>	<b>16-byte bit map of AL_PAs</b>
-----------------	----------------------------------

The loop master primes the bit map with zeroes (0) then sends the bit map around the loop in the LIFA payload.

#### Example

The loop master places zeroes in the bit map corresponding to each bit position.

Bit position	0	1	2	3	4	5	6	7	8	...	128
AL_PA positions	--	00	01	02	04	08	0F	10	17	...	EF
Switch address	--	7E	7D	7C	7B	7A	79	78	77	...	00
<b>Bit map content</b>	<b>L</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>...</b>	<b>0</b>

Any port which has an AL\_PA assigned by the fabric will set a '1' in the bit map at the position corresponding to its AL\_PA. If a '1' already exists, no map entry is made.

**Loop Initialization Previously Assigned (LIPA)**

**20-byte payload**

11030000	16-byte bit map of AL_PAs
----------	---------------------------

The loop master transmits the bit map resulting from the LIPA.

The L\_Port checks to see if the bit that corresponds to its previously acquired AL\_PA is set. If not, the L\_Port sets it to '1'. If the L\_Port's bit has already been set by another port, it will attempt to assume a soft-assigned AL\_PA (LISA)..

**Example** The L\_Port had a previously assigned AL\_PA of 4 which was not already set by another port, so it set the bit at position 4 to '1'.

Bit position	0	1	2	3	4	5	6	7	8	...	128
AL_PA positions	--	00	01	02	04	08	0F	10	17	...	EF
Switch address	--	7E	7D	7C	7B	7A	79	78	77	...	00
<b>Bit map content</b>	<b>L</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	...	<b>0</b>

The L\_Port at AL\_PA 4 claims its' \_\_\_\_\_  
previously assigned address.

The L\_Port then retransmits the LIPA frame.

**Loop Initialization Hard Assigned (LIHA)**

**20-byte payload**

11040000	16-byte bit map of AL_PAs
----------	---------------------------

The loop master transmits the bit map resulting from the LIPA.

The L\_Port checks to see if the bit that corresponds to its hard address is set (usually using switches or jumpers). If not, the L\_Port sets it to '1'. If the L\_Port's bit has already been set by another port, it will attempt to assume a soft-assigned AL\_PA (LISA).

**Example** The L\_Port had a hard address set by switch or jumper at AL\_PA 8 which was not already set by another port, so it set the bit at position 8 to '1'.

Bit position	0	1	2	3	4	5	6	7	8	...	128
AL_PA positions	--	00	01	02	04	08	0F	10	17	...	EF
Switch address	--	7E	7D	7C	7B	7A	79	78	77	...	00
<b>Bit map content</b>	<b>L</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	...	<b>0</b>

The L\_Port at AL\_PA 8 claims its' \_\_\_\_\_  
preferred (hard-assigned) address.

The L\_Port then retransmits the LIHA frame.

## Loop Initialization Soft Assigned (LISA)

### 20-byte payload

11050100	16-byte bit map of AL_PAs
----------	---------------------------

The loop master transmits the bit map resulting from the LIHA.

The L\_Port checks to see if there are any free addresses left in the bit map by checking for the first available '0'. The L\_Port sets it to '1'. If there are no zeroes in the bit map, all 126 NL\_Port addresses have been taken and the port is not allowed to actively participate in the loop.

#### Example

The L\_Port saw that the first '0' occurred in bit position 1, so it changed that bit to a '1' to effectively select '1' as its AL\_PA.

Bit position	0	1	2	3	4	5	6	7	8	...	128
AL_PA positions	--	00	01	02	04	08	0F	10	17	...	EF
Switch address	--	7E	7D	7C	7B	7A	79	78	77	...	00
<b>Bit map content</b>	<b>L</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	...	<b>0</b>

First available '0' changed to '1'.

The L\_Port then retransmits the LISA frame.

## Loop Initialization Report Position (LIRP)

### 132-byte payload

11060000	128-byte map of AL_PA physical positions
----------	--

The LIRP and LILP sequences build a mapping between AL\_PA values and participating L\_Port positions. This allows all L\_Ports to know where all of the other AL\_PA addresses are physically located on the loop.

To build this address map, the loop master primes the 128-byte position map with 'FF' in each position. The loop master then sets byte 0 (the "counter" byte) of the position map to '01' and places its own AL\_PA in byte 1 and then sends the position map around the loop.

Each port increments the position counter (byte 0) by one and places its AL\_PA at the map position indicated by the counter. For example, the second device on the loop (with the loop master counted as the first device) increments byte 0 by one to make byte 0 have a value of '2' and then places its AL\_PA in position 2 of the position map.

Each port retransmits the LIPA frame until the map completes its journey to each of the devices on the loop and gets back to the loop master. At this point, the LIRP process results in a position map containing the physical location and AL\_PA of every device on the loop.

#### Example

This example position map shows that there are 6 ports on the loop. The loop master has AL\_PA 'E8'. The first port after the master on the outbound fibre has AL\_PA 'D6' and the last port on the loop before getting back to the master has AL\_PA '08'.

<b>Byte map content</b>	<b>06</b>	<b>E8</b>	<b>D6</b>	<b>E2</b>	<b>6A</b>	<b>5F</b>	<b>08</b>	<b>FF</b>	...	<b>FF</b>
-------------------------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----	-----------



### Loop Initialization Loop Position (LILP)

#### 132-byte payload

11070000	128-byte map of AL_PA physical positions
----------	--

When the loop master gets the LIRP frame back from the loop, it contains the AL\_PAs and physical location of each participating port on the loop. The loop master retransmits the completed position map (now called the LILP) to the next port on the loop. This informs all ports of the loop's physical make-up and also makes it possible for each port to make a copy of the map before retransmitting it to the next port.

When the loop master gets the LILP back from the loop, it sends a CLS followed by Idles. All of the other ports retransmit the CLS and transition to the Monitoring state. When the loop master gets the CLS back from the loop, it removes it and then transitions to the Monitoring state. This signals the end of the initialization process.

<b>Example</b>	This example LILP map shows that there are 6 ports on the loop. The hex values of the AL_PAs are in the appropriate positions indicating the physical order of the ports on the loop.									
<b>Byte map content</b>	06	E8	D6	E2	6A	5F	08	FF	...	FF

#### Detailed loop initialization explanation

1. Select initial AL\_PA
  - Each FL\_Port selects an AL\_PA hex value of '00'.
  - Each NL\_Port selects an AL\_PA hex value of 'EF'.
2. Select the loop master
  - Each L\_Port continuously<sup>1</sup> transmits a LISM loop initialization sequence with the D\_ID and S\_ID fields set to hex '0000xx' (where 'xx' is its initial AL\_PA) and its Port\_Name in the payload.
  - Each L\_Port monitors its receiver and proceeds as follows:
    - a. If the L\_Port receives a LISM loop initialization sequence that is the same as the one it transmits, it becomes the loop master and continues at step 3.
    - b. If the L\_Port received a LISM loop initialization sequence that is not the same as the one it transmits, the L\_Ports checks the D\_ID and payload as follows:
      - i. If the L\_Port is an FL\_Port and the received D\_ID = hex '000000', the loop initialization sequence is from another FL\_Port. If its Port\_Name is algebraically:
        - lower than the Port\_Name in the payload, the FL\_Port transmits a LISM loop initialization sequence with the payload containing its own Port\_Name.
        - higher than the Port\_name in the payload, the FL\_Port retransmits the same LISM that it received and goes to the MONITORING state in nonparticipating mode (another FL\_Port won the role of loop master).
      - ii. If the L\_Port is an FL\_Port and the received D\_ID is not equal to hex '000000', the FL\_Port discards the received sequence. This allows an FL\_Port to become the loop master.
      - iii. If the L\_Port is a NL\_Port and the received D\_ID equals hex '000000', the NL\_Port retransmits the received Loop Initialization Sequence. This allows an FL\_Port to become the loop master.
      - iv. If the L\_Port is an NL\_Port and the received D\_ID is not equal to hex '000000', the Loop Initialization Sequence is from another NL\_Port. If its Port\_Name is algebraically:
        - lower than the Port\_Name in the payload, the NL\_Port transmits a LISM loop initialization sequence with the payload containing its Port\_Name.

1. Frames are sent continuously because they may be discarded by any L\_Port that does not have a receive buffer available (flow control is not used during initialization).

- higher than the Port\_name in the payload, the NL\_Port retransmits the received Loop Initialization Sequence.

Each L\_Port continues with steps 2a through 2d.

- c. If the L\_Port receives an ARB(F0), it continues at step 4.
  - d. If it receives anything else, the value is discarded and the port continues with steps 2a to 2d.
3. Loop master — transmit remaining Loop Initialization Sequences
    - a. The loop master continuously transmits ARB(F0)s until its receives its own ARBx (ARB(F0)).
    - b. The L\_Port transmits the LIFA, LIPA, LIHA, and LISA loop initialization sequences. These sequences contain a 16-byte AL\_PA bit map in the payload. Each bit represents one AL\_PA. See figure 10 and tables 12 and 16.

**Table 16. Loop initialization sequence AL\_PA bit map**

		Bits							
		3322 1098	2222 7654	2222 3210	1111 9876	1111 5432	11 1098	7654	3210
Word	0	L000	0000	0000	0000	0000	0000	0000	0000
	1	0000	0000	0000	0000	0000	0000	0000	0000
	2	0000	0000	0000	0000	0000	0000	0000	0000
	3	0000	0000	0000	0000	0000	0000	0000	0000

Except for the L\_bit, each bit in table Table 16 represents a valid AL\_PA. The L\_bit is set by the FL\_Port or F/NL\_Port to indicate that the configuration has changed. Setting the L\_bit implicitly logs out all NL\_Ports. Private NL\_Ports are implicitly logged out since the public NL\_Ports with which they may have been communicating, may have a new AL\_PA.

The loop master transmits the four loop initialization sequences that contain the 16-byte AL\_PA bit maps as follows:

#### LIFA

The L\_Port primes the AL\_PA bit map with binary zero (0) and sets the bit that corresponds to its Fabric Assigned AL\_PA to one (1). If the L\_Port is an FL\_Port, it sets the bit associated with AL\_PA 00h. The L\_bit is set if this is the first initialization attempt of an FL\_Port or of an NL\_Port that has assumed the role of an F/NL\_Port.

#### LIPA

The L\_Port primes the AL\_PA bit map with the AL\_PA bit map of the previous LIFA loop initialization sequence. The L\_Port checks to see if the bit that corresponds to its previously acquired AL\_PA is set. If it is not set to 1, the L\_Port sets the bit (unless a bit was set in LIFA); if the bit is already set to 1, the L\_Port assumes a soft assigned AL\_PA.

#### LIHA

The L\_Port primes the AL\_PA bit map with the AL\_PA bit map of the previous LIPA loop initialization sequence. The L\_Port checks to see if the bit that corresponds to its hard assigned AL\_PA is set. If it is not set to 1, the L\_Port sets the bit (unless a bit was set in LIFA or LIPA); if the bit is already set to 1, the L\_Port assumes a soft assigned AL\_PA.

#### LISA

The L\_Port primes the AL\_PA bit map with the AL\_PA bit map of the previous LIHA loop initialization sequence. The L\_Port sets the first available bit to 1 (unless a bit was set in LIFA, LIPA, or LIHA) which corresponds to its soft assigned AL\_PA. If a bit was available, the L\_Port adjusts its AL\_PA according to which bit it set. If no bits are available, the L\_Port remains in the nonparticipating mode; the L\_Port may attempt to re-initialize at the request of the node. If the L\_Port does not support the AL\_PA position mapping loop initialization sequences, it sets byte 2 of the loop initialization identifier to 00h.

- c. When the loop master receives the LISA sequence, it checks the loop initialization identifier value. If the value is 11050100h<sup>5</sup>, the loop master transmits two additional loop initialization sequences as follows:

**LIRP**

The L\_Port sets the AL\_PA position map to all hex 'FF', enters an offset of 01h followed by its AL\_PA. For example, if AL\_PA = 05h, the AL\_PA position map contains 0105FFFFFF...FFh.

**LILP**

The L\_Port transmits the AL\_PA position map of the previous LIRP loop initialization sequence.

- d. When the last loop initialization sequence (identifier = LISA or LILP) is returned, the loop master transmits CLS to place all L\_Ports into Monitoring state. When the loop master received CLS, the L\_Port makes the transition to the Monitoring state and relinquishes its loop master role. At this time, all possible AL\_PA values have been assigned for the number of L\_Ports and every L\_Port that has a valid AL\_PA is in participating mode.

If any frame is received that is not formatted according to figure 10, the frame is discarded and the loop master restarts initialization at step 3b.

The loop master uses the E\_D\_TOV timer to wait for each of the above loop initialization sequences and the CLS. If the timer expires before each transmitted loop initialization sequence of CLS is received, the L\_Port goes to the Initializing state.

The L\_Port continues at step 5.

#### 4. Non loop master L\_Port—select unique AL\_PA

A non loop master L\_Port retransmits any received ARB(F0)s and prepares to receive (e.g. empties its receive buffers) and retransmits the following LIFA, LIPA, LIHA, LISA, LIRP, and LILP loop initialization sequences followed by CLS. The loop initialization sequences contain a 16-byte AL\_PA bit map in the payload. Each bit represents one AL\_PA (see figure 10 and tables 16 and 13).

**LIFA**

The L\_Port checks to see if the bit that corresponds to its fabric-assigned AL\_PA is set. If it is not set to 1, the L\_Port sets the bit; if the bit is already set to 1, the L\_Port assumes a soft-assigned AL\_PA. The L\_Port retransmits the loop initialization sequence.

**LIPA**

The L\_Port checks to see if the bit that corresponds to its previously-acquired AL\_PA is set. If it is not set to 1, the L\_Port sets the bit; if the bit is already set to 1, the L\_Port assumes a soft-assigned AL\_PA. The L\_Port retransmits the loop initialization sequence.

**LIHA**

The L\_Port checks to see if the bit that corresponds to its hard-assigned AL\_PA is set. If it is not set to 1, the L\_Port sets the bit (unless a bit was set in LIFA or LIPA); if the bit is already set to 1, the L\_Port assumes a soft-assigned AL\_PA. The L\_Port retransmits the loop initialization sequence.

**LISA**

The L\_Port sets the first available bit to 1 (unless a bit was set in LIFA, LIPA, or LIHA above) that corresponds to its soft-assigned AL\_PA. If a bit was available, the L\_Port adjusts its AL\_PA according to which bit was set. If no bits are available, the L\_Port remains in nonparticipating mode; the L\_Port may attempt to reinitialize at 10.3 at the request of the node. If the L\_Port does not support the AL\_PA position mapping loop initialization sequences, it sets byte 2 of the loop initialization identifier to 00h. The L\_Port retransmits the loop initialization sequence.

**LIRP**

If LIRP is received, the L\_Port reads the left-most byte (offset), increment it by one, store the offset, and store its AL\_PA into the offset position. The L\_Port retransmits the loop initialization sequence.

**LILP**

If LILP is received, the L\_Port may use the AL\_PA position map to save the relative positions of all L\_Ports on the loop. This information may be useful for error recovery. The L\_Port retransmits the loop initialization sequence.

If any frame is received that is not formatted according to figure 10 and as specified in step 3 on page 38, the frame is discarded. If a LIRP or LILP frame is received by an L\_Port which does not support the AL\_PA position map, the frame is discarded.

Each L\_Port uses the E\_D\_TOV timer to wait for each of the above loop initialization sequences and the CLS. If the timer expires before each loop initialization sequence of CLS is received, the L\_Port goes to the Initializing state. One possible reason for this is that the loop master was removed from the loop.

When CLS is received, the L\_Port retransmits CLS and goes to the Monitoring state in participating mode (if it acquired a valid AL\_PA).

The L\_Port continues at step 5.

5. Select final AL\_PA and exit initialization

- a. If an FL\_Port is in participating mode, it has completed initialization with an AL\_PA of 00h and exits the loop initialization.
- b. If a private NL\_Port is in participating mode, the NL\_Port has completed initialization with an AL\_PA in the range of 01h - EFh and exits loop initialization. If during initialization, the NL\_Port detected that the L\_bit (Login required) was set to 1, it implicitly logs out with all other NL\_Ports.
- c. If a public NL\_Port is in participating mode, the NL\_Port has discovered an AL\_PA in the range of 01h - EFh. If one of the following occurred, the NL\_Ports implicitly logout with all ports and attempt a fabric login to the address FFFFFFFEh - AL\_PA 00h:
  - the NL\_Port detected that the L\_bit (login required) was set to 1 in a LIFA, LIPA, LIHA, or LISA loop initialization sequence;
  - the NL\_Port was unable to set to 1 its fabric-assigned AL\_PA bit or its previously-acquired AL\_PA bit in the LIFA or LIPA loop initialization sequence (i.e., another NL\_Port is using the AL\_PA);
  - the NL\_Port has not previously executed a fabric login.

Normal responses to a fabric login request are:

- the transmitted OPN(00,AL\_PS) and login extended link service sequence are returned to the NL\_Port. No L\_Port on the loop has accepted this request. The NL\_Port sets its native address identifier to 0000xxh (where xx is its AL\_PA).

If the NL\_Port is capable of providing fabric services in the absence of an FL\_Port (i.e., it recognizes the well-known alias address FFFFFFFEh as well as its own native address identifier), this NL\_Port (also known as an F/NL\_Port) recognizes OPN(00,x) in addition to its own AL\_PA. If this is the first time that the NL\_Port is assuming the responsibility of an F/NL\_Port, to ensure that all previous login requests are reset, the F/NL\_Port goes to the Initializing state (REQ(initialize)) and sets the L\_bit (login required) to 1 in the LIFA loop initialization sequence.

**Note.** To prevent another L\_Port from winning arbitration, this F/NL\_Port should not relinquish control of the loop until it is prepared to receive OPN(00,AL\_PS).

If the NL\_Port is not capable of becoming an F/NL\_Port, the NL\_Port exits loop initialization.

- the NL\_Port receives an Accept (ACC) link service sequence. The NL\_Port uses the D\_ID in the ACC sequence as its native address identifier and bits 7 - 0 of the D\_ID as its fabric-assigned AL\_PA. The NL\_Port compares the fabric-assigned AL\_PA in the ACC sequence with the AL\_PA acquired prior to step 5. If they are equal, the NL\_Port exits loop initialization. If they are not equal, the NL\_Port goes to the Initializing state (REQ(initialize)) to re-initialize and acquire the fabric-assigned AL\_PA value.

8.2.1 Loop initialization state machine

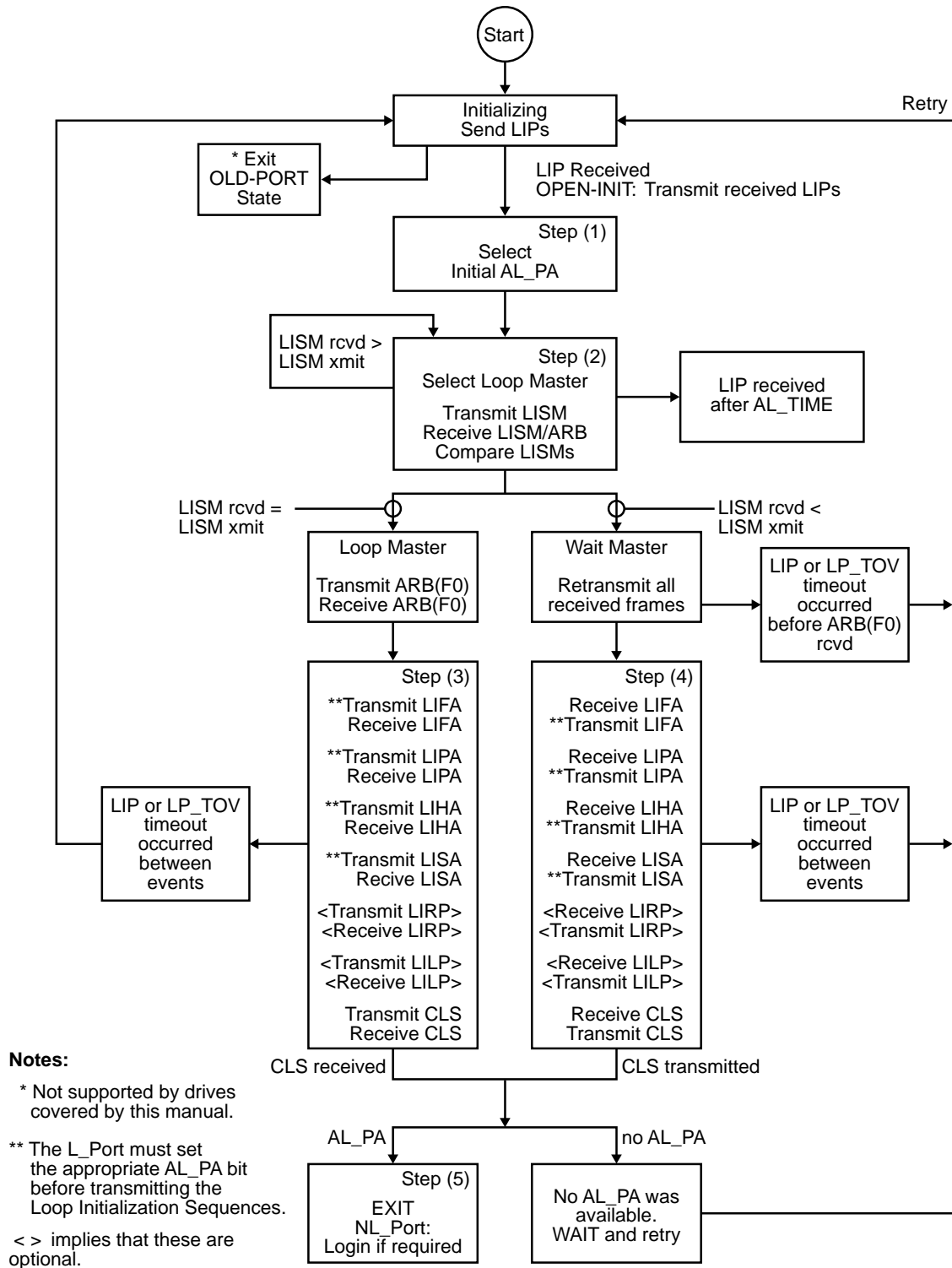


Figure 11. Loop initialization state machine

The loop initialization process is used whenever any unusual event occurs on the loop. One such event would be inserting a new NL\_Port into the loop. Invoking the loop initialization process permits the new NL\_Port to acquire an AL\_PA so it can begin operations.

### 8.2.2 Loop reinitialization

Loop reinitialization occurs when an L\_Port is added to the loop, removed from the loop, or for error recovery.

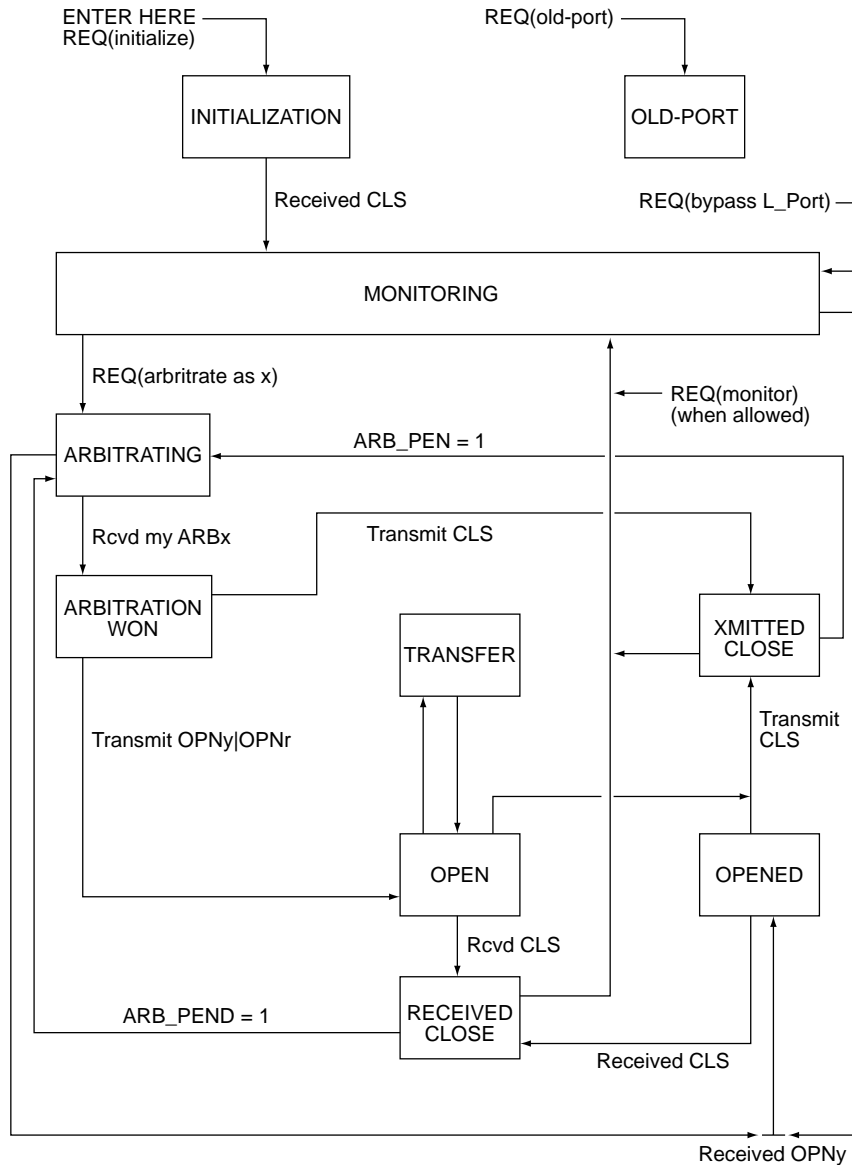


Figure 12. Loop state machine (simplified)

### 8.3 Accessing another L\_Port

Each port has its own private arbitration primitive (ARBx) signal. Each port uses this ARBx signal to arbitrate for and win access rights to the loop. This must be done before communicating with another port.

When an L\_Port is not communicating with another port, it is in a monitoring state to see if some other L\_Port is trying to communicate with it. The L\_Port is also retransmitting the stream of transmission words it is receiving. If a port needs to communicate, it sends out its arbitration primitive signal by replacing the fill words<sup>1</sup> between frames. If the arbitration primitive signal (ARBx) travels completely around the loop without being replaced, that port has won arbitration of the loop and is free to open the loop between its receiver and transmitter and is also free to stop retransmitting received transmission words. This means the NL\_Port is no longer in repeat mode and all words transmitted on its outbound fiber are generated by the NL\_Port.

1. Fill words may be Idles, ARBx's, or ARB(F0)'s. Fill words are transmitted between frames and may be deleted for clock skew management purposes.

When operating in full duplex mode, the port that wins arbitration sends out a special primitive signal called OPNyx to select a destination port on the loop and to identify the port sending the OPNyx primitive signal. The “y” value of OPNyx is the arbitrated loop physical address of the destination device (AL\_PD). If a port receives an OPNyx and recognizes its AL\_PD, the L\_Port opens the loop at its L\_Port. This L\_Port and the one that sent the OPNyx begin normal FC-2 protocols.

When the port that won arbitration and sent the OPNyx to initiate communication between itself and another L\_Port wants to close communication with the port, it uses another primitive signal called close (CLS) to signal the other port of its intent to close the loop. The receiving L\_Port finishes its work and then transmits a CLS back to the originating L\_Port. At this point, the two ports return to the monitoring state, and other L\_Ports can start communicating.

When operating in half duplex mode, OPNyx only identifies the destination port; therefore, the sending port cannot be determined.

### 8.3.1 Access fairness

So what happens when two or more ports happen to request access to the loop at exactly the same time? Or what happens when one port has already won access to the loop and others then want to arbitrate to win access? The answers lie in the access fairness algorithm that most NL\_Ports on a loop use. This access fairness algorithm ensures that all participating NL\_Ports will have equal access to the loop. NL\_Ports that use the access fairness algorithm are called “fair” NL\_Ports. Seagate Fibre Channel drives fully implement the access fairness algorithm.

Remember that each L\_Port can continuously arbitrate to access the loop. Each L\_Port has a priority assigned to it based on its Arbitrated Loop Physical Address (AL\_PA). AL\_PA “01” has the highest priority for an NL\_Port and AL\_PA “EF” has the lowest priority (except for the special arbitration primitive signal ARB(F0) discussed below). See section 8.1 for additional information about AL\_PAs. The access fairness algorithm creates an access window in which all L\_Ports are given an opportunity to arbitrate and win access to the loop regardless of its assigned priority. After all L\_Ports have had an opportunity to win access to the loop, a new access window is started; however, all L\_Ports don't have to actually choose to win access, they just have to be given the opportunity to win access in each access window.

When a fair L\_Port has arbitrated for and won access to the loop, that L\_Port will not arbitrate again until it receives at least one Idle. The time between the first L\_Port to win arbitration and transmitting an Idle is an access window. A special arbitration Primitive Signal (ARB(F0)) prevents the access window from being reset too early.

When a fair NL\_Port has arbitrated for and won access to the loop and does not detect that another L\_Port is arbitrating, it may keep the existing circuit open indefinitely or close the circuit and retain control of the loop (without re-arbitrating) to open another L\_Port on the loop.

How does the open NL\_Port know when another port is arbitrating? The open NL\_Port transmits ARB(F0) primitive sequences and monitors to see if its ARB(F0) is replaced by a higher priority address. Since xF0 is the lowest-priority address, any other NL\_Port that is arbitrating will replace the ARB(F0) with its own ARBx (which will always be higher-priority than ARB(F0)) and the highest priority arbitrating L\_Port will win arbitration. If the OPEN L\_port receives the ARB(F0) back it knows that no other NL\_Port is arbitrating for the loop.

Once an L\_Port has won access to the loop, it may retain control of the loop indefinitely; however, if access is denied longer than the Error Detect Timeout Value (E\_D\_TOV), the offended L\_Port can reset the access window to force arbitration. When a Seagate drive is operating as a target, it closes the loop when it has transmitted all of the frames it needed to send. Seagate drives do not hold the loop open to monitor the input stream for ARBs.

When a fair NL\_Port has arbitrated for and won access to the loop and does detect that another L\_Port is arbitrating, the NL\_Port closes the loop at the earliest possible time and arbitrates again in the next access window before opening a different L\_Port.

### 8.3.2 Access unfairness

Some loops may require that certain NL\_Ports have more access to the loop than just one access per access window. Examples of this situation include an NL\_Port for a subsystem controller or file server. Any NL\_Port

can be initialized to not use the fairness algorithm. If this occurs, the NL\_Port is called an “unfair” NL\_Port. An NL\_Port can also be configured to be temporarily unfair.

When an unfair L\_Port has arbitrated for and won access to the loop and does not detect that another L\_Port is arbitrating, that L\_Port may keep the existing circuit open indefinitely or close that circuit and retain ownership of the loop without re-arbitrating to open another L\_Port on the loop.

When an unfair NL\_Port controls the loops and detects that another L\_Port is arbitrating, the unfair NL\_Port may close the loop at the earliest possible time.

If you have a public loop connected to a fabric, the participating FL\_Port is always the highest priority L\_Port on the loop based on its AL\_PA value of 00h (see Section 8.1).

**Note.** There can be only one participating FL\_Port on any one loop. Additional FL\_Ports can be present, but they will be in nonparticipating mode.

The FL\_Port doesn't use the access fairness algorithm because it must control communications with the attached fabric. This means the FL\_Port will always win arbitration.

### 8.3.3 Clock skew management

Each loop port receives an input stream from the port upstream that is based on the clock frequency of that upstream device. The clock frequency of the upstream device may be slightly faster or slower than the frequency the loop port is using to transmit data. Each loop port captures data using the receive clock frequency and retimes it to its own transmit clock before forwarding the data. Over time, if the receive clock frequency is faster than the transmit frequency, data will start backing up in the port. If the receive clock frequency is slower than the transmit frequency, the port may run out of data.

To compensate for this difference in clock frequencies, each loop port contains an Elasticity (smoothing) FIFO (First In, First Out) buffer that allows words to be inserted or deleted as necessary to account for this difference in clock frequencies. Only fill words such as Idles or ARB's may be inserted or deleted during times when frames or R\_RDYs are not being transmitted. Each port originating frames is required to transmit at least six fill words between frames. This gives all monitoring loop ports an opportunity to insert or delete the fill words. A minimum of two fill words must be left between frames when it arrives at its destination.

## 8.4 Loop ports

A loop port (L\_Port) is a port designed specifically to operate in a Fibre Channel Arbitrated Loop topology. NL\_Ports have special additional functions which permit them to operate in the arbitrated loop topology as well as in the point-to-point physical topology when attached to an N\_Port or an F\_Port. N\_Ports are designed for point-to-point physical topologies, and F\_Ports are designed for fabric topologies.

### 8.4.1 Maximum number of NL\_Ports

Up to 126 NL\_Ports may be participating on a single arbitrated loop. There can be more than 126 NL\_Ports attached to the loop, but only 126 will be able to obtain a valid arbitrated loop physical address (AL\_PA). Only one (rare) or two NL\_Ports communicate at any one time, except during loop initialization. Only one NL\_Port can send frames but several NL\_Ports may copy that frame into their buffer.

### 8.4.2 Blocking switch emulation

When two NL\_Ports open communication with each other (see the OPNyx discussion in Section 8.3), communication between other devices is effectively blocked (other than to retransmit frames or insert fill words). This is known as a blocking environment since the two communicating ports block operation between any other L\_Ports.

### 8.4.3 Non-meshed environment

FC-AL is called a non-meshed environment due to the fact that there is only one route to any other port. A meshed environment (like a fabric) is like a telephone system in which there are many routes possible between two communicating entities.



#### 8.4.4 Assigned AL\_PA values

All AL\_PAs that are used in the loop protocol are listed in table 12. The AL\_PAs are assigned to the 16-byte AL\_PA bit maps of table 16 as shown in table 17.

Table 17. AL\_PA mapped to bit maps

AL_PA (hex)	Bit map Word	Bit	AL_PA (hex)	Bit map Word	Bit	AL_PA (hex)	Bit map Word	Bit	AL_PA (hex)	Bit map Word	Bit
--	0	31	3C	1	31	73	2	31	B3	3	31
00	0	30	43	1	30	74	2	30	B4	3	30
01	0	29	45	1	29	75	2	29	B5	3	29
02	0	28	46	1	28	76	2	28	B6	3	28
04	0	27	47	1	27	79	2	27	B9	3	27
08	0	26	49	1	26	7A	2	26	BA	3	26
0F	0	25	4A	1	25	7C	2	25	BC	3	25
10	0	24	4B	1	24	80	2	24	C3	3	24
17	0	23	4C	1	23	81	2	23	C5	3	23
18	0	22	4D	1	22	82	2	22	C6	3	22
1B	0	21	4E	1	21	84	2	21	C7	3	21
1D	0	20	51	1	20	88	2	20	C9	3	20
1E	0	19	52	1	19	8F	2	19	CA	3	19
1F	0	18	53	1	18	90	2	18	CB	3	18
23	0	17	54	1	17	97	2	17	CC	3	17
25	0	16	55	1	16	98	2	16	CD	3	16
26	0	15	56	1	15	9B	2	15	CE	3	15
27	0	14	59	1	14	9D	2	14	D1	3	14
29	0	13	5A	1	13	9E	2	13	D2	3	13
2A	0	12	5C	1	12	9F	2	12	D3	3	12
2B	0	11	63	1	11	A3	2	11	D4	3	11
2C	0	10	65	1	10	A5	2	10	D5	3	10
2D	0	9	66	1	9	A6	2	9	D6	3	9
2E	0	8	67	1	8	A7	2	8	D9	3	8
31	0	7	69	1	7	A9	2	7	DA	3	7
32	0	6	6A	1	6	AA	2	6	DC	3	6
33	0	5	6B	1	5	AB	2	5	E0	3	5
34	0	4	6C	1	4	AC	2	4	E1	3	4
35	0	3	6D	1	3	AD	2	3	E2	3	3
36	0	2	6E	1	2	AE	2	2	E4	3	2
39	0	1	71	1	1	B1	2	1	E8	3	1
3A	0	0	72	1	0	B2	2	0	EF	3	0

Notes: '--' is reserved for the L-bit (login required)

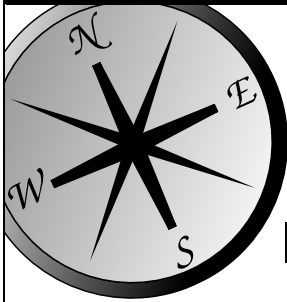
AL\_PA = '00' is reserved for the FL\_Port.



## 9.0 Fibre Channel link services

Link service frames are used to perform functions at the Fibre Channel layer. They are used to establish the operating parameters, perform channel level error recovery, and check the status of the physical link between two devices. Link service frames are divided into two groups, Basic and Extended.

### Navigation assistance



The field descriptions that are provided for most tables have sidebar labels which identify the table they are associated with. This helps orient you when nested tables occur within a section.

*Sidebar example*

**Table  
number**

#### **Field definitions (listed alphabetically)**

##### **1 Field name**

The sidebar (black background with reversed text) identifies this field as being associated with Table 1.

### 9.1 Basic link services

The drive supports the Abort Sequence (ABTS) and two basic services replies, Basic Accept (BA\_ACC) and Basic Reject (BA\_RJT). All other basic link services are discarded by the drive. Basic link service functions are identified by the R\_CTL field of the header.

**Table 18. Basic link services header**

Bit Byte	7	6	5	4	3	2	1	0								
0	R_CTL															
1	(MSB)															
2	D_ID															
3									(LSB)							
4	0	0	0	0	0	0	0	0								
Reserved																
5	(MSB)															
6	S_ID															
7									(LSB)							
8	0	0	0	0	0	0	0	0								
Type																
9	(MSB)															
10	F_CTL															
11									(LSB)							
12	SEQ_ID															
13	0	0	0	0	0	0	0	0								
DF_CTL																
14	(MSB)															
15	SEQ_CNT															
16									(LSB)							
16	(MSB)															
17	OX_ID															
17									(LSB)							
18	1	1	1	1	1	1	1	1								
19	1	1	1	1	1	1	1	1								
RX_ID																
20	(MSB)															
21	Parameter															
22																
23									(LSB)							

Table  
number**Field definitions (listed alphabetically)****18 D\_ID (Destination Identifier)**

The address of the drive for ABTS. This value must match the current address of the drive. For the basic link service replies, the D\_ID is the address of the initiator.

**18 DF\_CTL (Data Field Control)**

Set to 00h to indicate no optional Fibre Channel headers are used.

**18 F\_CTL (Frame Control)**

Set to 090000h for the ABTS. This indicates the ABTS is from the originator of the exchange, this is the last frame of the sequence, and sequence initiative is transferred for the drive to send the reply back.

For the reply frames, the drive sets the F\_CTL to 990000h. This indicates the frame is from the responder, this is the last sequence, this is the last frame of the sequence, and sequence initiative is returned to the initiator.

**18 OX\_ID (Originator Exchange Identifier)**

The OX\_ID for the sequence being identified by the basic link service.

**18 Parameter**

Not used for basic link services.

**18 R\_CTL (Routing Control)**

The basic link service frame. See the description of each basic link service below for the R\_CTL value.

**18 RX\_ID (Responder Identifier)**

Not used by the drive. The value of FFFFh indicates the RX\_ID is not being used.

**18 S\_ID (Source Identifier)**

The address of the initiator that sent the frame for ABTS. For the basic link service replies, the S\_ID contains the address of the drive.

**18 SEQ\_CNT (Sequence Count)**

Set to 0000h to indicate this is the first frame of the Fibre Channel sequence.

**18 SEQ\_ID (Sequence Identifier)**

Contains the last used SEQ\_ID for the exchange for ABTS. The drive does not check the SEQ\_ID as the entire exchange (command) is aborted by the error recovery process. The drive returns the same SEQ\_ID in the reply frame as received from the initiator in the ABTS.

**18 Type**

00h Used for all basic link services frames.

**9.1.1 Abort Sequence (ABTS)**

The Abort Sequence (ABTS) is sent by the initiator to abort a single SCSI exchange (command) or FC exchange (one of the link service operations). The ABTS frame does not have a payload. All the information is included in the header.

The R\_CTL is 81h.

### 9.1.2 Basic Accept (BA\_ACC)

BA\_ACC is sent by the drive in response to all correctly structured ABTS. If the ABTS identifies an exchange in execution or buffered for execution, the drive will discard the exchange.

The R\_CTL is 84h.

**Table 19. BA\_ACC Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	SEQ_ID Valid							
1	Last SEQ_ID							
2	(MSB)	Reserved						(LSB)
3								
4	(MSB)	OX_ID Aborted						(LSB)
5								
6	(MSB)	RX_ID Aborted						(LSB)
7								
8	(MSB)	Lowest SEQ_CNT						(LSB)
9								
10	(MSB)	Highest SEQ_CNT						(LSB)
11								

**Table number** **Field definitions (listed alphabetically)**

**19 Highest SEQ\_CNT (Highest Sequence Count)**

FFFFh.

**19 Last SEQ\_ID (Last Sequence Identifier)**

Not used.

**19 Lowest SEQ\_CNT (Lowest Sequence Count)**

0.

**19 OX\_ID Aborted (Originator Exchange Identifier Aborted)**

The same value as received in the ABTS.

**19 RX\_ID Aborted (Responder Identifier Aborted)**

FFFFh.

**19 SEQ\_ID Valid (Sequence Identifier Valid)**

00h Marks the Last SEQ\_ID field as invalid. The SEQ\_ID is not used because the error recovery procedure requires the entire exchange (command) to be aborted.

### 9.1.3 Basic Reject (BA\_RJT)

BA\_RJT is sent by the drive in response to an ABTS with a RX\_ID not set to FFFFh.

The R\_CTL is 85h.

**Table 20. BA\_RJT Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Reason Code							
2	Reason Explanation							
3	Vendor Unique							

**Table  
number**

#### Field definitions (listed alphabetically)

##### **20 Reason Code**

03h (Logical Error) is the only Reason code sent by the drive if the RX\_ID sent with the ABTS is not FFFFh.

##### **20 Reason Explanation**

00h No Additional Explanation. This is the only Reason Explanation code sent by the drive.

##### **20 Vendor Unique**

Not supported by the drives described in this manual.

## 9.2 Extended link services

The type of extended link service is identified by the LS Command Code in the first word of the payload. The R\_CTL field of the frame header identifies whether the extended link service is a request or a reply to a request. The accept for extended link services varies with the function. A description of the accept for each request is included with the description of the request.

**Table 21. Extended link services header**

Bit Byte	7	6	5	4	3	2	1	0	
0	0	0	1	0	0	0	1	X	
	R_CTL								
1	D_ID								(MSB)
2									
3									(LSB)
4	0	0	0	0	0	0	0	0	
	Reserved								
5	S_ID								(MSB)
6									
7									(LSB)
8	0	0	0	0	0	0	0	1	
	Type								
9	F_CTL								(MSB)
10									
11									(LSB)
12	SEQ_ID								
13	0	0	0	0	0	0	0	0	
	DF_CTL								
14	SEQ_CNT								(MSB)
15									(LSB)
16	OX_ID								(MSB)
17									(LSB)
18	1	1	1	1	1	1	1	1	
19	1	1	1	1	1	1	1	1	
	RX_ID								
20	Parameter								(MSB)
21									
22									
23									(LSB)



Table  
number**Field definitions (listed alphabetically)****21 D\_ID (Destination Identifier)**

Frame destination address.

**21 DF\_CTL (Data Field Control)**

Set to 00 to indicate no optional Fibre Channel headers are used.

**21 F\_CTL (Frame Control)**

Set to 290000h for extended link service requests. This indicates the frame is from the originator of the exchange, this is the last frame of the sequence, and sequence initiative is transferred for the responder to send the reply back.

For the reply frames, the F\_CTL is set to 990000h. This indicates the frame is from the responder, this is the last sequence, this is the last frame of the sequence, and sequence initiative is returned to the originator.

**21 OX\_ID (Originator Exchange Identifier)**

The drive sends 0000 to the OX\_ID field in extended link services requests it originates. For extended link services replies, the drive uses the OX\_ID value received from the initiator.

**21 Parameter**

Not used for extended link services.

**21 R\_CTL (Routing Control)**

22h Extended link services and unsolicited control for extended link service request, PLOGI, PRLI, RLS, RRQ, and PDISC.

23h Extended link services and solicited control for replies, ACC and LS\_RJT.

**21 RX\_ID (Responder Identifier)**

Not used by the drive. The value of FFFFh indicates the RX\_ID is not being used.

**21 S\_ID (Source Identifier)**

The address of the originator of the frame. This address is used by the destination to return any responses that may be required by the operation.

**21 SEQ\_CNT (Sequence Count)**

Not checked by the drive. For extended link services replies and requests sent by the drive, SEQ\_CNT equals 0000.

**21 SEQ\_ID (Sequence Identifier)**

Not checked by the drive. For extended link services replies, the drive uses the SEQ\_ID value received from the initiator. The drive sends SEQ\_ID equal to FFh for extended link services requests it originates.

**21 Type**

01h All extended link services frames.

### 9.2.1 Port Login (PLOGI)

Port Login (PLOGI) is sent by the initiator to a drive to establish the Fibre Channel operating parameters. The PLOGI causes any open exchanges (commands) the initiator may have queued in the drive to be discarded.

**Table 22. PLOGI Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	1
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
LS Command Code								
4-19	N_Port Common Service Parameters							
20-27	Port Name							
28-35	Node Name							
36-51	Class 1 Service Parameters							
52-67	Class 2 Service Parameters							
68-83	Class 3 Service Parameters							
84-99	Reserved							
100-115	Vendor Version							

Table  
number

#### Field definitions (listed alphabetically)

##### 22 Class 1 and 2 Service Parameters

May be present in the PLOGI frame. The drive checks only for class 3 service parameters.

##### 22 Class 3 Service Parameters

Required by the drive. See Table 25 on page 57.

##### 22 LS Command Code (Link Services Command Code)

03h PLOGI payload.

##### 22 N\_Port Common Service Parameters

See Table 24 on page 56.

##### 22 Port Name and Node Name

Used to identify the device. The device may have multiple Fibre Channel ports with each having a unique Port Name. The drive is a dual-ported device.

The Port and Node Names in the PLOGI identify the initiator. The drive saves the Port Name of the initiator with the login parameters. If a change of the Port Name/AL\_PA address association is detected during a Port Discovery (PDISC), an implicit logout occurs (any queued commands for the previous Port Name/AL\_PA are discarded, the previous login is cleared) and a LS\_RJT is returned to the initiator.

The Port and Node Names in the Port Login Accept (PLOGI ACC) identify the drive. The drive uses a format for the Port and Node Names defined as the IEEE extended address. See Table 23.

**Table 23. Port/Node Name format**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	0	(MSB N_Port Identifier (LSB)			
1								
2	(MSB)							
3	Company Identifier Assigned by IEEE							
4	(LSB)							
5	(MSB)							
6	Unique Drive Identifier Assigned by Seagate							
7	(LSB)							

**23 Company Identifier Assigned by IEEE**

This Seagate-unique value is registered with the IEEE.

**23 N\_Port Identifier**

Used by the drive to identify the name of a specific port or node.

000h Drive Node Name

001h Port A

002h Port B

**23 Network Address ID**

2h Defines the name as the IEEE extended format.

**23 Unique Drive Identifier Assigned by Seagate**

Assigned by Seagate. Uniquely assigned to each disc drive.

**22 Vendor Version**

Vendor-unique.

Table 24. N\_Port Common Service Parameters

Bit Byte	7	6	5	4	3	2	1	0
0	Highest ANSI FC-PH Version							
1	Lowest ANSI FC-PH Version							
2	(MSB) _____							
3	Buffer to Buffer Credit _____ (LSB)							
4	Contin Increasing Offset	Random Relative Offset	Valid Vendor Version	F_Port	Alternate Credit Model	E_D_TOV Resolution	0 Reserved	0 Reserved
Common Features								
5	0	0	0	0	0	Dynamic Half Duplex	Continuous Increase SEQ_CNT	Payload Length
6	0	0	0	0	(MSB) _____			
7	Reserved				Receive Data Field Size _____ (LSB)			
8	Reserved							
9	(MSB) _____ Total Concurrent Sequences _____ (LSB)							
10	(MSB) _____							
11	Relative Offset by Info Category _____ (LSB)							
12	(MSB) _____							
13	_____							
14	E_D_TOV (Pt to Pt)							
15	_____ (LSB)							

**Table number** Field definitions (listed alphabetically)

**24** Buffer to Buffer Credit

Not checked by the drive. The drive requires the Alternate Credit Model and assumes a Buffer to Buffer Credit of zero. When the drive opens a device on the loop, it waits until it receives a R\_RDY or a Close. The drive returns 0000 in the accept.

**24 Common Features**

This is a bit significant field which requests options that are used in all classes of service by initiator login. Below is a list of the features and the drive requirements. The drive returns an LS\_RJT to PLOGI requests that do not satisfy the requirements.

**Table 25. Common Features bits**

Feature	Drive requirement
Continuously Increasing Offset	Must be a one (1).
Random Relative Offset	Not checked. Port Login Accept returns a value of zero (0). Not supported.
Valid Vendor Version	X
F_Port (Fabric Port)	Must be a zero (0) to denote a N_Port.
Alternate Credit Model	Must be a one (1).
E_D_TOV Resolution	Not checked. Port Login ACC returns 0.
Dynamic Half Duplex	If drive model supports it, the drive returns 1 in Port Login ACC. If the drive model does not support DHD, a 0 is returned in Port Login ACC. Reference the drive's product manual to determine whether DHD is supported.
Continuous Increase SEQ_CNT	Not checked. Port Login ACC returns 0.
Payload Length	Not checked. Port Login ACC returns 0.

**24 E\_D\_TOV (Pt to Pt) (Error Detect Time Out Value)**

This field is only for point-to-point connections and is not valid for loop operation.

**24 Highest ANSI FC-PH Version and Lowest ANSI FC-PH Version**

The highest and lowest version of the ANSI Fibre Channel Physical and Signaling standards supported by the drive.

A version level of 09h is defined for FC-PH, Rev. 4.3. A version level of 20h is defined for FC-PH-3, Rev. 9.4.

Earlier drives supported by this manual require 09h in the highest and lowest version fields. An LS\_RJT will be returned in response to any PLOGI that does not satisfy this requirement. Later drives do not check the version fields in PLOGI and return 20h in the PLOGI ACC. The version fields are not considered an accurate indicator of functionality. Reference the drive product manual for specific behavior.

**24 Receive Data Field Size**

In the common and class 3 service parameters. Checked for the range  $128 < fs < 2112$  and a multiple of four bytes. For multiple frame sequences, all frames but the last frame of the sequence must be this size. The drive uses the receive buffer field size in the class 3 parameters when it sends frames. The drive returns the receive buffer field size in the class 3 parameters from the initiator in the PLOGI ACC.

**24 Relative Offset by Info Category**

Indicates on a bit position basis which categories (e.g., solicited control, data descriptor) support the relative offset in the FC header. The drive does not require relative offset and does not check this field in the PLOGI. The drive sends Relative Offset in FCP Data frames (it sets 02h, bit 1 set, in the accept to indicate Relative Offset is supported for solicited data, category 0001b).

**24 Total Concurrent Sequences**

Number of concurrent sequences across all classes of service. Sequences are concurrent if they are open and delivery verification has not been received. It is the initiator's responsibility to not issue commands to the drive that will exceed the initiator's capabilities for concurrent sequences.

The drive returns FFh in Concurrent Sequences field of the PLOGI ACC payload.

Table 26. Class Service Parameters

Bit Byte	7	6	5	4	3	2	1	0
0	Class Valid	Intermix Mode	Stacked Connect Request		Sequence Delivery	0 Reserved	0 Reserved	0 Reserved
Service Options								
1	Reserved							
2	X_ID Reassignment		Initial Process Associator		ACK_0 Capable	ACK_N Capable	0 Reserved	0 Reserved
Initiator Control								
3	Reserved							
4	ACK_0 Capable	ACK_N Capable	X_ID Interlock	Error Policy		0 Reserved	Categories per Sequence	
Recipient Control								
5	Reserved							
6	0	0	0	0	(MSB)			
Reserved					Receive Data Field Size			
7	(LSB)							
8	Reserved							
9	(MSB) Concurrent Sequences							(LSB)
10	0	(MSB)						
11	N_Port End to End Credit							(LSB)
12	Reserved							
13	(MSB) Open Sequences per Exchange							(LSB)
14	Reserved							
15	Reserved							

**Table number** Field definitions (listed alphabetically)

**26** Concurrent Sequences

Must be greater than 0. The drive returns FFh in the PLOGI ACC.

**26 Initiator Control**

The transmit capabilities of the initiator in the PLOGI. The drive returns an LS\_RJT to PLOGI requests that do not satisfy the drive's requirements. The Initiator Control bits in the PLOGI ACC indicate the capabilities of the drive. The drive returns zero (0) for all bits that are not applicable for class 3 services and for all reserved bits.

**Table 27. Initiator Control fields**

Option	Drive requirement
X_ID (Exchange Identifier) Reassignment	Not applicable. Not valid for class 3.
Initial Process Associator	00 Initial Process Associator not supported. 01 Initial Process Associator supported. 10 Reserved. 11 Initial Process Associator Values of 10 or 11 cause the Login to be rejected. Other values are accepted.
ACK_0 (Acknowledge 0) Capable	Not applicable. Not valid for class 3.
ACK_N (Acknowledge N) Capable	Not applicable. Not valid for class 3.

**26 N\_Port End to End Credit**

Not valid for class 3.

**26 Open Sequences per Exchange**

Must be greater than zero (0). The drive returns 01h in the PLOGI ACC.

The PLOGI ACC returns the drive's parameters to the initiator. The PLOGI ACC Payload has the same definition as the PLOGI Payload except the LS Command Code.

**26 Receive Data Field Size**

A class 3 service parameter. This value must be in the range  $128 < fs < 2112$ . It must also be a multiple of four bytes. For multiple frame sequences, all frames but the last frame of the sequence must be this size. The drive uses the receive buffer field size in the class 3 parameters when it sends frames. The drive returns the receive buffer field size in the class 3 parameters from the initiator in the PLOGI ACC.

**26 Recipient Control**

Indicates the receive capabilities of the initiator in the PLOGI. The Recipient Control bits in the PLOGI ACC indicate the capabilities of the drive. The drive returns zero (0) for all bits that are not applicable for class 3 services and for all reserved bits.

**Table 28. Recipient Control fields**

Option	Drive requirement
ACK_0 (Acknowledge 0) Capable	Not applicable. Not valid for class 3.
ACK_N (Acknowledge N) Capable	Not applicable. Not valid for class 3.
X_ID (Exchange Identifier) Interlock	Not applicable. Not valid for class 3.
Error Policy	00 Only discard supported. 01 Reserved. 10 Discard and process supported. 11 Reserved. The drive supports only the discard error policy. It does not check the Error Policy bits in the PLOGI as all FC devices are required to support the discard policy. The drive returns 00 in the PLOGI ACC.
Categories per Sequence	The drive does not check the Categories per Sequence bits in the PLOGI. The drive originates only one category per sequence. The drive returns 00 in the PLOGI ACC to indicate it only supports receiving one category per sequence.

**26 Service Options**

These bits are only checked for class 3 service parameters. The drive returns an LS\_RJT to PLOGI requests that do not satisfy the drive's requirement.

**Table 29. Service Option fields**

Option	Drive requirement
Class Valid	Must be a one (1).
Intermix Mode	Not applicable. Not valid for class 3.
Stacked Connect Request	Not applicable. Not valid for class 3.
Sequence Delivery	Not applicable. Valid only for Fabric login.



**Table 30. Port Login Accept Payload (PLOGI ACC)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
LS Command Code								
4-19	N_Port Common Service Parameters							
20-27	Port Name							
28-35	Node Name							
36-51	Class 1 Service Parameters							
52-67	Class 2 Service Parameters							
68-83	Class 3 Service Parameters							
84-99	Reserved							
100-115	Vendor Version							

**Table number** **Field definitions (listed alphabetically)**

**30 Class 1 and 2 Service Parameters**

May be present in the PLOGI frame. The drive returns only class 3 service parameters. Class parameters for all other classes of service are set to all zeros.

**30 Class 3 Service Parameters**

Sent by the drive. See Table 26 for details.

**30 LS Command Code (Link Services Command Code)**

02h PLOGI ACC.

**30 N\_Port Common Service Parameters**

See Table 24.

**30 Port Name and Node Name**

Used to identify the device. The device may have multiple Fibre Channel ports with each having a unique Port Name. The drive is a dual-ported device.

The Port and Node Names in the PLOGI identify the initiator. The drive saves the Port Name of the initiator with the login parameters. If a change of the Port Name/AL\_PA address association is detected during a Port Discovery (PDISC), an implicit logout occurs (any queued commands for the previous Port Name/AL\_PA are discarded, the previous login is cleared) and a LS\_RJT is returned to the initiator.

The Port and Node Names in the PLOGI ACC identify the drive. The drive uses a format for the Port and Node Names defined as the IEEE extended address. The format is in Table 23.

**30 Vendor Version**

Vendor-unique. Not supported.

### 9.2.2 Port Logout (LOGO)

Port Logout (LOGO) is sent by the target in response to any frame from an initiator that has not completed N\_Port Login. LOGO may also be sent by an initiator when it has no further need for a target.

**Table 31. LOGO Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	0	1
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
LS Command Code								
4	Reserved							
5	N_Port Identifier							
6								
7								
8	Port Name							
:								
:								
15								

**Table number** **Field definitions (listed alphabetically)**

**31 LS Command Code (Link Services Command Code)**

05h LOGO Payload.

**31 N\_Port Identifier**

The three-byte address used in the D\_ID and S\_ID fields of the frame headers.

**31 Port Name**

The unique eight-byte address assigned to the port.

**Table 32. LOGO Accept**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
LS Command Code								

**Table number** **Field definitions (listed alphabetically)**

**32 LS Command Code (Link Services Command Code)**

02h LOGO Accept.

### 9.2.3 Fabric Login (FLOGI)

Fabric Login (FLOGI) is sent by the drive to the fabric to establish the Fibre Channel operating parameters in a public loop environment. When the drive sends FLOGI, any open exchanges (commands) queued in the drive are discarded.

**Table 33. FLOGI Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
LS Command Code								
4-19	N_Port Common Service Parameters							
20-27	Port Name							
28-35	Node Name							
36-51	Class 1 Service Parameters							
52-67	Class 2 Service Parameters							
68-83	Class 3 Service Parameters							
84-99	Reserved							
100-115	Vendor Version							

**Table  
number**

#### Field definitions (listed alphabetically)

##### **33 Class 1 and 2 Service Parameters**

The drive supports only class 3 service parameters. The drive sends all zeros for all other classes of service.

##### **33 Class 3 Service Parameters**

Sent by the drive. See Table 36 on page 66.

##### **33 LS Command Code (Link Services Command Code)**

04h FLOGI payload.

##### **33 N\_Port Common Service Parameters**

See Table 34 on page 64.

##### **33 Port Name and Node Name**

Used to identify the device. The drive is a dual-ported device.

The Port and Node Names in the FLOGI uniquely identify the drive and the port sending the FLOGI.

The drive uses a format for the Port and Node Names defined as the IEEE extended address. See Table 23.

##### **33 Vendor Version**

Vendor-unique. Not supported.

Table 34. F\_Port Common Service Parameters

Bit Byte	7	6	5	4	3	2	1	0
0	Highest ANSI FC-PH Version							
1	Lowest ANSI FC-PH Version							
2	(MSB) _____							
3	Buffer to Buffer Credit _____ (LSB)							
4	Contin Increasing Offset	Random Relative Offset	Valid Vendor Version	F_Port	Alternate Credit Model	E_D_TOV Resolution	Multicast	Broadcast
Common Features								
5	Hunt Groups	Dedicated Simplex	0	0	0	Dynamic Half Duplex	Continuous Increase SEQ_CNT	Payload Length
			Reserved					
6	0	0	0	0	(MSB) _____	Receive Data Field Size _____		
Reserved								
7	(LSB)							
8	(MSB) _____							
:	Reserved							
15	(LSB)							

**Table number** Field definitions (listed alphabetically)

**34** Buffer to Buffer Credit

The drive sets the Alternate Credit Model and sets the Buffer to Buffer Credit to zero.

**34 Common Features**

This is a bit significant field which indicates the options that are supported by the drive. Below is a list of the features. The drive returns an LS\_RJT to FLOGI ACC for requests that do not satisfy the drive's requirements.

**Table 35. Common Features bits**

Feature	Drive	
	Support (FLOGI)	Requirement (FLOGI ACC)
Continuously Increasing Offset	1	Must = 1
Random Relative Offset	0	Not checked
Valid Vendor Version	0	Not checked
F_Port (Fabric Port)	0	Must = 1
Alternate Credit Model	1	Must = 1
E_D_TOV Resolution	0	Not checked. Not valid for loop operation.
Multicast	0	Not checked
Broadcast	0	Not checked
Hunt Groups	0	Not checked
Dedicated Simplex	0	Not checked
Dynamic Half Duplex	[1]	[1]
Payload Length	0	Not checked

[1] If the drive and the fabric both support Dynamic Half Duplex (DHD), drives that support DHD will originate DHD in place of a CLS primitive when they have won arbitration and completed any pending transfer. Reference the drive product manual to determine if a particular model supports DHD.

**34 Highest ANSI FC-PH Version and Lowest ANSI FC-PH Version**

The highest and lowest version of the ANSI Fibre Channel Physical and Signaling standards supported by Public loop drives is FC-PH-3 Rev. 9.4

A version level of 20h is defined for FC-PH-3 Rev. 9.4.

**34 Receive Data Field Size**

The drive sends a receive buffer size of 2112 bytes.

Table 36. Class 3 Service Parameters

Bit Byte	7	6	5	4	3	2	1	0
0	Class Valid	Intermix Mode	Stacked Connect Request		Sequence Delivery	Dedicated Simplex	Camp-on	Buffered Class 1
	Service Options							
1	Priority	0	0	0	0	0	0	0
	Reserved							
2	Reserved							
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

**Table number** Field definitions (listed alphabetically)

**36** Service Options

The following class 3 service parameters are sent by the drive.

Table 37. Service Option Class 3 fields

Option	Drive	
	Support (FLOGI)	Requirement (FLOGI ACC)
Class Valid	1	Must = 1
Intermix Mode	0, not applicable or valid for class 3.	Not checked
Stacked Connect Request	00, not applicable or valid for class 3.	Not checked
Sequence Delivery	1	Must = 1
Dedicated Simplex	0, Not applicable or valid for class 3	Not checked
Camp-on	0, not applicable or valid for class 3.	Not checked
Buffered Class 1	0, not applicable or valid for class 3	Not checked
Priority	0, not applicable or valid for class 3	Not checked

**Table 38. Fabric Login Accept Payload (FLOGI ACC)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
LS Command Code								
4-19	F_Port Common Service Parameters							
20-27	Port Name							
28-35	Node Name							
36-51	Class 1 Service Parameters							
52-67	Class 2 Service Parameters							
68-83	Class 3 Service Parameters							
84-99	Reserved							
100-115	Vendor Version							

**Table number** **Field definitions (listed alphabetically)**

**38 Class 1 and 2 Service Parameters**

May be present in the FLOGI ACC frame. The drive returns only class 3 service parameters. Class parameters for all other classes of service are set to all zeros.

**38 Class 3 Service Parameters**

Sent by the drive. See Table 37 for details.

**38 F\_Port Common Service Parameters**

See Table 24.

**38 LS Command Code (Link Services Command Code)**

02h FLOGI ACC.

**38 Port Name and Node Name**

Used to identify the fabric. The device may have multiple Fibre Channel ports with each having a unique Port Name.

The Port and Node Names in the FLOGI ACC identify the fabric. The drive saves the Port Name of the fabric with the login parameters. If a change of the Port Name is detected during loop initialization, an implicit logout occurs (any queued commands for the previous Port Name/AL\_PA are discarded, the previous login is cleared).

**38 Vendor Version**

Vendor-unique. Not supported.

### 9.2.4 Process Login (PRLI)

Process Login (PRLI) is sent by the initiator to a target to establish the SCSI FCP operating features.

**Table 39. PRLI Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	0	0	0	0	0
LS Command Code								
1	0	0	0	1	0	0	0	0
Page Length								
2	0	0	0	0	0	0	0	0
3	0	0	0	1	0	1	0	0
Payload Length								
4	0	0	0	0	1	0	0	0
Type Code								
5	0	0	0	0	0	0	0	0
Type Code Extension								
6	0 Orig Proc Assc Valid	0 Resp Proc Assc Valid	Est Image Pair	0	0	0	0	0
Reserved								
7	Reserved							
8	(MSB)							
9	Originator Process Associator							
10								
11								
12	(MSB)							
13	Responder Process Associator							
14								
15								
16	Reserved							
17	Reserved							
18	Reserved							
19	0 Reserved	Data Overlay Allow	Initiator Function	Target Function	Command/ Data Mix	Data/ Response Mix	RD XFR RDY Disable	WR XFR RDY Disable
Service Parameters								

**Table number** **Field definitions (listed alphabetically)**

**39 Command/Data Mixed Allowed**

- 1 The initiator sends data in the same sequence as the command. The drive does not support Command/Data Mixed. It will accept a PRLI with the Allow bit set, but will return a 0 in the accept to indicate the function cannot be used.

**39 Data Overlay Allow**

Not supported by the drive. The Data Overlay Allowed bit is not checked.



**39 Data/Response Mix Allowed**

- 1 Allows the drive to send the FCP RSP in the same sequence as the data. The drive does not support the Data/Response Mix. It will accept a PRLI with the Allow bit set, but will return zero (0) in the accept to indicate the function cannot be used.

**39 Establish Image Pair**

- 1 The drive establishes a SCSI login for the initiator.
- 0 The PRLI is only an inquiry of the drive's support of the process. The accept is still returned, but the login is not retained.

**39 Initiator Function**

Must be set to one (1) for the drive to accept the login request.

**39 LS Command Code (Link Services Command Code)**

20h PRLI Payload.

**39 Orig Proc Assc Valid (Originator Process Associator Valid)**

Not supported by the drive. Not checked by the drive.

Must be set to zero (0).

**39 Page Length**

Length of the service parameter page (in bytes). For a SCSI FCP service page, the length is 10h.

**39 Payload Length**

Length of PRLI payload (in bytes). The count includes the LS Command Code. The drive supports one service parameter page per PRLI.

The Payload Length must be 14h (20 decimal).

**39 RD XFR RDY Disable (Read Transfer Ready Disable)**

- 1 FCP\_XFR\_RDY will not be sent before read data. The drive requires this bit to be set to one (1).

**39 Resp Proc Assc Valid (Responder Process Associator Valid)**

Not supported by the drive. Not checked by the drive.

Must be set to zero (0).

**39 Target Function**

May be set in addition to the Initiator Function bit. The drive does not check this bit.

**39 Type Code**

08h SCSI FCP process as included in the frame header for FCP frames.

**39 Type Code Extension**

- 0 Not defined for SCSI FCP and must be set to zero (0).

**39 WR XFR RDY Disable (Write Transfer Ready Disable)**

- 1 FCP\_XFR\_RDY will not be sent to request write data.
- 0 The drive requires this bit to be set to zero (0). The drive also requires the use of the WR\_XFR\_RDY bit.

The PRLI recipient returns a PRLI Accept or a LS\_RJT to a PRLI request. The PRLI Accept may indicate success or failure of the process login request in the Response Code field. A LS\_RJT is returned to a PRLI with a basic format error, e.g. page length error, payload length, and type code.

**Table 40. PRLI Accept Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	0
LS Command Code								
1	0	0	0	1	0	0	0	0
Page Length								
2	0	0	0	0	0	0	0	0
3	0	0	0	1	0	1	0	0
Payload Length								
4	0	0	0	0	1	0	0	0
Type Code								
5	0	0	0	0	0	0	0	0
Type Code Extension								
6	0 Orig Proc Assc Valid	0 Resp Proc Assc Valid	Est Image Pair	0 Reserved	Response Code			
7	Reserved							
8	(MSB)							
9	Originator Process Associator							
10								
11								
12	(MSB)							
13	Responder Process Associator							
14								
15								
16	Reserved							
17	Reserved							
18	Reserved							
19	0 Reserved	Data Overlay Allow	Initiator Function	Target Function	Command/ Data Mix	Data/ Response Mix	RD XFR RDY Disable	WR XFR RDY Disable
Service Parameters								

**Table number** Field definitions (listed alphabetically)

**40** Command/Data Mixed Allowed

1 The initiator sends data in the same sequence as the command. The drive does not support Command/Data Mixed. It will accept a PRLI with the Allow bit set, but will return a 0 in the accept to indicate the function cannot be used.

**40** Data Overlay Allow

Not supported by the drive. The Data Overlay Allowed bit is not checked.

**40 Data/Response Allowed**

- 1 Allows the drive to send the FCP RSP in the same sequence as the data. The drive does not support the Data/Response Mix. It will accept a PRLI with the Allow bit set, but will return a 0 in the accept to indicate the function cannot be used.

**40 Establish Image Pair**

- 1 The drive establishes a SCSI login for the initiator.
- 0 The PRLI is only an inquiry of the drive's support of the process. The accept is still returned, but the login is not retained.

**40 Initiator Function**

Must be set to one (1) for the drive to accept the login request.

**40 LS Command Code (Link Services Command Code)**

02h PRLI Accept Payload.

**40 Orig Proc Assc Valid (Originator Process Associator Valid)**

Not supported by the drive. Not checked by the drive.

Must be set to zero (0).

**40 Page Length**

Length of the service parameter page (in bytes). For a SCSI FCP service page, the length is 10h.

**40 Payload Length**

Length of PRLI payload (in bytes). The count includes the LS Command Code. The drive supports one service parameter page per PRLI.

The Payload length must be 14h (20 decimal).

**40 Rd XFR RDY Disable (Read Transfer Ready Disable)**

- 1 FCP\_XFR\_RDY will not be sent before read data. The drive requires this bit to be set to one (1).

**40 Resp Proc Assc Valid (Responder Process Associator Valid)**

Not supported by the drive. Not checked by the drive.

Must be set to zero (0).

**40 Response Code**

The result of the PRLI request.

Only codes 1 and 7 are supported by the drive.

- 0 Reserved.
- 1 Request executed.
- 2 The target has no resources available for establishing the login.
- 3 Initialization is not complete. The PRLI may be retried.
- 4 The Image Pair does not exist.
- 5 The Image Pair cannot be established due to a predefined configuration.
- 6 Request executed conditionally. Some of the parameters were not able to be set to their requested state.
- 7 The destination port is unable to process multiple page PRLI request. The PRLI request may be retried as a single page request.

**40 Target Function**

May be set in addition to the Initiator Function bit. The drive does not check this bit.

**40 Type Code**

08h SCSI FCP process as included in the frame header for FCP frames.

**40 Type Code Extension**

- 0 Not defined for SCSI FCP and must be set to zero (0).

**40** **Wr XFR RDY Disable (Write Transfer Ready Disable)**

- 1 FCP\_XFR\_RDY will not be sent to request write data.
- 0 The drive requires this bit to be set to zero (0). The drive also requires the use of the WR\_XFR\_RDY bit.

### 9.2.5 Process Logout (PRLO)

Process Logout (PRLO) is sent by the initiator to a target to remove an existing SCSI login. This frees target resources for use by other initiators.

**Table 41. PRLO Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	0	0	0	0	1
LS Command Code								
1	0	0	0	1	0	0	0	0
Page Length								
2	0	0	0	0	0	0	0	0
3	0	0	0	1	0	1	0	0
Payload Length								
4	0	0	0	0	1	0	0	0
Type Code								
5	0	0	0	0	0	0	0	0
Type Code Extension								
6	Orig Proc Assc Valid	Resp Proc Assc Valid	0	0	0	0	0	0
Reserved								
7	Reserved							
8	Originator Process Associator							
9								
10								
11								
12	Responder Process Associator							
13								
14								
15								
16	Reserved							
17								
18								
19								

**Table number** **Field definitions (listed alphabetically)**

**41** **LS Command Code (Link Services Command Code)**

21h PRLO Payload.

**41** **Page Length**

Length of the service parameter page in bytes. For a SCSI FCP service page, the length is 10h.

**41** **Payload Length**

Length of PRLO payload (in bytes). The count includes the LS Command Code. The drive supports one service parameter page per PRLO. The Payload Length must be 14h (20 decimal).

**41 Process Associators**

Not supported by the drive. The originator and responder process associator valid bits must be set to zero (0). The process associator fields are not checked by the drive.

**41 Type Code**

00h All FC-4 processes between the initiator and target are removed. The drive treats 08h and 00h the same.

08h The SCSI-FCP process will be removed.

**41 Type Code Extension**

Not defined for SCSI-FCP and must be zero (0).

**Table 42. PRLO Accept Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	0
LS Command Code								
1	0	0	0	1	0	0	0	0
Page Length								
2	0	0	0	0	0	0	0	0
3	0	0	0	1	0	1	0	0
Payload Length								
4	Reserved							
5	Reserved							
6	Orig Proc Assc Valid	Resp Proc Assc Valid	0 Reserved	0 Reserved	Response Code			
7	Reserved							
8	Originator Process Associator							
9								
10								
11								
12	Responder Process Associator							
13								
14								
15								
16	Reserved							
17								
18								
19								

**Table number** **Field definitions (listed alphabetically)**

**42 LS Command Code (Link Services Command Code)**

02h PRLO Accept Payload.

**42 Page Length**

Length of the service parameter page in bytes. For a SCSI FCP service page, the length is 10h.

**42 Payload Length**

Length of PRLO payload (in bytes). The count includes the LS Command Code. The drive supports one service parameter page per PRLO. The Payload Length must be 14h (20 decimal).

**42 Process Associators**

Not supported by the drive. The originator and responder process associator valid bits must be set to zero (0). The process associator fields are not checked by the drive.

**42 Response Code**

The result of the PRLO request.

Codes 1, 4, and 7 are supported by the drive.

- 0 Reserved.
- 1 Request executed.
- 2 Reserved.
- 3 Reserved.
- 4 The Image Pair does not exist.
- 5 Reserved.
- 6 Reserved
- 7 The destination port is unable to process a multiple page PRLO request. The PRLO request may be retried as a single page request.



### 9.2.6 Third Party Process Logout (TPRLO)

Third Party Process Logout (TPRLO) is sent by the initiator to a target to remove an existing SCSI login. This frees target resources for use by other initiators.

**Table 43. TPRLO Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	0	0	1	0	0
LS Command Code								
1	0	0	0	1	0	0	0	0
Page Length								
2	0	0	0	0	0	0	0	0
3	0	0	0	1	0	1	0	0
Payload Length								
4	0	0	0	0	1	0	0	0
Type Code								
5	0	0	0	0	0	0	0	0
Type Code Extension								
6	Third Party Orig Proc Assc Valid	Third Party Resp Proc Assc Valid	Third Party Orig N_Port ID Validity	Global Process Logout	0	0	0	0
Reserved								
7	Reserved							
8	(MSB)							
9	Third Party Originator Process Associator							
10								
11								
12	(MSB)							
13	Third Party Responder Process Associator							
14								
15								
16	Reserved							
17	(MSB)							
18	Third Party Originator N_Port ID							
19								

**Table number** **Field definitions (listed alphabetically)**

**43 Global Process Logout**

- 00h Only the process login for the port identified in the N\_Port ID field and type code is removed.
- 01h All process logins for the specified type code are removed.

**43 LS Command Code (Link Services Command Code)**

- 24h TPRLO Payload.

**43 Page Length**

- The length must = 10h.

**43 Payload Length**

Length of TPRLO payload (in bytes). The count includes the LS Command Code. The drive supports one service parameter page per TPRLO. The Payload Length must be 14h (20 decimal).

**43 Process Associators**

Not supported by the drive. The originator and responder process associator valid bits must be set to zero (0). The process associator fields are not checked by the drive.

**43 Third Party Originator N\_Port ID**

This field specifies the N\_Port address associated with the process login to be removed.

**43 Third Party Originator N\_Port ID Validity**

00h Third Party Originator N\_Port ID field is not valid.

01h Third Party Originator N\_Port ID field is valid.

**43 Type Code**

00h All FC-4 processes between the initiator and target are removed. The drive treats 08h and 00h the same.

08h The SCSI-FCP process will be removed.

**43 Type Code Extension**

Not defined for SCSI-FCP and must be zero (0).

**Table 44. TPRLO Accept Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	0
LS Command Code								
1	0	0	0	1	0	0	0	0
Page Length								
2	0	0	0	0	0	0	0	0
3	0	0	0	1	0	1	0	0
Payload Length								
4	Reserved							
5	Reserved							
6	Third Party Orig Proc Assc Valid	Third Party Resp Proc Assc Valid	Third Party Orig N_Port ID Validity	Global Process Logout	Reserved			
7	Reserved							
8	Third Party Originator Process Associator							
9								
10								
11								
12	Third Party Responder Process Associator							
13								
14								
15								
16	Reserved							
17	Third Party Originator N_Port ID							
18								
19								

**Table number** **Field definitions (listed alphabetically)**

**44 Global Process Logout**

- 00h Only the process login for the port identified in the N\_Port ID field and type code is removed.
- 01h All process logins for the specified type code are removed.

**44 LS Command Code (Link Services Command Code)**

- 02h TPRLO Accept Payload.

**44 Page Length**

Length of the service parameter page in bytes. For a SCSI FCP service page, the length is 10h.

**44 Payload Length**

Length of TPRLO payload (in bytes). The count includes the LS Command Code. The drive supports one service parameter page per TPRLO. The Payload Length must be 14h (20 decimal).

**44 Process Associators**

Not supported by the drive. The originator and responder process associator valid bits must be set to zero (0). The process associator fields are not checked by the drive.

**44 Response Code**

The result of the TPRLO request.

Codes 1, 4, and 7 are supported by the drive.

- 0 Reserved.
- 1 Request executed.
- 2 Reserved.
- 3 Reserved.
- 4 The Image Pair does not exist.
- 5 Reserved.
- 6 Reserved
- 7 The destination port is unable to process a multiple page TPRLO request. The TPRLO request may be retried as a single page request.

**44 Third Party Originator N\_Port ID**

This field specifies the N\_Port address associated with the process login to be removed.

**44 Third Party Originator N\_Port ID Validity**

- 00h Third Party Originator N\_Port ID field is not valid.
- 01h Third Party Originator N\_Port ID field is valid.

### 9.2.7 Read Link Error Status Block (RLS)

Read Link Error Status Block (RLS) is sent by the initiator to request the drive to return the Fibre Channel link error information. The error information is contained in the Link Error Status Block (LESB) that is returned in the accept to the RLS. The drive maintains a separate LESB for each port.

**Table 45. RLS Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	1	1	1	1
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
LS Command Code								
4	Reserved							
5	Port Identifier							
6								
7								

**Table number** **Field definitions (listed alphabetically)**

**45 LS Command Code (Link Services Command Code)**

0Fh RLS Payload.

**45 Port Identifier**

This field is interpreted to determine whether to return the Link Error Status Block for port A or B.

0 Return the LESB for the port the RLS was received on.

1 Return the LESB for port A.

2 Return the LESB for port B.

Others LS\_RJT is returned with Invalid N\_Port Identifier.

The RLS Accept includes the LS Command Code and the LESB. The LESB counts are not cleared by a reset. There is no protocol for clearing the counts. The requester must compare the current values with those read previously.

**Table 46. RLS Accept Payload**

Bit Byte	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	1	0	
1	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	
LS Command Code									
4	Link Failure Count								(MSB)
5									
6									
7									(LSB)
8	Loss of Synchronization Count								(MSB)
9									
10									
11									(LSB)
12	Loss of Signal Count								(MSB)
13									
14									
15									(LSB)
16	Primitive Sequence Protocol Error								(MSB)
17									
18									
19									(LSB)
20	Invalid Transmission Word								(MSB)
21									
22									
23									(LSB)
24	Invalid CRC Count								(MSB)
25									
26									
27									(LSB)

**Table number** **Field definitions (listed alphabetically)**

**46 Invalid CRC Count**

Number of frames discarded due to CRC errors while the drive is in an “open” state. Reference the specific drive product manual to determine if this field is supported.

**46 Invalid Transmission Word**

Number of invalid transmission words received while in word sync. Reference the specific drive product manual to determine if this field is supported.

**46 Link Failure Count**

Number of times synchronization was lost for greater than R\_T\_TOV (Receiver Transmitter Timeout Value). A Link Failure results in sending Loop Initialization Primitive Sequence (LIP).

**46 Loss of Signal Count**

Not supported.

**46 Loss of Synchronization Count**

Number of times the drive detects loss of synchronization.

**Note.** This count includes the Link Failure Count.

**46 LS Command Code (Link Services Command Code)**

02h      RLS Accept Payload.

**46 Primitive Sequence Protocol Error**

Not supported.

### 9.2.8 Reinstatement Recovery Qualifier (RRQ)

The Reinstatement Recovery Qualifier (RRQ) is sent by the initiator to the drive to indicate the Recovery Qualifier (S\_ID, D\_ID, OX\_ID, RX\_ID, SEQ\_ID, and SEQ\_CNT) for an aborted exchange may be reused. The drive allows reuse of the Recovery Qualifier immediately after sending the accept to an ABTS and does not require RRQ. It returns accepts to all RRQs.

**Table 47. RRQ Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	1	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
LS Command Code								
4	Reserved							
5	(MSB)							
6	Originator S_ID							
7								
8	(MSB)							
9	OX_ID							
10	(MSB)							
11	RX_ID							
12	(MSB)							
:	Association Header (optional)							
43								

**Table number** **Field definitions (listed alphabetically)**

**47 Association Header**

Not supported by the drive.

**47 LS Command Code (Link Services Command Code)**

12h RRQ Payload.

**47 Originator S\_ID (Originator Source Identifier)**

Address identifier of the port that originated the exchange.

**47 OX\_ID (Originator Exchange Identifier)**

The RRQ is the OX\_ID of the Recovery Qualifier.

**47 RX\_ID (Responder Identifier)**

The RRQ is the RX\_ID of the Recovery Qualifier.



Table 48. RRQ Accept Payload

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0

LS Command Code

Table  
number

Field definitions (listed alphabetically)

48 LS Command Code (Link Services Command Code)

Not supported by the drive.

### 9.2.9 Port Discovery (PDISC)

Port Discovery (PDISC) is sent by an initiator to a drive after loop initialization to verify addresses have not changed. The PDISC transfers the same information as the PLOGI except that the LS Command code in the first word of the payload is 50000000h. The PDISC does not cause the open exchanges (commands) to be discarded if the initiator address and parameters have not changed. For other contents of the payload, see Section 9.2.1, Port Login (PLOGI).

The accept for the PDISC is the same as for the PLOGI if the drive detects the initiator AL\_PA (Physical Address) or parameters have not changed from a previous login. Section 9.2.1, Port Login (PLOGI). If the drive detects either the initiator addresses or parameters have changed from a previous login, the drive will not send an accept. The drive will return a LOGO to indicate to the initiator a PLOGI is required.

**9.2.10 Discover Address (ADISC)**

Discover Address (ADISC) is sent by an initiator to a drive after loop initialization to verify addresses have not changed or to verify the drive was able to obtain the hard address select through the interface connector (SEL Lines) during loop initialization.

The ADISC allows the drive to compare the initiator’s address and Port Name with previous login values. If after the loop initialization process the address and Port Name pair provided by the initiator does not match the login values, the initiator is implicitly logged out.

**Table 49. ADISC Payload**

Bit Byte	7	6	5	4	3	2	1	0	
0	0	1	0	1	0	0	1	0	
1	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	
LS Command Code									
4	Reserved								
5	(MSB)								
6	Hard Address of Originator								
7									(LSB)
8									(MSB)
:	Port Name of Originator								
15									(LSB)
16									(MSB)
:	Node Name of Originator								
23									(LSB)
24									Reserved
25	(MSB)								
26	N_Port ID of Originator								
27									(LSB)

**Table number**

**Field definitions (listed alphabetically)**

**49 Hard Address of Originator**

This is the 24 bit NL\_Port Identifier. The lower 8 bits are the AL\_PA the initiator attempts to acquire in the LIHA sequence during loop initialization. If the initiator does not have a hard address, this 24 bit field is zeros. If the initiator has a hard address and is able to acquire it during the loop initialization process, the Hard Address and N\_Port ID fields of the ADISC will be the same.

**49 LS Command Code (Link Services Command Code)**

52h ADISC Payload.

**49 Node Name of Originator**

This is the unique 8 byte identifier for the initiator sending the ADISC. Refer to Table 23 for the format of the Node Name.

**49 N\_Port ID of Originator**

This is the 24 bit NL\_Port Identifier used in the S\_ID of the ADISC. The lower 8 bits are the AL\_PA the initiator acquired during loop initialization.

**49 Port Name of Originator**

This is the unique 8 byte identifier for the initiator port sending ADISC. Refer to Table 23 for the format of the Port Name.

**Table 50. ADISC Accept Payload**

Bit Byte	7	6	5	4	3	2	1	0								
0	0	0	0	0	0	0	1	0								
1	0	0	0	0	0	0	0	0								
2	0	0	0	0	0	0	0	0								
3	0	0	0	0	0	0	0	0								
LS Command Code																
4	Reserved															
5	(MSB)															
6	Hard Address of Responder															
7									(LSB)							
8									(MSB)							
:	Port Name of Responder															
15									(LSB)							
16									(MSB)							
:	Node Name of Responder															
23									(LSB)							
24									Reserved							
25	(MSB)															
26	N_Port ID of Responder															
27									(LSB)							

**Table number**

**Field definitions (listed alphabetically)**

**50 Hard Address of Responder**

This is the 24 bit NL\_Port Identifier. The lower 8 bits are the AL\_PA the drive attempts to acquire in the LIHA sequence during loop initialization. This field represents the address indicated on the drive interface connector. If the drive does not have a hard address, this 24 bit field is zeros. If the drive has a hard address and is able to acquire it during the loop initialization process, the Hard Address and N\_Port ID fields of the ADISC Accept will be the same.

**50 LS Command Code (Link Services Command Code)**

02h ADISC Accept Payload.

**50 Node Name of Responder**

This is the unique 8 byte identifier for the drive sending the ADISC Accept. Refer to Table 23 for the format of the Node Name.

**50 N\_Port ID of Responder**

This is the 24 bit NL\_Port Identifier used in the S\_ID of the ADISC Accept header. The lower 8 bits are the AL\_PA the drive acquired during loop initialization.

**50 Port Name of Responder**

This is the unique 8 byte identifier for the drive port sending the ADISC Accept. Refer to Table 23 for the format of the Port Name.

### 9.2.11 Report Node Capabilities (RNC)

Report Node Capabilities (RNC) is sent to a target node to request that the node report on its capabilities. The node does this by returning a list of specifications and the supported revision level of the specification.

**Table 51. RNC Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	LS Command Code							
1	Reserved							
2	Payload Length							
3								
4	RNC Flags							
5	Reserved							
6	Reserved							
7	VU Information Length							
8 . . 15	Vendor Identifier - RNC Accept Payload only							
16	Capability Entries							

Table  
number

#### Field definitions (listed alphabetically)

##### 51 Capability Entries

There may be from zero to n number of capability entries (see the table below for the format of capability entries). The limit is that the payload length can not be greater than 256 bytes.

**Table 52. Capability Entries**

Bit Byte	7	6	5	4	3	2	1	0
0	Flags							
1	Document Identifier							
2	Low Revision - RNC Accept Payload only							
3	High Revision - RNC Accept Payload only							

##### 52 Document Identifier

This number identifies the document. Valid document numbers range from:

01h through 05h

10h through 13h, and

20h through 27h

##### 52 Flags

Bit 7 = 0 - report on this capability.

Bit 7 = 1 - Invalidate this capability selection.

Bit 6 = 1 - There is an extension on the capability entry. This is not supported. This bit must = 0.

If either bit 5 or bit 4 = 1 - The Document Identifier is vendor unique. This feature is not supported.

Bits 4 and 5 must = 0.

**52 High Revision - RNC Accept Payload only**

This field contains the highest revision of the specified document that is supported. The values in the revision fields represent decimal revisions between 0.0 (00h) and 25.5 (FFh).

**52 Low Revision - RNC Accept Payload only**

This field contains the lowest revision of the specified document that is supported. The values in the revision fields represent decimal revisions between 0.0 (00h) and 25.5 (FFh).

**51 LS Command Code (Link Services Command Code)**

02h RNC Accept Payload.

53h RNC Payload.

**51 Payload Length**

Length of the RNC Payload (in bytes). This count includes the LS Command Code.

**51 RNC Flags**

00h Report on all available capabilities.

80h Report on the selected capabilities listed in the capability entries.

**51 Vendor Identifier - RNC Accept Payload only**

Eight bytes of ASCII data identifying the vendor of the product (node).

**51 VU Information Length**

00h Length of the Vendor Unique Information in the payload. This feature is not supported and this field must = 0.

### 9.2.12 Link Service Reject (LS\_RJT)

Link Service Reject (LS\_RJT) is a reply to an extended link service request that has been rejected. A reason code is included to communicate additional information about the reject.

**Table 53. LS\_RJT Payload**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
LS Command Code								
4	Reserved							
5	Reason Code							
6	Reason Explanation							
7	Vendor Unique							

#### Table number Field definitions (listed alphabetically)

##### 53 LS Command Code (Link Services Command Code)

01h LS\_RJT Payload.

##### 53 Reason Code

03h Logical Error. This reason code is sent in response to rejected PLOGI and PRLI requests. See Reason Explanation codes 01h, 03h, 07h, 09h, and 0Fh for PLOGI errors. For PRLI errors, the Reason Explanation code is 00, unspecified. The PRLI errors are Page Length Not 16, Type Code Not 8, and Payload Length Not 20.

09h Unable to perform command request. This reason code is sent in response to PLOGI. See Reason Explanation code 29h.

0Bh Not supported. This reason code is returned in response to extended link service frames that are not supported.

##### 53 Reason Explanation

The following reason code explanations are returned:

01h Invalid options. Returned in response to a PLOGI if class 3 parameters are not valid.

03h Initiator Control class service options. Returned in response to a PLOGI if the initiator requires process associators.

07h Receive data field size. Returned in response to a PLOGI if the initiator sends a receive buffer size in the common or class 3 service parameters that is not a multiple of four bytes or not in the range of 128–2112 bytes.

09h Invalid service parameter—concurrent sequences. Returned in response to a PLOGI if the initiator sets zero (0) concurrent sequences.

0Bh Invalid service parameter—credit. Returned in response to a PLOGI if the alternate credit model is not supported by the initiator.

0Fh Invalid common service parameters. Returned in response to a PLOGI if common service parameters contain an unsupported version of FC-PH, continuously increasing offset is not supported, or the F\_Port bit is set.

1Fh Invalid N\_Port identifier. This code is returned in response to a RLS if the port identifier value is not in the range of 0–2.

29h Insufficient resources for login. This code is returned to PLOGI if the login table is full and no initiator can be logged out (all logged in initiators have active commands in the queue). The PLOGI may be retried.

2Ch Request not supported.

##### 53 Vendor Unique

Not supported by the drive.



### 9.3 FC common transport

FC common transport (CT) provides a transport for service applications such as the fabric name server. The type of FC common transport service is identified by the command code in the third word of the payload. The R\_CTL field of the frame header identifies whether the common transport service is a request or a response to a request. The response for a common transport service varies with the function. A description of the accept for each request is included with the description of the request.

**Table 54. Common transport header**

Bit Byte	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	1	0	
R_CTL									
1	D_ID								(LSB)
2									
3									
4	0	0	0	0	0	0	0	0	
Reserved									
5	S_ID								(LSB)
6									
7									
8	0	0	1	0	0	0	0	0	
Type									
9	F_CTL								(LSB)
10									
11									
12	SEQ_ID								
13	0	0	0	0	0	0	0	0	
DF_CTL									
14	SEQ_CNT								(LSB)
15									
16	OX_ID								(LSB)
17									
18	1	1	1	1	1	1	1	1	
19	1	1	1	1	1	1	1	1	
RX_ID									
20	Parameter								(LSB)
21									
22									
23									

**Table number** Field definitions (listed alphabetically)

**54** D\_ID (Destination Identifier)

Frame destination address.

**54 DF\_CTL (Data Field Control)**

Set to 00 to indicate no optional Fibre Channel headers are used.

**54 F\_CTL (Frame Control)**

Set to 290000h for CT service requests. This indicates the frame is from the originator of the exchange, this is the last frame of the sequence, and sequence initiative is transferred for the responder to send the reply back.

For the reply frames, the F\_CTL is set to 990000h. This indicates the frame is from the responder, this is the last sequence, this is the last frame of the sequence, and sequence initiative is returned to the originator.

**54 OX\_ID (Originator Exchange Identifier)**

The drive sends 0000 to the OX\_ID field in extended link services requests it originates. For extended link services replies, the drive uses the OX\_ID value received from the initiator.

**54 Parameter**

Not used for CT services.

**54 R\_CTL (Routing Control)**

02h Unsolicited control for CT service request, PDISC.

03h Solicited control for responses.

**54 RX\_ID (Responder Identifier)**

Not used by the drive. The value of FFFFh indicates the RX\_ID is not being used.

**54 S\_ID (Source Identifier)**

The address of the originator of the frame. This address is used by the destination to return any responses that may be required by the operation.

**54 SEQ\_CNT (Sequence Count)**

Not checked by the drive. For extended link services replies and requests sent by the drive, SEQ\_CNT equals 0000.

**54 SEQ\_ID (Sequence Identifier)**

Not checked by the drive. For CT services requests, the drive uses the SEQ\_ID value equal to FFh.

**54 Type**

20h Fibre Channel services.

**9.3.1 Register FC-4 Types Name Service (RFT\_ID)**

Register FC-4 Types Name Service (RFT\_ID) is used to register the drive's Port\_Identifier and FC-4 type (SCSI-FCP) with the fabric name server.

**Table 55. RFT\_ID Payload**

Bit Byte	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	1	
FC-CT Revision									
1	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	
Reserved									
4	1	1	1	1	1	1	0	0	
FC Services Type Code (Directory Service Application)									
5	0	0	0	0	0	0	1	0	
FC Services Sub Type (Name Service)									
6	0	0	0	0	0	0	0	0	
Options									
7	0	0	0	0	0	0	0	0	
Reserved									
8	0	0	0	0	0	0	1	0	
9	0	0	0	1	0	1	1	1	
Command Code: RFT_ID									
10	0	0	0	0	0	0	0	0	
Reserved									
11	0	0	0	0	0	0	0	0	
Reserved									
12	0	0	0	0	0	0	0	0	
Reserved									
13	0	0	0	0	0	0	0	0	
Reason Code									
14	0	0	0	0	0	0	0	0	
Explanation Code									
15	0	0	0	0	0	0	0	0	
Vendor Unique									
16	0	0	0	0	0	0	0	0	
Reserved									
17	S_ID of Requesting N_Port								MSB
18									
19									LSB
20*	0	0	0	0	0	0	0	0	
21*	0	0	0	0	0	0	0	0	
22*	0	0	0	0	0	0	0	1	
23*	0	0	0	0	0	0	0	0	
.	.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	.	
51*	0	0	0	0	0	0	0	0	

\*Bytes 20-51 contain a bit map of supported FC-4 types. The 1 in byte 22 indicates type 08h (SCSI-FCP)

Table  
number**Field definitions (listed alphabetically)**

- 55 Command Code: RFT\_ID**  
0217h RFC-4
- 55 Explanation Code**  
00h Used only for reject responses.
- 55 FC-CT Revision**  
Revision level of the FC-CT.
- 55 FC Service Sub Type**  
02h Name Service.
- 55 FC Services Type Code**  
FCh FC Services.
- 55 Options**  
00h Single Exchange.
- 55 Reason Code**  
00h Used only for reject responses.
- 55 S\_ID (Source Identifier) of Requesting N\_Port**  
This field contains the Native Port Identifier of the port registering its FC-4 types.
- 55 Vendor Unique**  
00h Used only for reject responses.

## 10.0 Enclosure services interface (ESI)

ESI provides a path for the drive to input data from the enclosure and, optionally, transfer data to the enclosure. All transfers between the drive and its enclosure are initiated by the drive in response to SCSI Send Diagnostic and Receive Diagnostic Results commands from the host system.

There are two levels of ESI capability defined by specifications developed in the Small Form Factor (SFF) industry group. These specifications use the `-Parallel_ESI` (`-P_ESI`) and the seven `Select_ID` (`SEL_(6:0)`) pins in the drive interface connector to implement the ESI interface. The drives covered by this manual support both levels of capability.

The first level of functionality is defined by the SFF 8045 specification. It provides the simple capability for the drive to input up to seven signals of enclosure information at the direction of a Receive Diagnostic Results command and return the status to the host.

The second level of functionality is defined by the SFF 8067 specification. It defines a bidirectional capability that enables the drive to transfer information to and from its enclosure.

ESI data is transferred in diagnostic pages. The drive does not check the page contents to see if they are valid. It only provides a transfer function between the host and the enclosure. Reference the SCSI-3 Enclosure Services Command Set (SES) standard for details of the page contents.

### 10.1 Discovery process

The drive uses a discovery process to determine whether its enclosure supports an ESI and which specification is supported. The discovery process is initiated for each Send Diagnostic and Receive Diagnostic Results command with a Page Code of 01h to 08h. Reference Figure 13 for a flow diagram of the discovery process.

The drive enters the discovery phase by asserting `-Parallel ESI` low. The enclosure has a maximum of 1  $\mu$ sec to respond.

There are three reactions for the enclosure:

1. The `SEL_(6:0)` pins do not change.
2. `SEL_(3:0)` change to the binary complement of the address. This indicates that 8067 mode may be supported, but more discovery steps are required.
3. The `SEL_(6:0)` pins change, but `SEL_(3:0)` do not equal the binary complement of the address.

In cases 1 and 3, the 8067 support level is not available. The drive processes both cases as 8045 mode and returns only the seven bits of ESI status. In case 1, the drive is not able to detect whether the enclosure does not support ESI for this drive location or if ESI equals `Select_ID`. It is the host's responsibility to determine whether the returned information is ESI or `Select_ID` information. This may be accomplished by issuing a Receive Diagnostic Results command to a device location with redundant ESI capability.

In case 2, the drive continues the discovery process. The drive waits up to 1 second for the enclosure to assert the `-ENCL_ACK` (`SEL_4`) low. The time is allowed for the enclosure processor to complete processing other possible ESI requests through other devices.

If `-ENCL_ACK` is not asserted within one second, the drive assumes the enclosure has 8067 support but is not responding. The SCSI diagnostic command is failed with ASC/ASQ 35 02. If `ENCL_ACK` is detected, the drive asserts `-DSK_WR` and `-DSK_RD`, `SEL(6)` and `SEL(5)` respectively, low.

The enclosure is required to respond to `-DSK_WR` and `-DSK_RD` by negating `-ENCL_ACK` within 100  $\mu$ sec.

The drive responds to the negating of `-ENCL_ACK` by negating `-DSK_WR` and `-DSK_RD` and moving to the ESI command phase.

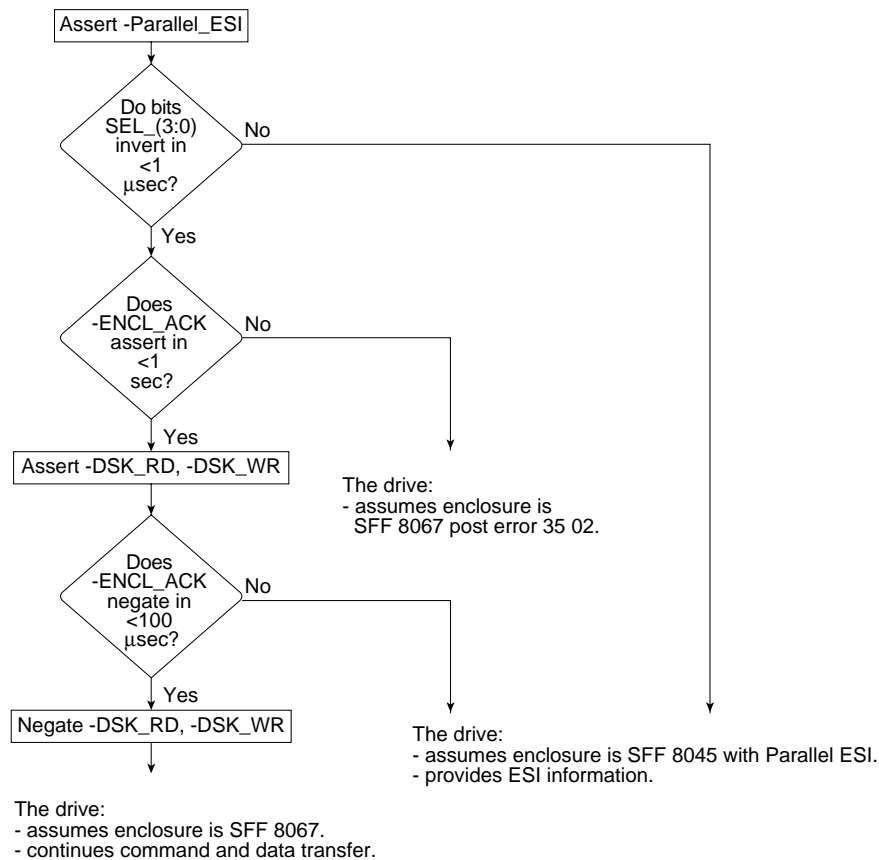


Figure 13. Discovery process flow diagram

## 10.2 8045 mode

In 8045 mode, the enclosure places the binary complement of ESI on the Select\_ID pins, SEL\_(6:0).

### 10.2.1 8045 ESI pinouts

The table below is a mapping of the Select pins to the SFF 8045 ESI function. The sense of the ESI information is complemented and the address function of the select pins is true. The drive returns the true state of the ESI in the diagnostic page.

Table 56. SFF 8045 ESI pinouts

Pin	ESI function
SEL 6	-ESI In 6
SEL 5	-ESI In 5
SEL 4	-ESI In 4
SEL 3	-ESI In 3
SEL 2	-ESI In 2
SEL 1	-ESI In 1
SEL 0	-ESI In 0

### 10.3 8067 mode

Transfers on an 8067 interface are started by the drive pulling the  $\text{-P\_ESI}$  pin low to enter the Discovery phase. For each transfer, there are three phases:

1. Discovery
2. ESI command
3. Data

The data phase is either a read or write to the enclosure depending on the SCSI command.

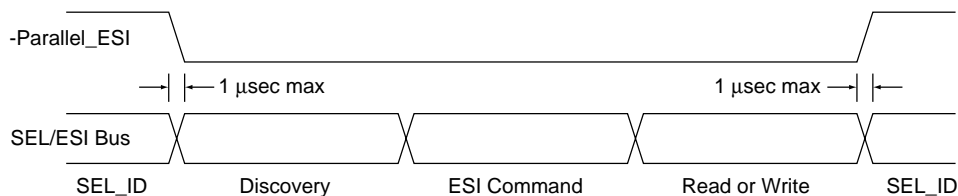


Figure 14. ESI transfer phases

#### 10.3.1 8067 ESI command

When the discover process determines 8067 mode is supported, the drive generates an ESI command to the enclosure based on the SCSI Send Diagnostic or Receive Diagnostic Results command received from the host. The format of the ESI command is shown in Table 57.

Table 57. ESI command format

Bit	7	6	5	4	3	2	1	0
Byte								
0	Page Code							
1	Reserved							Send
2	(MSB)	Send Diagnostic Parameter Length						
3							(LSB)	

Table number

#### Field definitions (listed alphabetically)

##### 57 Page Code

The Page Code is from the SCSI Send Diagnostic or Receive Diagnostic Results command diagnostic page that initiated the ESI transfer.

##### 57 Send

- 0 The ESI data transfer is from the enclosure to the drive.
- 1 The ESI data transfer is from the drive to the enclosure.

##### 57 Send Diagnostic Parameter Length

For a Send Diagnostic command, the Send Diagnostic parameter length is the page length from the diagnostic page header incremented by 4 to include the ESI command bytes, and reflects the total number of bytes that will be transferred to the enclosure unless the transfer is truncated by a shorted allocation length in the CDB. The Send Diagnostic parameter length is 0 for Receive Diagnostic Results commands.

### 10.3.2 8067 ESI interface pinouts

In 8067, the ESI function becomes a bi-directional interface. Three pins are defined for control functions and the remaining four pins become a 4-bit nibble interface. Table 58 is a mapping of the Select pins to the 8067 ESI interface function. 8067 specifies that open-collector type drivers be used for signals on the P\_ESI and Select lines.

**Table 58. SFF 8067 ESI pinouts**

Pin	ESI function
SEL 6	-DSK_WR
SEL 5	-DSK_RD
SEL 4	-ENCL_ACK
SEL 3	Data (3)
SEL 2	Data (2)
SEL 1	Data (1)
SEL 0	Data (0)

### 10.3.3 8067 information format

ESI in 8067 mode is transferred on the ESI interface a nibble (4 bits) at a time. Refer to Table 59 for the transfer order in bits and Table 60 for byte order.

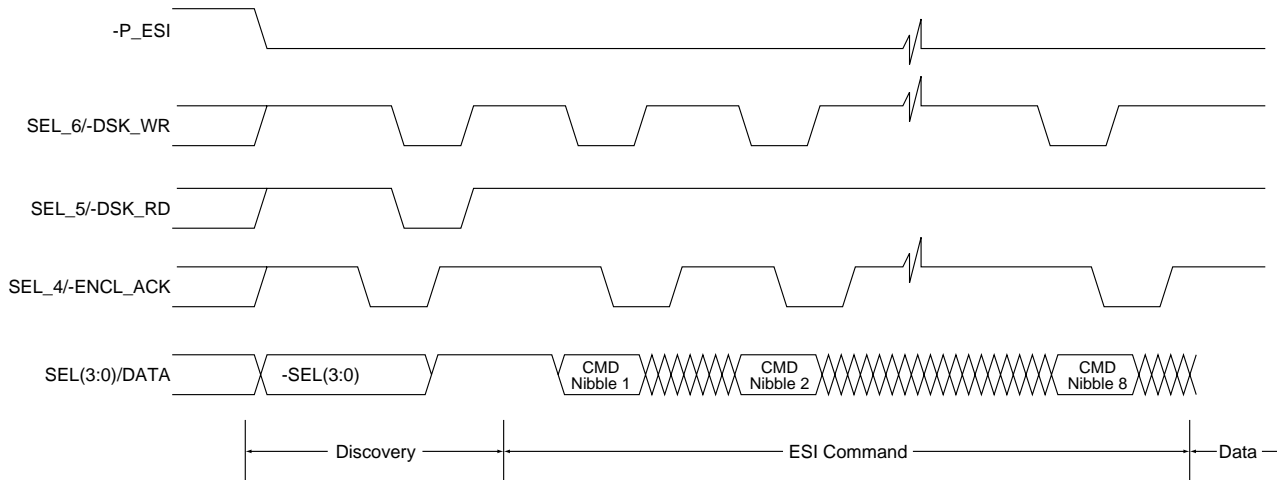
**Table 59. Bit order in 8067 mode ESI transfers**

	MSB							LSB
Bit order byte	7	6	5	4	3	2	1	0
Transfer order on ESI interface	First Nibble				Second Nibble			
Bit order is ESI data	D(3)	D(2)	D(1)	D(0)	D(3)	D(2)	D(1)	D(0)

**Table 60. Byte order in 8067 mode ESI transfers**

Byte order in SCSI transfer	0	1	.....	n - 1	n
Byte order is ESI transfer	first	second	.....	n - 1	n

## 10.4 ESI command transfer



**Figure 15. ESI command transfers**



### 10.4.1 ESI read transfer

To receive data from the enclosure, the drive pulls  $\text{-DSK\_RD}$  pin low to request information from the enclosure. The enclosure responds by driving the Data pins with ESI and pulling  $\text{-ENCL\_ACK}$  low to signal that the data is valid. The drive strobbs the data and allows high  $\text{-DSK\_RD}$  to return high. The enclosure responds to the  $\text{-DSK\_RD}$  going high by allowing  $\text{-ENCL\_ACK}$  to return to high. This sequence may be repeated for as many bytes, two nibble each, requested by the host. The drive exits the ESI mode by not pulling  $\text{-P\_ESI}$  low—the pull up resistor returns  $\text{-P\_ESI}$  to a high level.

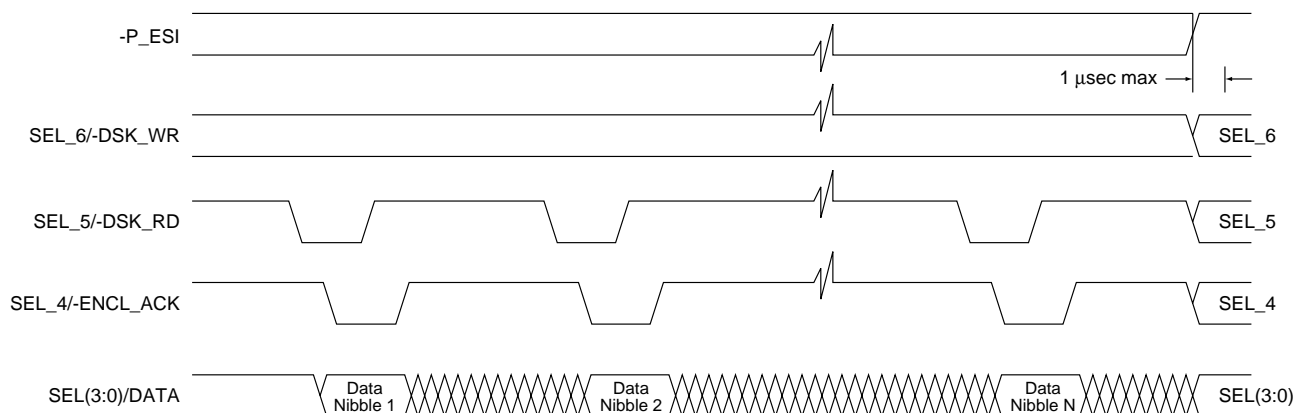


Figure 16. ESI reads

### 10.4.2 ESI write transfer

To send data to the enclosure, the drive places ESI data on the data pins and pulls  $\text{-DSK\_WR}$  in low. The enclosure strobbs the data and responds by pulling  $\text{-ENCL\_ACK}$  low to signal the drive it has taken the data. The drive stops pulling  $\text{-DSK\_WR}$  low, allows the pin to return to a high. The enclosure responds to the  $\text{-DSK\_WR}$  going high by allowing  $\text{-ENCL\_ACK}$  to return to high. This sequence may be repeated for as many bytes, two nibble each, sent by the host. The drive exits the ESI mode by allowing  $\text{-P\_ESI}$  low to return to a high.

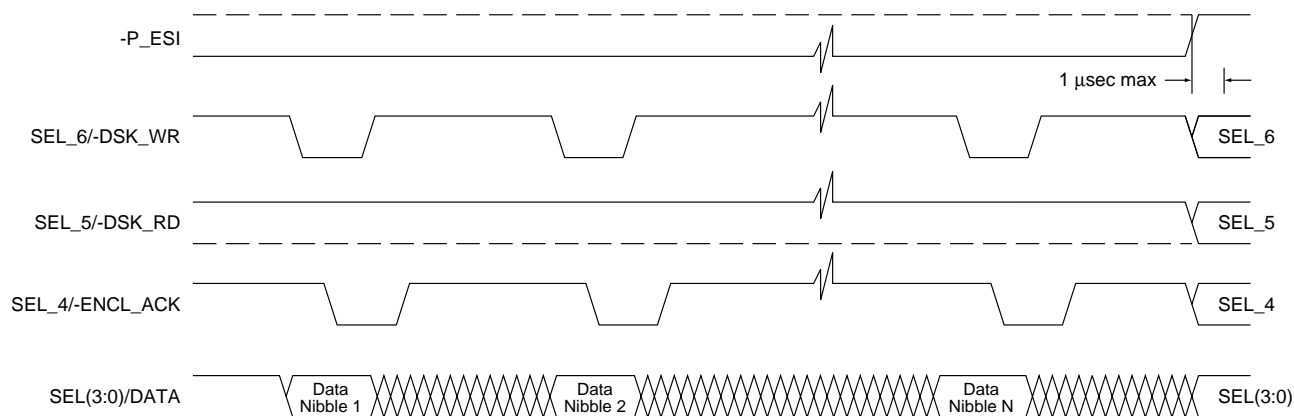


Figure 17. ESI writes

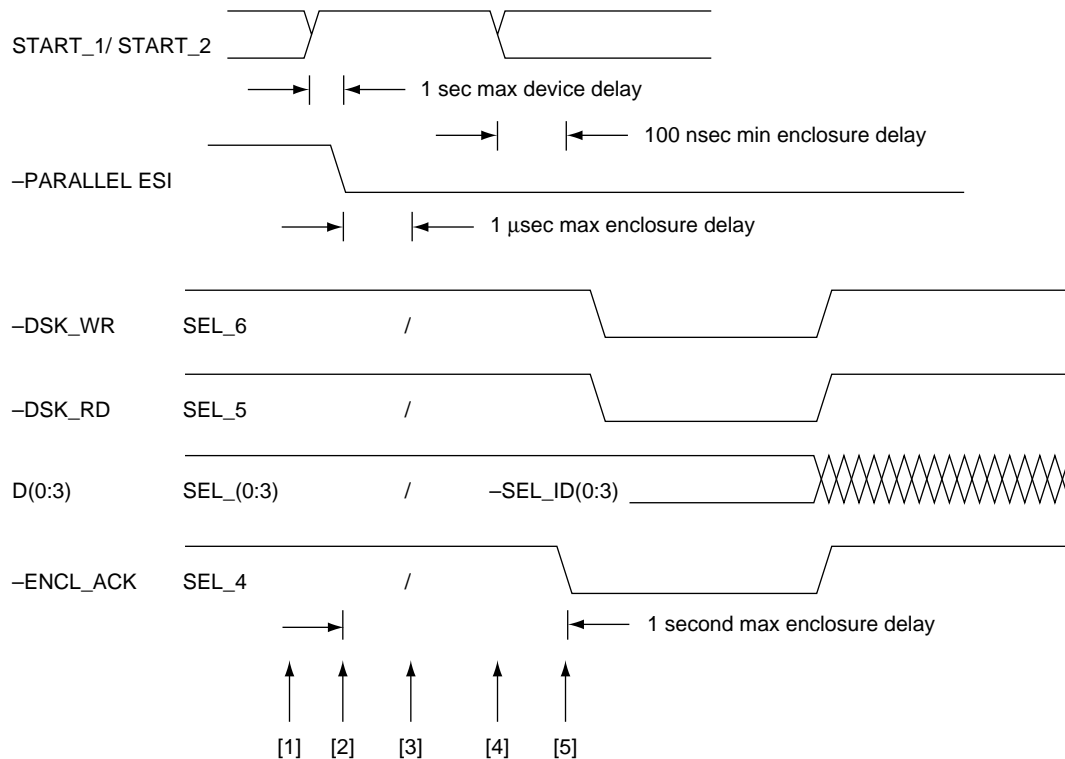
## 10.5 Enclosure-initiated ESI transfer

Enclosure-initiated ESI (EIE) provides a means for the enclosure to request information or action from a drive that supports an 8067 ESI interface. The transfer of information is independent of the SCSI interface. The format of the information, however, is similar to the SES information transferred on the SCSI interface for ease of implementation.

### 10.5.1 EIE Discovery

A modified discovery phase is defined to allow the enclosure to initiate an information request and allow the drive to detect the request.

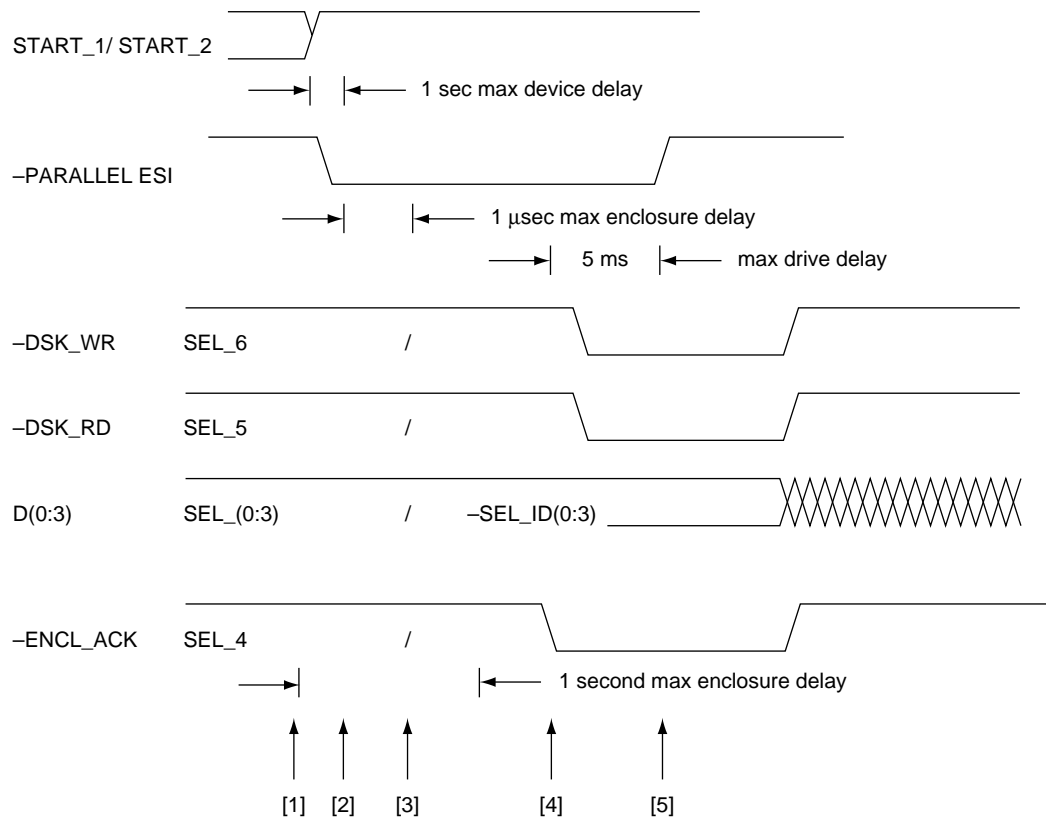
If the drive supports detection of the Un-Mated condition of the START\_1 and START\_2 signals (case 1), and supports Enclosure Initiated ESI (EIE) transfers, it monitors the START\_1 and START\_2 signals. When the device detects a transition from a valid mated condition (case 2, 3, or 4), to Un-Mated, the device asserts –PARALLEL ESI. If the enclosure is requesting a transfer with the Un-Mated condition, it returns the START\_1 and START\_2 signals to a valid mated condition a minimum of 100 nanoseconds before asserting the –ENCL\_ACK signal. The discovery phase continues. Figure 18 below illustrates a successful discovery of an EIE transfer request.



- [1] Enclosure Services Processor negates START\_1 and START\_2 to indicate that it is requesting communication with the drive.
- [2] The drive asserts –PARALLEL ESI to indicate it is ready to begin communication with the Enclosure Services Processor.
- [3] The drive determines that enclosure is SFF-8067 compliant by noting that SEL\_(0:3) bits have inverted and that SEL\_5 and SEL\_6 have the value that the drive is presenting.
- [4] The Enclosure Services Processor returns START\_1 and START\_2 to Case 2, 3, or 4.
- [5] The Enclosure Services Processor asserts –ENCL\_ACK and discovery continues.

**Figure 18. Enclosure Initiated ESI Request**

If discovery determines the enclosure does not support an 8067 capable interface or the enclosure does not return the START\_1 and START\_2 signals to a valid mated condition, the device negates –PARALLEL\_ESI and prepares for power removal. Figure 19 shows a case where the enclosure does support 8067 ESI transfer but the enclosure is requesting the drive to prepare for removal.



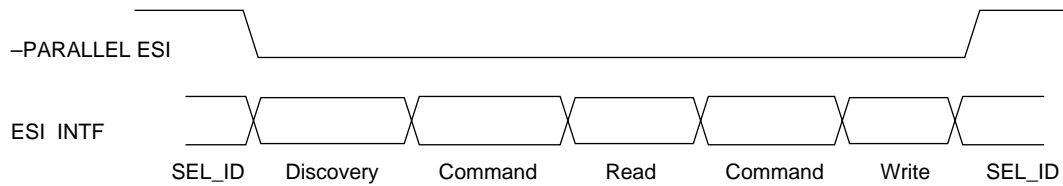
- [1] Enclosure Services Processor negates START\_1 and START\_2 to indicate that it is requesting communication with the drive.
- [2] The drive asserts -PARALLEL ESI to indicate it is ready to begin communication with the Enclosure Services Processor.
- [3] The drive determines that enclosure is SFF-8067 compliant by noting that SEL\_(0:3) bits have inverted and that SEL\_6 and SEL\_7 have the value that the drive is presenting.
- [4] The Enclosure Services Processor asserts -ENCL\_ACK to indicate it is ready to begin communication with the drive.
- [5] The drive negates -PARALLEL ESI to end the ESI transfer and prepares for power removal.

**Figure 19. Prepare for Removal**

**10.5.2 EIE operations**

Following successful discovery of an EIE transfer request, the drive transfers an ESI command to the enclosure using the write and command phase procedure defined in the *SFF-8067 Specification for 40-pin SCA-2 Connector w/Bidirectional ESI*, Rev. 2.3, section 6.4.2.2. The contents of the command are defined in 8.3. The device follows the command with a read phase procedure as described in the *SFF-8067 Specification for 40-pin SCA-2 Connector w/Bidirectionally ESI*, Rev. 2.3, section 6.4.2.3 to retrieve the transfer request information from the enclosure.

If the enclosure is requesting information, the drive sends an ESI command with Send = 1 to indicate to the enclosure it is ready to transfer the requested information. The command is followed by a write of the information requested by the enclosure. This information is defined in the *SFF-8067 Specification for 40-pin SCA-2 Connector w/Bidirectionally ESI*, Rev. 2.3, section 8.3. Following the write, the drive negates -Parallel ESI to end the operation. Figure 20 is a summary of these operations.



**Figure 20. EIE Operation Phases**

If any errors or timeouts are detected during the EIE operation, the drive aborts the operation and continues normal operation. Errors are not reported.

### 10.5.3 Enclosure requested information

If the enclosure services interface transfer is initiated by the enclosure, the drive sends ESI Command Phase information as defined in the *SFF-8067 Specification for 40-pin SCA-2 Connector w/Bidirectional ESI*, Rev. 2.3, table 7-3 to the enclosure following successful discovery. The page code in the ESI command is 00h. This page code is reserved for SCSI diagnostic commands between the host and the drive and will not appear in ESI transfers initiated by SCSI commands. The ESI command is a read operation, SEND=0, with parameter length of 6h.

The enclosure responds to the ESI command from the drive with an ESI request as defined in Table 61. The information requested by the enclosure is identified by the action code.

If the ESI request contains a valid Action Code and non-zero Parameter Length, the drive responds with a write operation with the requested information. Table 62 defines the format of the Enclosure Initiated ESI (EIE) page. Tables 63, 65, 66, 67, and 68 define the page contents for the identified action codes.

**Table 61. Enclosure Request**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
	Page Code (00h)							
1	0	0	0	0	Action Code			
2	0	0	0	0	0	0	0	0
	Reserved							
3	Action Specific							
4	(MSB)							
5	Parameter Length							
	(LSB)							

**Table number 61** **Field definitions (listed alphabetically)**

#### Action Code

The information requested by the enclosure is identified by one of the action codes listed below.

00h Device Standard Inquiry Data (see Section 10.5.3.1).

01h Device Address (see Section 10.5.3.2).

02h Loop Position Map (see Section 10.5.3.3).

03h Initiate Loop Initialization.

**Note:** The Initiate Loop Initialization action code (03h) does not include a transfer of information to the enclosure. The Action Specific bits in the Enclosure Request define the operation to be performed. See Table 67.

04h Device Identification (see Section 10.5.3.4).

05h Device Temperature (see Section 10.5.3.5).

06h Port Parameters (see Section 10.5.3.6).

07h Link Status (see Section 10.5.3.7).

0Ah-0Fh Reserved.

**61 Action Specific**

The Action Specific bit for all action codes other than action code 03h is 0.

**61 Page Code**

The Page Code identifies the page of enclosure data being transferred.

**61 Parameter Length**

The parameter length in the enclosure request is set by the enclosure to the number of bytes it is requesting including the four header bytes. The drive sends the actual length of the requested information or the length identified in the request parameter length whichever is less. If the parameter length is equal to 0, The drive ends the ESI transfer by negating Parallel\_ESI.

**Table 62. Enclosure Initiated ESI Page Format**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	ESI Page (00h)			
1	0	0	0	0	Action Code			
2 3	(MSB) _____ Page Length (n - 3)							(LSB)
4 . . n	(MSB) _____ Data							(LSB)

**Table number 62 Field definitions (listed alphabetically)**

**62 Action Code**

00h Device Standard Inquiry Data

**62 Data**

The first n - 4 bytes of ESI data.

**62 ESI Page**

00h Identifies the ESI page code used (00h).

**62 Page Length**

The length of the ESI page (n - 3 bytes).

### 10.5.3.1 Device Standard Inquiry Data page

**Table 63. Device Standard Inquiry Data page**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	ESI Page (00h)			
1	0	0	0	0	Action Code (00h)			
2 3	(MSB) _____ Page Length (24h)							(LSB)
4 . . 39	(MSB) _____ Inquiry Data							(LSB)

**Table number** **Field definitions (listed alphabetically)**

**63** **Action Code**

00h Device Standard Inquiry Data

**63** **ESI Page**

00h Identifies the ESI page code used (00h).

**63** **Inquiry Data**

The first 36 bytes of Standard Inquiry data. Refer to Section 12.6 for a definition of this data. Note: the vendor specific, VS, bit in byte 6 is not valid.

**63** **Page Length**

24h The length of the ESI page (in bytes).

10.5.3.2 Device Address page

Table 64. Device Address page

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	ESI Page (00h)			
1	0	0	0	0	Action Code (01h)			
2 3	(MSB) _____ Page Length (24h)							(LSB)
4 : 11	(MSB) _____ Node Name							(LSB)
12	Port A (01h)							
13 14 15	(MSB) _____ Port A Port_Identifier							(LSB)
16	Port A Position							
17	0	0	0	0	0	0	0	0
18 : 25	(MSB) _____ Port A Name							(LSB)
26	Port B (02h)							
27 28 29	(MSB) _____ Port B Port_Identifier							(LSB)
30	Port B Position							
31	0	0	0	0	0	0	0	0
32 : 39	(MSB) _____ Port B Name							(LSB)

**Table number** Field definitions (listed alphabetically)

**64** Action Code

01h Device Address

**64** ESI Page

00h Identifies the ESI page code used (00h).

**63** Node Name

The 64-bit Fibre Channel unique Name\_Identifier assigned to the drive.

**63** Page Length

24h The length of the ESI page (in bytes).

**63** Port\_Identifier

The FC 24-bit address assigned to the port. The lower byte is the current FC-AL AL\_PA for this port. If the port does not have a Port\_Identifier, a value of FF FF FFh is returned in the Port\_Identifier field.

**63 Port Name**

The 64-bit Fibre Channel unique Name\_Identifier assigned to the port.

**63 Port Position**

The offset value for this port's AL\_PA in the FC-AL AL Loop Initialization Loop Position (LILP) Frame. If the port does not have an AL\_PA, a value of FFh is returned in the Port Position field.



10.5.3.3 Loop Position Map page

Table 65. Loop Position Map page

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	ESI Page (00h)			
1	0	0	0	0	Action Code (02h)			
2 3	(MSB) _____ Page Length (m – 3)							(LSB)
4	Offset Port A (n – 4)							
5 . . n	(MSB) _____ Loop Map Port A							(LSB)
n + 1	Offset Port B (m – n + 1)							
n + 2 . . m	(MSB) _____ Loop Map Port B							(LSB)

**Table number** Field definitions (listed alphabetically)

**65** Action Code

02h Device Address

**65** ESI Page

00h Identifies the ESI page code used (00h).

**65** Loop Map Port x

This field contains the valid AL\_PA entries from the payload of the FC-AL LILP frame. Only the valid AL\_PA entries are transferred to minimize the transfer time on the ESI interface. The maximum Loop Map size is 127 bytes.

**65** Offset Port x

This field Indicates the number of bytes of offset from the FC-AL LILP frame in the Loop Map. A value of 00h indicates the Loop Map is not available for the port.

**65** Page Length

24h The length of the ESI page (in bytes).

Table 66. Initiate LIP Action Specific Bits

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	LIP Loop B	LIP Loop A

**Table number** Field definitions (listed alphabetically)

**66** LIP Loop A/B

1 The drive enters the Loop Initialization Process on either loop A, B, or both as indicated by these bits. The drive originates a LIP(F7,AL\_PS) if it has a valid AL\_PA. The drive originates a LIP(F7,F7) if it does not have a valid AL\_PA.

### 10.5.3.4 Device Identification page

Table 67. Device Identification page

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	ESI Page (00h)			
1	0	0	0	0	Action Code (04h)			
2 3	(MSB) _____ Page Length (n – 3)							(LSB)
4 . . n	(MSB) _____ Device ID Data							(LSB)

**Table number** Field definitions (listed alphabetically)

**67** Action Code

04h Device Identification.

**67** Device ID Data

This field contains the same data as the SCSI Vital Product Data Device Identification page (83h). See Section 12.6.4 for the complete SCSI Vital Product Data device Identification information.

**67** ESI Page

00h Identifies the ESI page code used (00h).

**67** Page Length

24h The length of the ESI page (in bytes).

### 10.5.3.5 Device Temperature page

**Table 68. Device Temperature page**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	ESI Page (00h)			
1	0	0	0	0	Action Code (05h)			
2 3	(MSB) _____ Page Length (06h)							_____ (LSB)
4	Temperature							
5 . . 9	Reserved							

**Table number** **Field definitions (listed alphabetically)**

**68** **Action Code**

05h Device Temperature

**68** **ESI Page**

00h Identifies the ESI page code used (00h).

**68** **Temperature**

The value of the drive temperature sensor in degrees Celsius, offset by +20 degrees. The range expresses a temperature between -19 and +235 degrees Celsius. The value of 0 is reserved.

**68** **Page Length**

06h The length of the ESI page (in bytes).

### 10.5.3.6 Port Parameters page

Table 69. Port Parameters page

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	ESI Page (00h)			
1	0	0	0	0	Action Code (06h)			
2	(MSB) _____ Page Length (06h) _____ (LSB)							
3								
4	Drive Capabilities							
5	Reserved							LSP CHG
6	0	0	Port A Link Fail	Port A Bypass	0	Port A Link Rate		
7	Reserved							
8	0	0	Port B Link Fail	Port B Bypass	0	Port B Link Rate		
9	Reserved							

**Table number** Field definitions (listed alphabetically)

**69** Action Code

06h Port Parameters.

**69** Drive Capabilities

This is a bit-significant field that indicates which device control codes defined by SFF 8045 are supported by the drive. The corresponding device control code is supported. For example, a one in bits 7 and 6 indicates that device control codes 7 and 6 are supported. This indicates the drive supports Fibre Channel link rates or 1 and 2 GHz.

**69** ESI Page

00h Identifies the ESI page code used (00h).

**69** LSP CHG (Link Status Page Change)

This bit-significant field indicates which device control codes defined in SFF 8045 are supported by the drive.

0 The Link Status Page data has not changed.

1 The date in the Link Status Page has changed since the enclosure last read the Link Status Page.

**69** Port Bypass

0 The drive is not requesting bypass.

1 The drive is asserting the –ENBL BYP CH signal in the SCA connector for the port.

**69** Port Link Fail

0 The drive is not currently detecting a loop failure condition as defined in FC-AL for the port.

1 The drive is currently detecting a loop failure condition as defined in FC-AL for the port.

**69** Port Link Rate

This field contains the value defined for the Fibre Channel link rate by the Device Control Code inputs in SFF 8045. For example, seven represents 1 GHz.

**10.5.3.7 Link Status page**

Implementation of the fields in this page is optional. A value of zero either indicates the field is not supported or no count has occurred.

When the drive changes a value in this page, the drive sets the LSP CHG bit in the Port Parameter page. The enclosure may poll the Port Parameter page to determine if it needs to read and process the Link Status page. When the Link Status page is read by the enclosure, the LSP CHG bit is cleared.

The fields listed in this section are extracted from the FC-PH defined Link Error Status Block (LESB).

**Table 70. Link Status page**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	ESI Page (00h)			
1	0	0	0	0	Action Code (07h)			
2 3	(MSB)	Page Length (60h)						(LSB)
4 7	(MSB)	Link Failure Count, Port A						(LSB)
8 11	(MSB)	Loss of Sync Count, Port A						(LSB)
12 15	(MSB)	Loss of Signal Count, Port A						(LSB)
16 19	(MSB)	Primitive Sequence Protocol Error, Port A						(LSB)
20 23	(MSB)	Invalid Transmission Word Count, Port A						(LSB)
24 27	(MSB)	Invalid CRC Count, Port A						(LSB)
28 31	(MSB)	LIP F7 Initiated Count, Port A (valid in loop mode only)						(LSB)
32 35	(MSB)	LIP F7 Received Count, Port A (valid in loop mode only)						(LSB)
36 39	(MSB)	LIP F8 Initiated Count, Port A (valid in loop mode only)						(LSB)
40 43	(MSB)	LIP F8 Received Count, Port A (valid in loop mode only)						(LSB)
44 51	Reserved							
52 55	(MSB)	Link Failure Count, Port B						(LSB)

Table 70. Link Status page (Continued)

Bit Byte	7	6	5	4	3	2	1	0
56 .	(MSB)	Loss of Sync Count, Port B						(LSB)
59								
60 .	(MSB)	Loss of Signal Count, Port B						(LSB)
63								
64 .	(MSB)	Primitive Sequence Protocol Error, Port B						(LSB)
67								
68 .	(MSB)	Invalid Transmission Word Count, Port B						(LSB)
71								
72 .	(MSB)	Invalid CRC Count, Port B						(LSB)
75								
76 .	(MSB)	LIP F7 Initiated Count, Port B						(LSB)
79								
80 .	(MSB)	LIP F7 Received Count, Port B						(LSB)
83								
84 .	(MSB)	LIP F8 Initiated Count, Port B						(LSB)
87								
88 .	(MSB)	LIP F8 Received Count, Port B						(LSB)
91								
92 .		Reserved						
99								

**Table number** Field definitions (listed alphabetically)

**70** Action Code

07h Link Status.

**70** ESI Page

00h Identifies the ESI page code used (00h).

**70** Invalid CRC Count

The count of the number of write data frames that have been received with invalid CRCs on the port. These errors are only detected when this drive is the target of the data transfer.

**70** Invalid Transmission Word Count

The count of the number of invalid transmission words/running disparity errors that have been detected on the port.

**70** Link Failure Count

The count of the number of invalid transmission words/running disparity errors that have been detected on the port.

**70** LIP F7 Initiated Count

Count of the number of loop initialization processes originated by the port with LIP – F7's (Initialize LIP).

**70** LIP F7 Received Count

Count of the number of loop initialization processes initiated on the port by receiving LIP – F7's (Initialize LIP).

**70 LIP F8 Initiated Count**

Count of the number of loop initialization processes originated by the port with LIP – F8's (Failure LIP).

**70 LIP F8 Received Count**

Count of the number of loop initialization processes initiated on the port by receiving LIP – F8's (Failure LIP).

**70 Loss of Signal Count**

The count of the number of Loss of Signal conditions on the port.

**70 Loss of Sync Count**

The count of the number of short (< 100 ms) Loss of Synchronization conditions that have occurred on the port.

**70 Page Length**

60h The length of the Link Status page (in bytes).

**70 Primitive Sequence Protocol Error, Port A**

The number of FC-PH defined Primitive Sequence Protocol Errors on port A. This field is not valid in loop mode.

**70 Primitive Sequence Protocol Error, Port B**

The number of FC-PH defined Primitive Sequence Protocol Errors on port B. This field is not valid in loop mode.

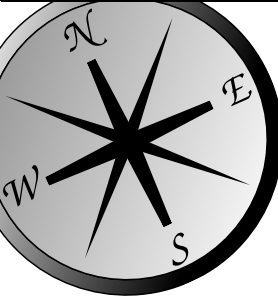




## 11.0 SCSI operations

SCSI information is transported in Fibre Channel frames. All SCSI Fibre Channel Protocol (SCSI-FCP) operations start with an FCP CMND (Command) frame and end with an FCP RSP (Response) frame. Operations initiated with an FCP CMND may be SCSI commands such as read or write data. The operations also include control operations called Task Management functions. Task Management functions provide reset and Task Set (queue) control.

**Navigation assistance**



The field descriptions that are provided for most tables have sidebar labels which identify the table they are associated with. This helps orient you when nested tables occur within a section.

*Sidebar example*

<b>Table number</b>	<b>Field definitions (listed alphabetically)</b>
<b>1</b>	<b>Field name</b>

The sidebar (black background with reversed text) identifies this field as being associated with Table 1.

### 11.1 SCSI-FCP

SCSI-FCP is an FC-4 mapping protocol for applying the SCSI command set to the Fibre Channel. This protocol retains the half-duplex nature of parallel SCSI within each I/O operation. For example, a single operation, such as a Read command, operates over a single port pair between the initiator and target.

#### 11.1.1 FC-4 mapping layer

All devices communicating with a Seagate Fibre Channel disc drive must implement the SCSI-FCP mapping protocol. The FC-4 mapping layer uses the services provided by FC-PH to execute the steps required to perform the functions defined by the FC-4.

11.2 FCP CMND

The content of the FCP CMND frame is shown below. Details of the FCP CMND contents are in Tables 71 and 72.

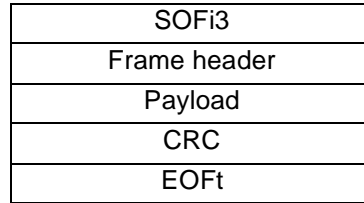


Table 71. FCP CMND frame header

Bit Byte	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	1	1	0	
R_CTL									
1	D_ID								(MSB)
2									(LSB)
3									
4	0	0	0	0	0	0	0	0	
Reserved									
5	S_ID								(MSB)
6									(LSB)
7									
8	0	0	0	0	1	0	0	0	
Type									
9	F_CTL								(MSB)
10									(LSB)
11									
12	SEQ_ID								
13	0	0	0	0	0	0	0	0	
DF_CTL									
14	0	0	0	0	0	0	0	0	
15	0	0	0	0	0	0	0	0	
SEQ_CNT									
16	OX_ID								(MSB)
17									(LSB)
18	1	1	1	1	1	1	1	1	
19	1	1	1	1	1	1	1	1	
RX_ID									
20	Parameter								(MSB)
21									(LSB)
22									
23									

**Table  
number****Field definitions (listed alphabetically)****71 DF\_CTL (Data Field Control)**

00h No optional Fibre Channel headers are used.

**71 D\_ID (Destination Identifier)**

The address of the drive. This value must match the current address of the drive.

**71 F\_CTL (Frame Control)**

290000h for FCP CMND frames. This indicates the frame is the first sequence of the exchange and last frame of that sequence. Sequence initiative is also transferred so the drive may respond to the FCP CMND.

**71 OX\_ID (Originator Exchange Identifier)**

Assigned by the initiator. This value must be unique for all commands issued by this initiator to the drive. If duplicate OX\_IDs are detected by the drive for uncompleted commands from an initiator, an overlap command error will be returned.

**71 Parameter**

Not used for the FCP CMND.

**71 R\_CTL (Routing Control)**

Set to Unsolicited Command data sequence for the FCP CMND frame.

**71 RX\_ID (Responder Identifier)**

Not used by the drive. FFFFh indicates the RX\_ID is not being used.

**71 SEQ\_CNT (Sequence Count)**

0000h value indicates that this is the first frame of the Fibre Channel sequence. The FCP CMND is a single frame sequence.

**71 SEQ\_ID (Sequence Identifier)**

May be set to any value. The OX\_ID field uniquely identifies each command between the initiator and the drive.

**71 S\_ID (Source Identifier)**

The address of the initiator that sent the frame. This address is used by the drive to return any responses that may be required by the operation.

**71 Type**

08h All SCSI FCP frames must be set to this value.

Table 72. FCP CMND Payload

Bit Byte	7	6	5	4	3	2	1	0
0 : 7	(MSB) _____ Logical Unit Number _____ (LSB)							
8	0	0	0	0	0	0	0	0
	Reserved							
9	0	0	0	0	0	Task Attribute		
	Reserved							
10	Term Task	Clear ACA	Target Reset	0	0	Clear Task Set	Abort Task Set	0 Reserved
	Reserved					0	0	0
11	0	0	0	0	0	0	Read Data	Write Data
	Reserved							
12 : 27	(MSB) _____ CDB _____ (LSB)							
28 29 30 31	(MSB) _____ DL _____ (LSB)							

**Table number** Field definitions (listed alphabetically)

**72 Abort Task Set**

Clears only the queue of commands from the initiator originating the Abort Task Set.

**72 CDB (Command Descriptor Block)**

Always 16 bytes long. The actual contents depends on the command type. Unused bytes are not checked by the drive. If any of the Task Management flags are set in byte 10, the CDB field is ignored.

**72 Clear ACA (Clear Auto Contingent Allegiance)**

When this bit is set to one (1) by the initiator that caused the ACA condition, the drive will clear the ACA condition and allow the drive to resume normal processing of commands.

**72 Clear Task Set**

Clears the queue for all initiators. A Unit Attention condition is created for all initiators with commands in the queue other than the initiator originating the Clear Task Set.

**72 DL (Data Length)**

The maximum amount of data (in bytes) to be transferred by the command specified in the CDB.

If the DL value is zero, no data will be transferred regardless of the CDB or Read/Write bits in byte 11.

If the DL value is less than the transfer length in the CDB, the drive will transfer up to the DL value, set the Residual Over Run bit in the FCP RSP, and place the difference between the actual transfer and DL in the FCP RSP Residual Count field.

If the DL value is greater than the transfer length in the CDB, the drive will transfer the CDB requested length, set the Residual Under Run bit in the FCP RSP, and place the difference between the actual transfer and DL in the FCP RSP Residual Count field.

If the DL value equals the actual transfer length in the CDB, the Residual Over Run and Residual Under Run bits in the FCP RSP will be cleared.

**72 Logical Unit Number (LUN)**

Addresses physical devices or virtual devices attached to a target.

- 0 Zero is the only valid LUN number for the drives supported by this manual. The drive will reject Inquiry, Test Unit Ready, and Request Sense commands that select an invalid LUN by sending Check Condition status in the FCP RSP frame. Inquiry commands will return Inquiry Data with the Peripheral Device Type field set to Logical Unit Not Present (7Fh). Request Sense and Inquiry commands will send Check Condition status in response to an invalid LUN selection. For all other commands, the Logical Unit field is not tested.

**72 Read Data**

Set to one (1) when the command specified by the CDB field will result in a data transfer to the initiator.

**72 Target Reset**

When the drive receives a Target Reset, it clears the command queue for all initiators and returns a Unit Attention status in response to the next command received from initiators other than the initiator that originated the Target Reset. N\_Port and Process Logins are preserved.

**72 Task Attribute**

Specifies the type of command queue management requested for the SCSI command in the CDB field of this FCP CMND. The drive supports:

- 0 Simple Queue. Specifies that the I/O process be placed in the drive's I/O process queue for execution. The order of execution can be arranged by the disc drive in accordance with a performance optimization algorithm.
- 1 Head of Queue. Specifies that the I/O process be placed first in that logical unit's queue for the initiator originating the I/O process. An I/O process already being executed by the drive is not preempted. A subsequent I/O process received with a Head of Queue attribute is placed at the head of the queue for execution in last-in, first-out order.
- 2 Ordered Queue. Specifies that the I/O process be placed in the disc drive's I/O process queue for execution in the order received, with respect to other commands with Ordered Queue attributes, except for I/O processes received with a Head of Queue, which are placed at the head of the queue.
- 4 ACA Queue. When an ACA condition is active in the drive, only FCP CMNDs with the ACA Queue attribute received from the initiator that originated the I/O process that caused the ACA condition will be executed.
- 5 Untagged Queue. Allows the drive to accept only one command from each initiator. If another command is received for an initiator with an active command, the drive will return a check in the FCP RSP.

**72 Term Task (Terminate Task)**

Not supported by the drive.

**72 Write Data**

Set to one (1) when the command specified by the CDB field will result in a data transfer from the initiator.

### 11.2.1 Command Descriptor Block (CDB)

A request by an initiator to a disc drive is performed by sending a Command Descriptor Block (CDB) to the disc drive. For several commands, the request is accompanied by a list of parameters sent in FCP DATA frames. See the specific commands for detailed information.

The Command Descriptor Block always has an operation code as the first byte of the command. This is followed by command parameters (if any) and a control byte. For all commands, if there is an invalid parameter in the Command Descriptor Block, the disc drive terminates the command without altering the medium. The format description for the Command Descriptor Block as supported by the disc drive is shown in Tables 74 and 75.

#### 11.2.1.1 Operation Code

The Operation Code (Table 73) of the Command Descriptor Block has a Group Code field and a Command Code field. The three-bit Group Code field provides for eight groups of command codes. The five-bit Command Code field provides for 32 command codes in each group. Thus, a total of 256 possible operation codes exist. Operation codes are defined in Section 12.0.

For the disc drive, the group code specifies one of the following groups:

Group 0 - Six-byte commands (see Table 74)

Group 1 - Ten-byte commands (see Table 75)

Group 2 - Ten-byte commands (see Table 75)

Group 3 - Reserved

Group 4 - Sixteen-byte commands

Group 5 - Twelve-byte commands

Group 6 - Vendor specific

Group 7 - Vendor specific

**Table 73. Operation Code format for CDB**

Bit Byte	7	6	5	4	3	2	1	0
0	Group Code			Command Code				

**Table 74. Typical CDB for six-byte commands**

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code							
1	0	0	0	(MSB)				
	Reserved			Logical Block Address (if required)				
2								
3								
4	Transfer Length (if required)							
5	Control Byte							

**Table number**

**Field definitions (listed alphabetically)**

**74 Control Byte**

See Section 11.2.1.6.

**74 Logical Block Address**

See Section 11.2.1.2.

**74 Operation code**

See Section 11.2.1.3.

**74 Transfer Length**

See Section 11.2.1.5.

**Table 75. Typical CDB for ten-byte commands**

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code							
1	0	0	0	0	0	0	0	RelAdr
	Reserved			Logical Block Address (if required)				
2	(MSB)							
3								
4	(LSB)							
5								
6	Reserved							
7	(MSB)							
8								
9	Control Byte							

**Table number**

**Field definitions (listed alphabetically)**

**75 Control Byte**

See Section 11.2.1.6.

**75 Logical Block Address**

See Section 11.2.1.2.

**75 Operation Code**

See Section 12.0.

**75 RelAdr (Relative Address)**

See Section 11.2.1.4.

**75 Transfer Length**

See Section 11.2.1.5

**11.2.1.2 Logical block address**

The logical block address in the Command Descriptor Block begins with block zero and is continuous up to the last logical block on drive.

Group 0 command descriptor block contains 21-bit logical block addresses. Groups 1 and 2 command descriptor blocks contain 32-bit logical block addresses.

The logical block concept implies that the initiator and target have previously established the number of data bytes per logical block. This may be established through the use of the Read Capacity command or the Mode Sense command or by prior arrangement.

The maximum logical block address for the disc drive which is accessible by the initiator is defined in Read Capacity Command data in Section 12.19.

**11.2.1.3 Operation code**

Operation codes are defined in Section 12.0.

**11.2.1.4 Relative address bit**

Relative addressing is a technique of accessing logical blocks relative to the logical blocks accessed in a previous linked command. Seagate fibre channel drives do not support relative addressing.

**11.2.1.5 Transfer length**

The Transfer Length field specifies the amount of data to be transferred, usually the number of blocks. For several commands, the Transfer Length indicates the requested number of bytes to be sent as defined in the command description. For these commands, the Transfer Length field may be identified by a different name. See the following descriptions and the individual command descriptions for further information.

Commands that use one byte for the Transfer Length field allow up to 256 blocks of data to be transferred by one command. A Transfer Length field value of 1 to 255 indicates the number of blocks that are transferred. A value of zero indicates 256 blocks.

Commands that use two bytes for the Transfer Length field allow up to 65,535 blocks of data to be transferred by one command. In this case, a Transfer Length of zero indicates that no data transfer takes place. A value of 1 to 65,535 indicates the number of blocks that are transferred.

For several commands, more than two bytes are allocated for the Transfer Length field. Refer to the specific command description for further information.

The Transfer Length field of the commands that are used to send a list of parameters to a disc drive is called the Parameter List Length field. The Parameter List Length field specifies the number of bytes sent during the FCP DATA sequences for the command.

The Transfer Length field of the commands used to return sense data (e.g., Request Sense, Inquiry, Mode Sense, etc.) to an initiator is called the Allocation Length field. The Allocation Length field specifies the number of bytes that the initiator has allocated for returned data. The disc drive terminates the data in the FCP DATA sequence when Allocation Length bytes have been transferred or when all available data have been transferred to the initiator, whichever is less.



**11.2.1.6 Control byte**

Normally all zeros unless the extended features of ACA or Link commands are being used.

**Table 76. Control byte**

Bit Byte	7	6	5	4	3	2	1	0
LAST	0	0	0	0	0	NACA	Flag	Link

**Table number** **Field definitions (listed alphabetically)****76** **Flag**

Drives supported by this manual do not use this bit.

**76** **Link**

This bit is set to one (1) to indicate that the initiator desires an automatic link to the next command upon successful completion of the current command. If the link bit is one (1), upon successful termination of the command, the drive returns Intermediate status in the FCP RSP frame.

**Note.** The OX\_ID must be the same for all linked commands because it is considered the same exchange.

**76** **NACA (Normal Auto Contingent Allegiance)**

- 1 Enables ACA handling rules for the command. If a Check Condition occurs during the processing of the command, an ACA condition is entered.
- 0 Disables ACA handling rules for the command.

### 11.3 FCP XFER RDY

The FCP XFER RDY (Transfer Ready) frame is sent by the drive when it requests data for a transfer to the drive. Examples of commands resulting in data transfers to the drive are Write, Mode Select, and Write Buffer.

**Table 77. FCP XFER RDY header**

Bit Byte	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	1	0	1	
	R_CTL								
1	D_ID								(MSB)
2									
3									(LSB)
4	0	0	0	0	0	0	0	0	
	Reserved								
5	S_ID								(MSB)
6									
7									(LSB)
8	0	0	0	0	1	0	0	0	
	Type								
9	F_CTL								(MSB)
10									
11									(LSB)
12	SEQ_ID								
13	0	0	0	0	0	0	0	0	
	DF_CTL								
14	0	0	0	0	0	0	0	0	
15	0	0	0	0	0	0	0	0	
	SEQ_CNT								
16	OX_ID								(MSB)
17									(LSB)
18	1	1	1	1	1	1	1	1	
19	1	1	1	1	1	1	1	1	
	RX_ID								
20	Parameter								(MSB)
21									
22									
23									(LSB)

**Table number** Field definitions (listed alphabetically)

**77** DF\_CTL (Data Field Control)

00h No optional Fibre Channel headers are used.

**77** D\_ID (Destination Identifier)

The address of the initiator that originated the command for which the data is being requested.

**77 F\_CTL (Frame Control)**

Set to 890000h for FCP CMND frames. This indicates the frame is sent by the responder of the exchange, not the originator, and the frame is the last of the Fibre Channel sequence. Sequence initiative is transferred so the initiator may send the requested data.

**77 OX\_ID (Originator Exchange Identifier)**

The drive returns the OX\_ID it received from the initiator with the FCP CMND.

**77 Parameter**

Not used for the FCP XFER RDY.

**77 R\_CTL (Routing Control)**

Set to Data Descriptor.

**77 RX\_ID (Responder Identifier)**

Not used by the drive. The value of FFFFh indicates the RX\_ID is not being used.

**77 SEQ\_CNT (Sequence Count)**

0000h Indicates that this is the first frame of the Fibre Channel sequence. The FCP XFER RDY is a single frame sequence.

**77 SEQ\_ID (Sequence Identifier)**

The drive sends FFh.

**77 S\_ID (Source Identifier)**

Address of the drive.

**77 Type**

08h For all SCSI FCP frames.

Table 78. FCP XFER RDY Payload

Bit Byte	7	6	5	4	3	2	1	0	
0	Relative Offset								(MSB)
1									
2									
3									(LSB)
4	Burst Length								(MSB)
5									
6									
7									(LSB)
8	Reserved								(MSB)
9									
10									
11									(LSB)

**Table number** Field definitions (listed alphabetically)

**78** Burst Length

The amount of data (in bytes) requested by the drive for transfer in this Fibre Channel sequence. The maximum length the drive will request is the remaining data to complete the transfer, the Maximum Burst Size in the Disconnect/Reconnect SCSI mode (page 2), or the maximum length that may be transferred in a Fibre Channel sequence, whichever is less.

**78** Relative Offset

The byte offset of the requested transfer relative to the first byte of the data addressed in the CDB.

### 11.4 FCP DATA

The payload of FCP DATA frames transfer the user data associated with a command.

FCP DATA format	
SOFi3	<b>Note:</b> EOFt is used on the last frame of a sequence. Single frame sequences end with an EOFt. All other FCP DATA frames use EOFn.
Frame Header	
Payload (Data)	
CRC	
EOFn or EOFt	

Table 79. FCP DATA frame header

Bit Byte	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	1	
R_CTL									
1	D_ID								(MSB)
2									(LSB)
3									
4	0	0	0	0	0	0	0	0	
Reserved									
5	S_ID								(MSB)
6									(LSB)
7									
8	0	0	0	0	1	0	0	0	
Type									
9	F_CTL								(MSB)
10									(LSB)
11									
12	SEQ_ID								
13	0	0	0	0	0	0	0	0	
DF_CTL									
14	SEQ_CNT								(MSB)
15									(LSB)
16									
16	OX_ID								(MSB)
17									(LSB)
18									
18	1	1	1	1	1	1	1	1	
19	1	1	1	1	1	1	1	1	
RX_ID									
20	RO								(MSB)
21									
22									
23									(LSB)

Table  
number**Field definitions (listed alphabetically)****79 DF\_CTL (Data Field Control)**

00h Indicates no optional Fibre Channel headers are used.

**79 D\_ID (Destination Identifier)**

The address of the drive if transfer is data to the drive and the address of the initiator originating the command if the transfer is from the drive.

**79 F\_CTL (Frame Control)**

This field is determined by the direction of the transfer and whether or not the frame is the last frame of the sequence.

For transfers to the drive, the initiator sets the F\_CTL to 000008h or 000000h for all frames except the last frame of the sequence. These values indicate the frame is from for the originator of the exchange (command) and whether the parameter field is the relative offset. For the last frame of the sequence, the initiator sets the F\_CTL to 09000Xh. This indicates the frame is the last frame of the sequence and sequence initiative is transferred so the drive may send an additional FCP XFER RDY or FCP RSP. The X represents the lower four bits of the F\_CTL.

**Table 80. Frame Control bit descriptions**

Bit	Description
3	Set to one (1) to indicate the parameter field is the relative offset.
2	0 (Reserved)
1 - 0	Number of fill bytes in the last word of the frame. The drive requires all data frames for transfers to and from the media to be integer multiples of four bytes, so the drive requires the fill byte count to be 0. For transfers that do not require media operations (e.g., inquiry data, read, and write buffer), the drive supports the fill byte count.

For transfers to the initiator, the drive sets the F\_CTL to 800008h for all frames but the last frame of the sequence. This indicates the frame is from the responder of the exchange (command) and the parameter field is the relative offset. For the last frame of the sequence, the drive sets the F\_CTL to 88000Xh. This indicates the frame is the last frame of the sequence. Sequence initiative is held for transfer of another sequence or the FCP RSP. The X has the same meaning as defined above.

**79 OX\_ID (Originator Exchange Identifier)**

The value assigned by the initiator in the FCP CMND.

**79 R\_CTL (Routing Control)**

Set to Solicited Data for the FCP DATA frame.

**79 RO (Relative Offset)**

The RO is a byte count offset between the first byte of the transfer address identified in the command and the first byte of data in the frame payload. The drive sends a continually increasing RO on data frames when sending data. The drive does not require or check the RO field on frames it receives. The drive uses the SEQ\_CNT field to verify frames are received in order.

**79 RX\_ID (Responder Identifier)**

Not used by the drive. The value of FFFFh indicates the RX\_ID is not being used.

**79 SEQ\_CNT (Sequence Count)**

Set to 0000h on the first frame transferred. The SEQ\_CNT is required to continually increase through a sequence and across sequence boundaries if additional sequences are required to complete the transfer. The drive requires all received frames to be in sequential order. Frames originated by the drive are sent in sequential order.

**79 SEQ\_ID (Sequence Identifier)**

For transfers to the drive, the drive captures the SEQ\_ID from the first frame of the sequence and requires all subsequent frames of the sequence to have the same SEQ\_ID. For transfers to the initiator, the drive sets the SEQ\_ID to 00h for the first data sequence of a command (exchange). The SEQ\_ID is sequentially increased for additional data sequences, if required, for the command.

**79 S\_ID (Source Identifier)**

The address of the initiator originating the command if transfer is data to the drive and the address of the drive if the transfer is from the drive.

**79 Type**

08h For all SCSI FCP frames.

## 11.5 FCP RSP

An FCP Response (RSP) frame is returned by the drive for each FCP CMND operation unless the drive receives:

1. A Clear Task Set
2. An Abort Task Set
3. A Target Reset
4. A Loop Initialization Primitive Sequence (LIP) Reset
5. An Abort Sequence (ABTS) for the command

**Table 81. FCP RSP header**

Bit Byte	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	1	1	1	
	R_CTL								
1	D_ID								
2									(MSB)
3									(LSB)
4	0	0	0	0	0	0	0	0	
	Reserved								
5	S_ID								
6									(MSB)
7									(LSB)
8	0	0	0	0	1	0	0	0	
	Type								
9	F_CTL								
10									(MSB)
11									(LSB)
12	SEQ_ID								
13	0	0	0	0	0	0	0	0	
	DF_CTL								
14	0	0	0	0	0	0	0	0	
15	0	0	0	0	0	0	0	0	
	SEQ_CNT								
16	OX_ID								
17									(MSB)
18	1	1	1	1	1	1	1	1	
19	1	1	1	1	1	1	1	1	
	RX_ID								
20	Parameter								
21									(MSB)
22									
23									(LSB)



**Table  
number****Field definitions (listed alphabetically)****81 DF\_CTL (Data Field Control)**

00h Indicates no optional Fibre Channel headers are used.

**81 D\_ID (Destination Identifier)**

The address of the initiator that originated the command.

**81 F\_CTL (Frame Control)**

Set to 990000h for FCP RSP frames. This indicates the frame is sent by the responder of the exchange, not the originator, the frame is the last frame of the sequence (FCP RSP is a single frame sequence for this drive), and the sequence is the last for the Fibre Channel exchange.

**81 OX\_ID (Originator Exchange Identifier)**

The value assigned by the initiator in the FCP CMND. The OX\_ID field uniquely identifies each command between the initiator and the drive.

**81 Parameter**

Not used for the FCP RSP.

**81 R\_CTL (Routing Control)**

Set to Command Status for the FCP RSP frame.

**81 RX\_ID (Responder Identifier)**

Not used by the drive. The value of FFFFh indicates the RX\_ID is not being used.

**81 SEQ\_CNT (Sequence Count)**

Set to 0000h to indicate this the first frame of the Fibre Channel sequence. The FCP RSP is a single frame sequence.

**81 SEQ\_ID (Sequence Identifier)**

Set to FFh by the drive.

**81 S\_ID (Source Identifier)**

The address of the drive.

**81 Type**

08h The value for all SCSI FCP frames.

Table 82. FCP RSP Payload

Bit Byte	7	6	5	4	3	2	1	0
0 : 9	(MSB) _____ Reserved _____ (LSB)							
10	0	0	0	0	Resid Under Run	Resid Over Run	Sense Length Valid	RSP Length Valid
11	SCSI Status							
12 13 14 15	(MSB) _____ Residual Count _____ (LSB)							
16 17 18 19	(MSB) _____ Length of Sense Information _____ (LSB)							
20 21 22 23	(MSB) _____ Length of Response Information _____ (LSB)							
24 : 31	(MSB) _____ Response Information _____ (LSB)							
32 : 51	(MSB) _____ SCSI Extended Sense Information _____ (LSB)							

**Table number** **Field definitions (listed alphabetically)**

**82 Length of Response Information**

- 1 The Length of Response Information contains the byte length of the FCP response information in the frame. Valid lengths for the response information are 0, 4, and 8. The Length of Response Information field is always transferred in the FCP RSP frame.

**82 Length of Sense Information**

- 1 The Length of Sense Information contains the byte length of the additional SCSI sense information in the frame. The Length of Sense Information field is always transferred in the FCP RSP frame.

**82 Residual Count**

Only valid when a Resid Under Run or Resid Over Run bit is set. When this field is valid, the value is a byte count.

**82 Resid Over Run (Residual Over Run)**

- 1 The byte count in the Residual Count field, bytes 12–15, is the number of bytes not transferred because the length of the transfer in the CDB exceeded the DL field in the FCP CMND.

**82 Resid Under Run (Residual Under Run)**

- 1 The number of bytes transferred was less than the DL of the FCP CMND by the byte count in the Residual Count field, bytes 12–15.

**82 Response Information**

Format is shown in Table 83. The response information codes supported are:

<u>Value</u>	<u>Definition</u>
00	Task Management function Complete or No Failure
01	FCP DATA length different than Burst Length
02	FCP CMND fields invalid
03	RO in the data frame header mismatch with FCP XFER RDY DATA RO
04	Task Management Function not supported
05	Task Management Function failed

**Table 83. Response Information format**

<b>Bit Byte (*)</b>	<b>7</b>	<b>6</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>
0 (24) : 2 (26)	(MSB) _____ Reserved _____ (LSB)							
3 (27)	Response Information Code							
4 (28) : 7 (31)	(MSB) _____ Reserved (optional) _____ (LSB)							

\*Fibre Channel frame number shown in parenthesis.

**82 RSP Length Valid (Response Length Valid)**

- 1 Additional FCP response information is included in the payload. The length is given in the Length of Response Information field, bytes 20–23.

**82 SCSI Extended Sense Information**

Additional information related to a Check Condition returned in the SCSI Status byte. See Table 84 on page 137.

**82 SCSI Status**

The ending (returned) status for FCP CMND operations with a valid CDB field.

<u>Value</u>	<u>Definition</u>
00h	Good. This status indicates that the target has successfully completed the command.
02h	Check Condition. Any error, exception, or abnormal condition that causes sense data to be sent, causes a Check Condition status. The extended sense data the drive has regarding the nature of the condition will be in the SCSI Sense Information in the FCP RSP frame with the Check Condition.
08h	Busy. The drive is busy. This status is returned whenever a drive is unable to process the command from an otherwise acceptable initiator. The normal initiator recovery action is to issue the command again at a later time.
10h	Intermediate. This status is returned for every command in a series of linked commands (except the last command), unless an error, exception or abnormal condition causes a Check Condition status, a Reservation Conflict status or a Command Terminated status to be set. If this status is not returned, the chain of linked commands is broken; no further commands in the series are executed.
18h	Reservation Conflict. This status is returned whenever a SCSI device attempts to access a logical unit or an extent within a logical unit that is reserved with a conflicting reservation type for another SCSI device (see Reserve and Reserve Unit command). The normal initiator recovery action is to issue the command again at a later time.
28h	Task Set (queue) Full. This status is implemented if tagged queuing is implemented. This status is returned when a command is received and the command can not be accepted because the command queue is full. The command is not executed.
30h	ACA Active. This status is returned when an auto contingent allegiance (ACA) exists with another initiator. The initiator may reissue the command after the ACA condition has been cleared.

**82 Sense Length Valid**

- 1 Additional SCSI sense information (extended sense data) is included in the payload. The length is given in the Length of Sense Information field, bytes 16–19.

### 11.5.1 Extended Sense Data format

The drive is capable of sending 18 bytes of extended sense data. The Extended Sense Data format is summarized in Table 84. The 1's and 0's shown in the tables below represent the logical 1's and 0's as sent by the disc drive.

**Table 84. Disc Drive Extended Sense Data Summary**

Bit Byte (*)	7	6	5	4	3	2	1	0
0 (32)	Validity Bit	1	1	1	0	0	0	0
		1	1	1	0	0	0	1
Error Code								
1 (33)	0	0	0	0	0	0	0	0
Segment Number								
2 (34)	0 Filemark	0 EOM	0 ILI	0	Sense Key			
3 (35)	Information							
4 (36)								
5 (37)								
6 (38)								
7 (39)	Additional Sense Length 10 decimal (Max)							
8 (40)	Command Specific Data							
9 (41)								
10 (42)								
11 (43)								
12 (44)	Additional Sense Code (ASC)							
13 (45)	Additional Sense Code Qualifier (ASCQ)							
14 (46)	Reserved for Seagate internal use only							
15 (47)	SKSV	Sense Key Specific						
16 (48)								
17 (49)								
18-n (50-n)	Product Unique Sense Data							

\*Fibre Channel frame byte number shown in parenthesis.

**Table number**

#### Field definitions (listed alphabetically)

##### 84 Additional Sense Code and Additional Sense Code Qualifier

Provide additional clarification of errors when Sense Key is valid. Error code definitions are in Table 90. If the condition is not reportable by the disc drive, the Additional Sense Code and Additional Sense Code Qualifier are set to No Additional Sense Information (Code 0000).

##### 84 Additional Sense Length 10 (Max)

Specifies additional sense bytes are to follow. This is limited to a maximum of 10 (decimal) additional bytes. If the Allocation Length of the Command Descriptor Block is too small to transfer all of the additional sense bytes, the additional sense length is not adjusted to reflect the truncation.

##### 84 Command Specific Data

These four bytes contain data for the command.

**84 EOM (End of Medium)**

Always zero (0) for disc drives.

**84 Error Code**

70h Current error.

71h Deferred error.

These two error conditions are described in Section 11.5.1.2.

**84 Filemark**

Always zero (0) for disc drives.

**84 ILI (Incorrect Length Indicator)**

The requested (previous command) block of data did not match the logical block length of the data on the medium.

**84 Information**

If the validity bit is one (1), these bytes contain the unsigned logical block address associated with the sense key. Unless otherwise specified, the Information bytes contain the address of the current logical block. For example, if the sense key is Medium Error, it is the logical block address of the failure block.

**84 Product Unique Sense Data**

Not presently used.

**84 Segment Number**

Always zeros.

**84 Sense Key**

General error category. These are listed in Table 89. The code given in byte 12 provides additional clarification of errors. See the Additional Sense Code field definition for related information.

**84 SKSV (Sense Key Specific Valid) and Sense Key Specific**

The additional sense bytes field may contain command specific data, peripheral device specific data, or vendor-specific data that further defines the nature of the Check Condition status. See Section 11.5.1.1.

The Sense Key Specific field is defined by this specification when the value of the SKSV bit is one (1). The definition of this field is determined by the value of the Sense Key field. This field is reserved for sense keys described in Table 89.

**Note.** During a format started by a Format Immediate command or a Device Self-test started by a Send Diagnostic command, bytes 16 and 17 become a progress indicator with values ranging from 0h to FFFFh. Value 0h indicates the operation just started and FFFFh indicates the operation is complete.

**84 Validity Bit**

1 The Information bytes (Bytes 3–6) are valid.

0 The Information bytes (Bytes 3–6) are not valid.

### 11.5.1.1 Sense Key Specific Valid (SKSV) and Sense Key Specific

Refer to the appropriate tables in this section for sense key specific values.

**Table 85. Sense Key Specific reference tables**

Sense Key field value	SKSV	Error description	See table
05h (Illegal Request)	1	These fields point to illegal parameters in command descriptor blocks and data parameters sent by the initiator.	86
01h (Recovered Error) 04h (Hardware Error) or 03h (Medium Error)	1	These fields identify the actual number of retries used in attempting to recover from the error condition.	87
02h (Not Ready)	1	These fields are only defined for the Format Unit command with the Immed bit set to one (1).	88

**Table 86. Field Pointer bytes**

Bit Byte	7	6	5	4	3	2	1	0
15	SKSV	C/D	Reserved		BPV	Bit Pointer		
16	(MSB) _____							
17	_____							(LSB)

**Table number** **Field definitions (listed alphabetically)**

**86 BPV (Bit Pointer Valid) and Bit Pointer**

- 0 The value in the bit pointer field is not valid.
- 1 The bit pointer field specifies the bit of the byte designated by the field pointer that is in error. When a multiple-bit field is in error, the bit pointer field points to the most significant (left-most) bit of the field.

**86 C/D (Command Data)**

- 1 The illegal parameter is in the command descriptor block.
- 0 The illegal parameter is in the data parameters sent by the initiator.

**86 Field Pointer**

The byte of the command descriptor block or of the parameter data that was in error. Bytes are numbered starting from zero, as shown in the tables describing the commands and parameters. When a multiple-byte field is in error, the pointer points to the most significant (left-most) byte of the field.

**Note.** Bytes identified as being in error are not necessarily the place that has to be changed to correct the problem.

**86 SKSV (Sense Key Specific Valid)**

This bit indicates whether the sense key specific data is valid.

- 0 Data is not valid.
- 1 Data is valid. See Table 85.

Table 87. Actual Retry Count bytes

Bit Byte	7	6	5	4	3	2	1	0
15	SKSV	Reserved						
16	(MSB)	Actual Retry Count						
17		(LSB)						

**Table number** Field definitions (listed alphabetically)

**87** Actual Retry Count

Returns implementation-specific information on the actual number of retries used in attempting to recover an error or exception condition.

**Note.** This field relates to the retry count fields specified within the Verify Error Recovery Page (07h) parameters of the Mode Select command. See Table 147.

**87** SKSV (Sense Key Specific Valid)

This bit indicates whether the sense key specific data is valid.

0 Data is not valid.

1 Data is valid. See Table 85.

Table 88. Format Indication bytes

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

**Table number** Field definitions (listed alphabetically)

**88** Progress Indication

Percent complete indication in which the returned value is the numerator that has 65536 (10000h) as its denominator. The progress indication is based upon the total format operation including any certification or initialization operations.

Support or non-support for format progress indication is given in individual drive's Product Manual, Volume 1.

**Note.** Bytes 18–n are not presently used.

**88** SKSV (Sense Key Specific Valid)

This bit indicates whether the sense key specific data is valid.

0 Data is not valid.

1 Data is valid. See Table 85.



Table 89 lists the sense keys in the extended sense data format that are used by the disc drive.

**Table 89. Applicable disc drive sense keys**

Sense Key	Description
0h	No Sense: There is no specific sense key information to be reported for the disc drive. This would be the case for a successful command or when the ILI bit = 1.
1h	Recovered Error: The last command completed successfully with some recovery action performed by the disc drive. When multiple recovered errors occur, the last error that occurred is reported by the additional sense bytes. Note: For some Mode settings, the last command may have terminated before completing.
2h	Not Ready: Indicates the logical unit addressed cannot be accessed. Operator intervention may be required to correct this condition.
3h	Medium Error: Indicates the command terminated with a nonrecovered error condition, probably caused by a flaw in the medium or an error in the recorded data.
4h	Hardware Error: Indicates the disc drive detected a nonrecoverable hardware failure while performing the command or during a self-test. This includes controller failure, device failure, etc.
5h	Illegal Request: Indicates an illegal parameter in the command descriptor block or in the additional parameters supplied as data for some commands (Format Unit, Mode Select, etc.). If the disc drive detects an invalid parameter in the Command Descriptor Block, it terminates the command without altering the medium. If the disc drive detects an invalid parameter in the additional parameters supplied as data, the disc drive may have already altered the medium. This sense key may also indicate that an invalid Identify message was received. This could also indicate an attempt to write past the last logical block.
6h	Unit Attention: Indicates the disc drive may have been reset. See Section 12.11.1 for more detailed information about the Unit Attention condition.
7h	Data Protect: Indicates that a command that reads or writes the medium was attempted on a block that is protected from this operation. The read or write operation is not performed.
9h	Firmware Error: Vendor-specific sense key.
Bh	Aborted Command: Indicates the disc drive aborted the command. The initiator may be able to recover by trying the command again.
Ch	Equal: Indicates a Search Data command has satisfied an equal comparison.
Dh	Volume Overflow: Indicates a buffered peripheral device has reached the end of medium partition and data remains in the buffer that has not been written to the medium.
Eh	Miscompare: Indicates that the source data did not match the data read from the medium.

Table 90 lists the extended sense, additional sense, and additional sense qualifier codes.

**Table 90. Error codes for bytes 12 and 13 of sense data (values are in hexadecimal)**

Byte 12 (ASC)	Byte 13 (ASCQ)	Description
00	00	No additional sense information
01	00	No index/sector signals found
02	00	No seek complete (no drive command complete)
03	00	Peripheral device write fault
04	00	Logical unit (drive) not ready, cause not reportable
04	01	Logical unit (drive) not ready, becoming ready
04	02	Logical unit (drive) not ready, initializing command (start unit) required
04	03	Logical unit (drive) not ready, manual intervention required
04	04	Logical unit (drive) not ready, format in progress
08	00	Drive communications failure
08	01	Drive communications timeout
09	00	Track following error
09	01	Write fault status during read
09	04	Head select fault
0A	00	Error log overflow
0C	00	Write error
0C	01	Write error recovered with auto reallocation
0C	02	Write error – auto reallocation failed
10	00	ID CRC or ECC error 11 00 unrecovered read error
11	00	Unrecovered read error
11	04	Unrecovered read error – auto reallocation failed
12	00	Address mark not found for ID field
12	01	Recovered data using headerless retry without ECC using previous sector ID
12	02	Recovered data using headerless retry with ECC using previous sector ID
14	01	Record not found
15	01	Mechanical positioning error
16	00	Data synchronization mark missing or incorrect
17	01	Recovered data using retries
17	02	Recovered data using positive offset
17	03	Recovered data using negative offset
17	06	Recovered data without ECC – data auto reallocated
18	00	Recovered data using ECC, no retries attempted
18	01	Recovered data using ECC after normal retries
18	02	Recovered data with ECC and/or retries, data auto-reallocated
18	05	Recovered data with ECC and/or retries, recommend reassignment
19	00	Defect list error
1A	00	Parameter list length error

Table 90. Error codes for bytes 12 and 13 of sense data (values are in hexadecimal) (Continued)

Byte 12 (ASC)	Byte 13 (ASCQ)	Description
1C	00	Defect list not found
1D	00	Miscompare during verify operation
20	00	Invalid command operation code
21	00	Logical block address out of range
24	00	Invalid field in CDB
25	00	Logical unit number not supported
26	00	Invalid field in parameter list
26	01	Invalid field parameter – parameter not supported
26	02	Invalid field parameter – parameter value invalid
26	03	Invalid field parameter – threshold parameter not supported
26	04	Invalid release of persistent reservation
26	97	Invalid field parameter – TMS firmware tag
26	98	Invalid field parameter – check sum
26	99	Invalid field parameter – firmware tag
27	00	Write protected
29	00	Power-on or reset
29	01	Power on
29	02	LIP reset
29	03	Device reset
29	04	Internal reset
2A	00	Parameters changed
2A	01	Mode parameters changed
2A	02	Log parameters changed
2A	03	Reservations preempted
2A	04	Reservation released
2A	05	Registrations preempted
2C	00	Command sequence error
2F	00	Tagged commands cleared by another initiator
31	00	Medium format corrupted
31	01	Format failed
31	91	Format corrupted – ETF WWN is invalid
32	00	No defect spare location available
32	01	Defect list update error
32	02	No spares available – too many defects on one track
35	00	Enclosure services failure
35	01	Unsupported enclosure function
35	02	Enclosure services unavailable
35	03	Enclosure services transfer failure

Table 90. Error codes for bytes 12 and 13 of sense data (values are in hexadecimal) (Continued)

Byte 12 (ASC)	Byte 13 (ASCQ)	Description
35	04	Enclosure services transfer refused
37	00	Parameter rounded
3F	01	Microcode changed
3F	02	Changed operating definition
3F	05	Device identifier changed
3F	91	WWN mismatch, ETF WWN is valid
40	01	DRAM parity error
42	00	Power-on or self-test failure
43	00	Message reject error
44	00	Internal target failure
45	00	Select or reselect failure
47	00	<p>Interface error</p> <p>When the ASC and ASCQ are 47 and 00 respectively, the Sense Key Specific field of the Extended Sense Data has the meaning defined below. Note that more than one bit may be set.</p> <p>Byte 16:</p> <ul style="list-style-type: none"> <li>Bit 7 - Invalid destination ID</li> <li>Bit 6 - Invalid source ID</li> <li>Bit 5 - Invalid frame type</li> <li>Bit 4 - Invalid f_ctl</li> <li>Bit 3 - Invalid sequence ID</li> <li>Bit 2 - Invalid df_ctl</li> <li>Bit 1 - Invalid sequence count</li> <li>Bit 0 - Invalid Ox_id</li> </ul> <p>Byte 17:</p> <ul style="list-style-type: none"> <li>Bit 7 - Running disparity error</li> <li>Bit 6 - CRC error</li> <li>Bit 5 - Payload still coming after transfer count went to 0, or invalid primitive detected before EOF.</li> <li>Bit 4 - EOFa — 'abort' detected as EOR</li> <li>Bit 3 - Invalid EOF (EOFni EOFdti)</li> <li>Bit 2 - Unsupported EOF</li> <li>Bit 1 - Unsupported Class (Class 1 or 2 SOF primitive detected)</li> <li>Bit 0 - Invalid R_CTL</li> </ul>
48	00	Initiator detected error
49	00	Invalid message
4E	00	Overlapped commands attempted
55	01	XOR cache is not available
55	03	Insufficient reservation resources
55	04	Insufficient registration resources
5B	00	Log exception
5B	01	Threshold condition met
5B	02	Log parameter value at maximum
5C	00	Servo RPL status change

Table 90. Error codes for bytes 12 and 13 of sense data (values are in hexadecimal) (Continued)

Byte 12 (ASC)	Byte 13 (ASCQ)	Description
5C	01	Servo RPL spindles synchronized
5C	02	Servo RPL spindles not synchronized
5D	00	Failure prediction threshold exceeded
5D	FF	False failure prediction threshold exceeded
65	00	Voltage fault
80	00	General firmware error qualifier
80	80	FC FIFO error during read transfer
80	81	FC FIFO error during write transfer
80	82	Disc FIFO error during read transfer
80	83	Disc FIFO error during write transfer
80	84	LBA seeded CRC error on read
80	85	LBA seeded CRC error on write
80	86	IOEDC error on read
80	87	IOEDC error on write
81	00	Reassign power-fail recovery failed

### 11.5.1.2 Current and deferred errors

Error code 70h (current error) indicates that the Check Condition or Command Terminated status returned is the result of an error or exception condition on the command that returned the Check Condition or Command Terminated. This includes errors generated during execution of the command by the actual execution process. It also includes errors not related to any command that are first observed during execution of a command. Examples of this latter type of error include disc servo-mechanism off-track errors and power-up test errors.

Error code 71h (deferred error) indicates that the Check Condition status returned is the result of an error or exception condition that occurred during execution of a previous command for which Good status has already been returned. Such commands are associated with use of the Immediate bit (start unit), with some forms of caching, and with multiple command buffering.

The deferred error is indicated by returning Check Condition status to the appropriate initiator as described below. The subsequent execution of a Request Sense command returns the deferred error sense information.

If Check Condition status for a deferred error is returned, the current command has not performed any storage operations or output operations to the media. After the target detects a deferred error condition on a logical unit, it returns a deferred error according to the rules described below:

1. If a deferred error can be recovered with no external system intervention, a deferred error indication is not posted unless required by the error handling parameters of the Mode Select command. The occurrence of the error may be logged if statistical or error logging is supported.
2. If a deferred error can be associated with a causing initiator and with a particular function or a particular subset of data, and the error is either unrecovered or required to be reported by the mode parameters, a deferred error indication is returned to the causing initiator. If an initiator other than the causing initiator attempts access to the particular function or subset of data associated with the deferred error, a Busy status is returned to that initiator in response to the command attempting the access.

**Note.** Not all devices may be sufficiently sophisticated to identify the function or data that has failed. Those that cannot should treat the error in the following manner:

If a deferred error cannot be associated with a causing initiator or with a particular subset of data, a deferred error indication is returned on behalf of the failing logical unit to each initiator. If multiple deferred errors have accumulated for some initiators, only the last error is returned.

3. If a current command has not yet started executing, and a deferred error occurs, the command is terminated with Check Condition status and deferred error information posted in the sense data. If a deferred error occurs while a current command is executing and the current command has been affected by the error, the command is terminated by Check Condition status and current error information is returned in the sense data. In this case, if the current error information does not adequately define the deferred error condition, a deferred error may be returned after the current error information has been recovered. If a deferred error occurs while a current command is executing and the current command completes successfully, the target may choose to return the deferred error information after the completion of the current command.

Deferred errors may indicate that an operation was unsuccessful long after the command performing the data transfer returned Good status. If data that cannot be replicated or recovered from other sources is being stored using such buffered write operations, synchronization commands should be performed before the critical data is destroyed in the host initiator. This is necessary to be sure that recovery actions can be taken if deferred errors do occur in the storing of the data. The synchronizing process provides the necessary commands to allow returning Check Condition status and subsequent returning of deferred error sense information after all buffered operations are guaranteed to be complete.

### 11.6 Parameter rounding

Certain parameters sent to a target with various commands contain a range of values. Targets may choose to implement only selected values from this range. When the target receives a value that it does not support, it either rejects the command (Check Condition status with Illegal Request sense key) or it rounds the value received to a supported value. The target rejects unsupported values unless rounding is permitted in the description of the parameter.

To enable rounding, set Mode Select command, page code 00h, byte 2, bit 2.

Rounding of parameter values, when permitted, is performed as described below.

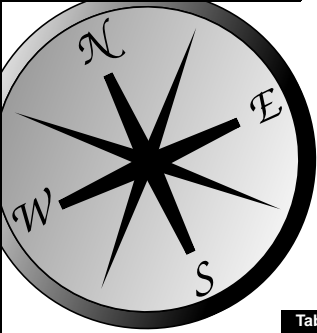
A target that receives a parameter value that is not an exact supported value adjusts the value to one that it supports and returns Check Condition status with a sense key of Recovered Error. The additional sense code is set to Rounded Parameter. The initiator is responsible for issuing an appropriate command to learn what value the target has selected.

Implementor: Generally, the target should adjust maximum-value fields down to the next lower supported value than the one specified by the initiator. Minimum value fields should be rounded up to the next higher supported value than the one specified by the initiator. In some cases, the type of rounding (up or down) is explicitly specified in the description of the parameter.

## 12.0 Command descriptions

This section contains information about the commands used by Seagate Fibre Channel disc drives. This section is organized to provide rapid access to command information.

### Navigation assistance



All commands are:

- Listed alphabetically by command name.
- Cross-referenced by command name and command operation code.

The field descriptions that are provided for most tables have sidebar labels which identify the table they are associated with. This helps orient you when nested tables complicate the structure of this section.

*Sidebar example*

Table number	Field definitions (listed alphabetically)
1	<b>Field name</b>

The sidebar (black background with reversed text) identifies this field as being associated with Table 1.

Table 91. Commands sorted by command name

Command name	Command operation code	Command type		Length		Reference
		All devices	Direct access devices	6 bytes	10 bytes	
Change Definition	40h	x				12.1 (see page 150)
Compare	39h	x				12.2 (see page 150)
Copy	18h	x				12.3 (see page 150)
Copy and Verify	3Ah	x				12.4 (see page 150)
Format Unit	04h		x	x		12.5 (see page 151)
Inquiry	12h	x		x		12.6 (see page 159)
Lock-unlock Cache	36h					
Log Select	4Ch	x			x	12.7 (see page 175)
Log Sense	4Dh	x			x	12.8 (see page 178)
Mode Select (6)	15h		x	x		12.9 (see page 194)
Mode Select (10)	55h		x		x	12.10 (see page 198)
Mode Sense (6)	1Ah		x	x		12.11 (see page 200)
Mode Sense (10)	5Ah		x		x	12.12 (see page 234)
Move Medium	A7h					
Persistent Reserve In	5Eh					12.13 (see page 236)
Persistent Reserve Out	5Fh					12.14 (see page 241)
Prefetch	34h					
Prevent/Allow Medium Removal	1Eh		x	x		12.15 (see page 245)
Read (6)	08h		x	x		12.16 (see page 246)
Read (10) (Read Extended)	28h		x		x	12.17 (see page 248)
Read Data Buffer	3Ch		x		x	12.18 (see page 250)
Read Capacity	25h		x		x	12.19 (see page 253)
Read Defect Data (10)	37h		x		x	12.20 (see page 255)
Read Defect Data (12)	B7h		x		x	12.21 (see page 258)
Read Element Status	B4h					
Read Long	3Eh		x		x	12.22 (see page 261)
Reassign Blocks	07h		x	x		12.23 (see page 262)
Rebuild	81h				x	12.24 (see page 264)
Receive Diagnostic Results	1Ch	x		x		12.25 (see page 267)
Regenerate	82h					12.26 (see page 273)
Release (6)	17h		x	x		12.27 (see page 276)
Release (10)	57h		x		x	12.28 (see page 277)
Report Device Identifier	A3h					12.29 (see page 279)
Report LUNs	A0h					
Request Sense	03h	x		x		12.30 (see page 281)
Reserve (6)	16h		x	x		12.31 (see page 282)
Reserve (10)	56h		x		x	12.32 (see page 283)
Rezero Unit	01h		x	x		12.33 (see page 286)
Search Data Equal	31h					
Search Data High	30h					
Search Data Low	32h					
Seek (6)	0Bh		x	x		12.34 (see page 287)
Seek (10) (Seek Extended)	2Bh		x		x	12.35 (see page 288)
Send Diagnostic	1Dh	x		x		12.36 (see page 289)
Set Device Identifier	A4h					12.37 (see page 291)
Set Limits	33h					
Start/Stop Unit	1Bh		x	x		12.38 (see page 296)
Synchronize Cache	35h		x		x	12.39 (see page 297)
Test Unit Ready	00h	x		x		12.40 (see page 298)
Verify	2Fh		x		x	12.41 (see page 299)
Write (6)	0Ah		x	x		12.42 (see page 300)
Write (10) (Write Extended)	2Ah		x		x	12.43 (see page 301)
Write and Verify	2Eh		x		x	12.44 (see page 303)
Write Data Buffer	3Bh	x			x	12.45 (see page 304)
Write Long	3Fh		x		x	12.46 (see page 308)
Write Same	41h		x		x	12.47 (see page 309)
XDread	52h					12.48 (see page 310)
XDwrite	50h					12.49 (see page 311)
XDwrite Extended	80h					12.50 (see page 313)
XPwrite	51h					12.51 (see page 315)



Table 92. Commands sorted by operation code

Command operation code	Command name	Command type		Length		Reference
		All devices	Direct access devices	6 bytes	10 bytes	
00h	Test Unit Ready	x		x		12.40 (see page 298)
01h	Rezero Unit		x	x		12.33 (see page 286)
03h	Request Sense	x		x		12.30 (see page 281)
04h	Format Unit		x	x		12.5 (see page 151)
07h	Reassign Blocks		x	x		12.23 (see page 262)
08h	Read (6)		x	x		12.16 (see page 246)
0Ah	Write (6)		x	x		12.42 (see page 300)
0Bh	Seek (6)		x	x		12.34 (see page 287)
12h	Inquiry	x		x		12.6 (see page 159)
15h	Mode Select (6)		x	x		12.9 (see page 194)
16h	Reserve (6)		x	x		12.31 (see page 282)
17h	Release (6)		x	x		12.27 (see page 276)
18h	Copy	x				12.3 (see page 150)
1Ah	Mode Sense (6)		x	x		12.11 (see page 200)
1Bh	Start/Stop Unit		x	x		12.38 (see page 296)
1Ch	Receive Diagnostic Results	x		x		12.25 (see page 267)
1Dh	Send Diagnostic	x		x		12.36 (see page 289)
1Eh	Prevent/Allow Medium Removal		x	x		12.15 (see page 245)
25h	Read Capacity		x		x	12.19 (see page 253)
28h	Read (10) (Read Extended)		x		x	12.17 (see page 248)
2Ah	Write (10) (Write Extended)		x		x	12.43 (see page 301)
2Bh	Seek (10) (Seek Extended)		x		x	12.35 (see page 288)
2Eh	Write and Verify		x		x	12.44 (see page 303)
2Fh	Verify		x		x	12.41 (see page 299)
30h	Search Data High					
31h	Search Data Equal					
32h	Search Data Low					
33h	Set Limits					
34h	Prefetch					
35h	Synchronize Cache		x		x	12.39 (see page 297)
36h	Lock-unlock Cache					
37h	Read Defect Data (10)		x		x	12.20 (see page 255)
39h	Compare	x				12.2 (see page 150)
3Ah	Copy and Verify	x				12.4 (see page 150)
3Bh	Write Data Buffer	x			x	12.45 (see page 304)
3Ch	Read Data Buffer		x		x	12.18 (see page 250)
3Eh	Read Long		x		x	12.22 (see page 261)
3Fh	Write Long		x		x	12.46 (see page 308)
40h	Change Definition	x				12.1 (see page 150)
41h	Write Same		x		x	12.47 (see page 309)
4Ch	Log Select	x			x	12.7 (see page 175)
4Dh	Log Sense	x			x	12.8 (see page 178)
50h	XDwrite					12.49 (see page 311)
51h	XPwrite					12.51 (see page 315)
52h	XDread					12.48 (see page 310)
55h	Mode Select (10)		x		x	12.10 (see page 198)
56h	Reserve (10)		x		x	12.32 (see page 283)
57h	Release (10)		x		x	12.28 (see page 277)
5Ah	Mode Sense (10)		x		x	12.12 (see page 234)
5Eh	Persistent Reserve In					12.13 (see page 236)
5Fh	Persistent Reserve Out					12.14 (see page 241)
80h	XDwrite Extended					12.50 (see page 313)
81h	Rebuild				x	12.24 (see page 264)
82h	Regenerate					12.26 (see page 273)
A0h	Report LUNs					
A3h	Report Device Identifier					12.29 (see page 279)
A4h	Set Device Identifier					12.37 (see page 291)
A7h	Move Medium					
B4h	Read Element Status					
B7h	Read Defect Data (12)		x		x	12.21 (see page 258)

**12.1 Change Definition command** 40h

Not implemented. If this command is received, the disc drive sends a Check Condition status and a sense key of Illegal Request.

**12.2 Compare command** 39h

Not implemented. A Check Condition status is sent if a Compare command is received.

**12.3 Copy command** 19h

Not implemented. If received, the disc drive sends a Check Condition status and a sense key of Illegal Request.

**12.4 Copy and Verify command** 3Ah

Not implemented. A Check Condition status is sent if a Copy and Verify command is received.

## 12.5 Format Unit command 04h

The Format Unit command ensures that the medium is formatted so all of the user-addressable data blocks can be accessed. There is no guarantee that the medium has or has not been altered. In addition, the medium may be certified and control structures may be created for the management of the medium and defects.

The drive allows an initiator to specify (or not specify) sectors which are to be reallocated during the format process. The format parameters to be specified in the Format Unit command are defined in Table 94.

The Format Unit command is rejected with Reservation Conflict status if the logical unit is reserved, or any extent reservation, from any initiator, is active in the specified logical unit.

During the format operation, the target responds to commands as follows:

- In response to all commands except Request Sense and Inquiry, the target returns Check Condition status unless a reservation conflict exists, in which case Reservation Conflict status is returned.
- In response to the Inquiry command, the target responds as commanded.

In response to the Request Sense command, unless an error has occurred, the target returns a sense key of Not Ready and an additional sense code of Logical Unit Not Ready Format In Progress. Refer to the Interface Requirements section of the individual drive's product manual to determine whether the drive supports format progress indication, or deferred error handling in case of an error occurrence during formatting.

**Table 93. Format Unit command (04h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	0	0
1	0	0 Reserved	0	FMT DATA	CMP LST	Defect List Format		
2	0	0	0	0	0	0	0	0
3 4	Interleave							
5	Control							

Table  
number

### Field definitions (listed alphabetically)

#### **93** CMP LST (Complete List)

- 1 The data supplied is the complete list of Growth defects. Any previous Growth defect data or Certification defect data is erased. The disc drive adds to this list as it formats the medium. The result is to purge any previous Growth or Certification defect list and to build a new defect list.
- 1 When FMT DATA equals 0, the Format Unit command is terminated with Check Condition status and a sense key of Illegal Request.
- 0 The data supplied is in addition to the existing Growth defect list.

The use of the P list and C list defect is controlled by byte 1 of the defect list header (see Table 95).

#### **93** Control

See Control Bytes in Section 11.2.1.6.

#### **93** Defect List Format

Specifies additional information related to the defect list. (See Table 94 for further information.)

#### **93** FMT DATA (Format Data)

- 1 The Format Unit Parameter list (Section 12.5.1) is supplied in a data transfer. The data transferred consists of a defect list header (Table 95), followed by an initialization pattern descriptor (Table 96 if any) followed by the defect descriptors. The format of the defect descriptor list is determined by the Defect List Format field.
- 0 The data transfer does not occur (no defect data will be supplied by the initiator).

**93 Interleave**

This field requests that logical blocks be related in a specific fashion to the physical blocks to facilitate data transfer speed matching.

- 0 The target uses its default interleave.
- 1 Consecutive logical blocks will be placed in consecutive physical order.
- ≥2 One or more (respectively) physical blocks separate consecutive logical blocks. The disc drive implements an optional prefetch (read look ahead) function which reads a user-specified number of sectors into its buffer beyond and contiguous to the sectors requested by the read command. This data is subsequently available for the next sequential read command without re-access of the disc media thereby increasing performance and negating the need for an interleave during format if this prefetch option is enabled (see Read Command, Section 12.16). Interleave values other than zero or one are vendor specific.

The following definitions of flaw categories are supplied to help you understand the alternatives listed in Table 94.

- P Primary Defect Type: P type flawed sectors are identified at the time of shipment in a list of defects (permanent flaws) supplied by Seagate and stored on the disc in an area that is not directly accessible by the user. (This list may be referred to as an ETF List). This defect list is not modified or changed by the disc drive (or initiator) after shipment.
- C Certification Defect Type: C type flawed sectors are sectors that fail a format verify during the format function.
- D Data Defect Type: D type sectors are sectors identified in a list supplied to the target by the initiator during a Data Out phase of the current Format Unit command. The D List follows a four-byte defect list header and is referred to as Defect Descriptor Bytes.
- G Growth Defect Type: G type flawed sectors contain medium flaws and have been reallocated as a result of receiving a Reassign Blocks command, or certification defects (C type) reallocated during a previous Format Unit command, or Data Defects (D type) reallocated during a previous Format Unit command or defects that have been automatically reallocated by the drive. This (G) list is recorded on the disc drive media and may be referenced for the current (and subsequent) Format Unit commands. This (G) list does not include the Primary (P) list of defects.

**Table 94. Format Unit parameter definition (format variations)**

CDB-Byte (see Table 93)					Comments
FMT DATA	CMP LIST	Defect List Format			
Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
0	X	X	X	X	Default format: No data is transferred. The disc drive reallocates all sectors in the P list plus any sector which fails to Format Verify phase (C type flaws). Any previous G list is erased.
Block format [2]					
1	0	0	X	X	Format with G and no D: A four-byte Defect List header must be sent by the initiator. No Defect Descriptors (D list) are sent by the initiator. The disc drive reallocates all sectors in the drive's current G list. See also note [1].
1	1	0	X	X	Format without G or D: A four-byte Defect List header must be sent by the initiator. No D list may be sent by the initiator. The disc drive erases any previous G list. See also note [1].
Bytes from Index format					
1	1	1	0	0	Format with D and without G: The initiator must send a four-byte Defect List header followed by a D list of the defects for the disc drive to reallocate. The D list must be in the bytes from Index format (see Table 99). The disc drive erases any previous G list. See also note [1].
1	0	1	0	0	Format with D and with G: The initiator must send a four-byte Defect List header followed by a D list of the defects for the disc drive to reallocate. The D list must be in the bytes from Index format (see Table 99). The disc drive also reallocates all sectors in the drive's current G list. See also note [1].
Physical Sector format					
1	1	1	0	1	Format with D and without G: The initiator must send a four-byte Defect List header followed by a D list of defects for the disc drive to reallocate. The D list must be in the Physical Sector format (see Table 100). The disc drive erases any previous G list. See also note [1].
1	0	1	0	1	Format with D and with G: The initiator must send a four-byte Defect List header followed by a D list of defects for the disc drive to reallocate. The D list must be in the Physical Sector format (see Table 100). The disc drive also reallocates all sectors in the drive's current G list. See also note [1].

[1] Byte 1 of the Defect List header determines whether the P and C defects are reallocated. See Table 95.  
 [2] See individual drive's Product Manual, Volume 1, for support/non-support.

The defect list shown in Table 95 contains a four-byte header followed by one or more defect descriptors. The Defect List Length in each table specifies the total length (in bytes) of the defect descriptors that follow. In Table 95 the Defect List Length is equal to eight times the number of defect descriptors.

### 12.5.1 Format Unit parameter list

Parameter	Reference
Defect List Header	See Table 95
Initialization Pattern Descriptor	See Table 96
Defect Descriptors	See Tables 98, 99, and 100

#### 12.5.1.1 Defect List header

Table 95. Defect List header

Bit Byte	7	6	5	4	3	2	1	0	
0	Reserved								
1	FOV	DPRY	DCRT	STPF	IP	DSP	Immed	VS	
2	(MSB)							Defect List Length	(LSB)
3									

#### Table number Field definitions (listed alphabetically)

##### 95 DCRT (Disable Certification)

- 1 The disc drive does not perform a verify function during formatting (thus no C list for this format is created or reallocated).
- 0 The disc drive performs a verify function during formatting and reallocates any sector that fails the verify (i.e., a C list is created and these flaws reallocated).

On drives that have MR (magnetoresistive) heads, the DCRT bit is always interpreted as a 0 when the user sets the IP bit (see Table 95) and specifies a format pattern of greater than 1 byte (see Table 96), and/or if the IP Modifier bits are set to 01 or 10 (see Table 96). This is done since the user format pattern and/or IP header is written onto the media during the format certification phase. Because of this the user may see G list entries added to the defect list even though the DCRT bit was set to 1.

##### 95 Defect List Length

The length of any following D list (Defect descriptors) must be equal to 8 times the number of sectors to be reallocated per Table 99 or Table 100.

**Note.** The initiator may not use any previously defined C, G, or D lists if the sector size (block length) has been changed.

##### 95 DPRY (Disable Primary)

- 1 Flaws in the disc drive P list are not reallocated during formatting. This means existing reallocations of the P list are canceled and no new reallocations made during formatting. The P list is retained.
- 0 Flaws in the disc drive P list are reallocated during formatting. A Check Condition is sent in the status if the P list cannot be found by the disc drive.

##### 95 DSP (Disable Saving Parameters)

- 1 The target does not save the Mode Select savable parameters to nonvolatile memory during the format operation.
- 0 The target saves all the Mode Select savable parameters for all initiators to nonvolatile memory during the format operation.

##### 95 FOV (Format Options Valid)

- 1 The disc drive interprets the remaining bits of byte 1.
- 0 The disc drive checks the remaining bits of byte 1 for zeros.

**95 Immed (Immediate)**

- 0 Status will be returned after the first operation has completed.
- 1 The target will return status as soon as the command descriptor block has been validated, and the entire defect list has been transferred.

Check individual drive's Product Manual, Volume 1, for applicability of this feature.

**95 IP (Initialization Pattern)**

This field indicates the type of pattern the target uses to initialize each logical block within the initiator accessible portion of the medium (Table 97). All bytes within a logical block are written with the initialization pattern. The initialization pattern is modified by the IP modifier field as described in Table 97.

- 1 An initialization pattern descriptor is included in the Format Unit parameter list immediately following the Defect List header.
- 0 An initialization pattern descriptor is not included and the target uses its default initialization pattern.

**95 STPF (Stop Format)**

- 1 Formatting is terminated with a Check Condition status if an error is encountered while accessing either the P or G defect list. The sense key is set to Medium Error and the additional sense code is set to either Defect List Not Found or Defect List Error.
- 0 Formatting is not terminated if an error is encountered while accessing either the P or G defect list.

**95 VS (Vendor Specific)**

Not used.

**12.5.1.2 Initialization Pattern descriptor**

The initialization pattern option specifies that the logical blocks contain the specified initialization pattern. The initialization pattern descriptor is sent to the target as part of the Format Unit parameter list.

**Table 96. Initialization Pattern descriptor**

Bit Byte	7	6	5	4	3	2	1	0
0	IP Modifier		Reserved					
1	Pattern Type							
2	(MSB) _____							
3	Initialization Pattern Length						_____ (LSB)	
0 – n	Initialization Pattern							

**Table number** **Field definitions (listed alphabetically)**

**96 Initialization Pattern (IP) and IP Modifier**

The Initialization Pattern field is modified in accordance with the specification of the IP Modifier field given in Table 97. The Initialization Pattern is sent by the host for the drive to write in each logical block by the Format command. Refer to the table below.

**Table 97. Initialization Pattern Modifier**

IP Modifier		Description
0	0	No header. The target does not modify the initialization pattern.
0	1	The target overwrites the initialization pattern to write the logical block address in the first four bytes of the logical block. The logical block address is written with the most significant byte first.
1	0	
1	1	Reserved.

**96 Initialization Pattern Length**

The number of bytes contained in the initialization pattern. If the length exceeds the current logical block size, this is an error. The initialization pattern is sent by the host for the drive to write in each logical block by the Format command.

**96 Pattern Type**

00h	Use default pattern. If the initialization pattern length is not zero, this is an error and the drive terminates the command with Check Condition status. The sense key is set to Illegal Request and the additional sense error code is set to Invalid Field In Parameter List.
01h	Use pattern supplied by host computer. If the Initialization Pattern Length is zero or insufficient data is provided by the initiator, this is an error and the drive terminates the command with Check Condition status. The sense key is set to Illegal Request and the additional sense error code is set to Invalid Field In Parameter List.
02-7Fh	Reserved.
80-FFh	Vendor specific.



### Defect List formats

This section describes the format of the defect list that follows the Defect List header described in Table 95. Three formats are possible:

- Block format (Seagate does not support the block format, except as a customer special option)
- Index format (see Table 99)
- Physical Sector format (see Table 100).

**Table 98. Defect descriptors**

Byte	Description
0–n	Defect descriptor bytes (Refer to Table 99 for Index format and Table 100 for Physical Sector format)

**Table 99. Defect descriptor bytes–Index format**

Byte	Description
0	Cylinder Number of Defect (MSB)
1	Cylinder Number of Defect
2	Cylinder Number of Defect (LSB)
3	Head Number of Defect
4	Defect Bytes from Index (MSB)
5	Defect Bytes from Index
6	Defect Bytes from Index
7	Defect Bytes from Index (LSB)

For defects to be specified in the Bytes from Index format, the defect list format field (Byte 1, bits 2, 1, 0) must be 100 (binary), see Tables 93 and 94.

Each defect descriptor for the Bytes from Index format specifies the beginning of an eight bit (1 byte) defect location on the medium. Each defect descriptor is comprised of the cylinder number of the defect, the head number of the defect and the number of bytes from Index to the defect location.

The defect descriptors are in ascending order. The drive may return Check Condition if the defect descriptors are not in ascending order. For determining ascending order, the Cylinder Number of Defect is considered the most significant part of the address and the Defect Bytes from Index is considered the least significant part of the address.

A value for Defect Bytes from Index of FFFFFFFFh (i.e., reassign the entire track) is illegal for the disc drive.

**Table 100. Defect descriptor bytes–Physical Sector format**

Byte	Description
0	Cylinder Number of Defect (MSB)
1	Cylinder Number of Defect
2	Cylinder Number of Defect (LSB)
3	Head Number of Defect
4	Defect Sector Number (MSB)
5	Defect Sector Number
6	Defect Sector Number
7	Defect Sector Number (LSB)

Information in this table is repeated for each defect.

For defects to be specified in the Physical Sector format, the Defect List format field (Byte 1, bits 2, 1, 0) must be 101 (binary). See Tables 93 and 94.

Each defect descriptor for the Physical Sector format specifies a sector size defect location comprised of the cylinder number of the defect, the head number of the defect and the defect sector number.

The defect descriptors are in ascending order. The drive may return Check Condition if the defect descriptors are not in ascending order. For determining ascending order, the Cylinder Number of the defect is considered the most significant part of the address and the Defect Sector Number is considered the least significant part of the address.

A value for Defect Sector Number of FFFFFFFFh (i.e., reassign the entire track) is illegal for the disc drive.

**12.6 Inquiry command** 12h

The Inquiry command requests that information regarding parameters of the disc drive be sent to the initiator. The Enable Vital Product Data (EVPD) option allows the initiator to request additional information about the disc drive. See Section 12.6.1.

Several Inquiry commands may be sent to request the vital product data pages instead of the standard data shown in Table 102 on page 161.

**Table 101. Inquiry command (12h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	1	0
1	0	0	0	0	0	0	0	EVPD
2	Page Code							
3	0	0	0	0	0	0	0	0
4	Allocation Length (in bytes)							
5	Control							

**Table  
number****Field definitions (listed alphabetically)****101 Allocation Length**

The allocation length specifies the number of bytes the initiator has allocated for returned data. The disc drive terminates the Data In phase when allocation length bytes have been transferred or when all available data have been transferred to the initiator, whichever is less.

**101 Control**

See Control Bytes in Section 11.2.1.6.

**101 EVPD (Enable Vital Product Data)**

- 0 The disc drive returns the standard Inquiry data.
- 1 The disc drive returns the vital product data specified by the page code field.

**101 Page Code**

The Page Code field specifies the page of vital product data information that the disc drive returns.

If the EVPD bit = 0 and the page code field is not 0, the disc drive returns Check Condition status with the sense key set to Illegal Request and an additional sense code of Invalid Field In CDB.

**Additional Inquiry command information**

The Inquiry command returns Check Condition status only when the disc drive cannot return the requested Inquiry data.

If an Inquiry command is received from an initiator with a pending unit attention condition (i.e., before the disc drive reports Check Condition status), the disc drive performs the Inquiry command and does not clear the Unit Attention condition.

The Inquiry command is typically used by the initiator after a reset or power-up condition to determine the device types for system configuration. To minimize delays after a reset or power-up condition, the standard Inquiry data is available without incurring any media access delays. Since the disc drive stores some of the Inquiry data on the device media it may return zeros or ASCII spaces (20h) in those fields until the data is available.

The Inquiry data may change as the disc drive executes its initialization sequence or in response to a Change Definition command. For example, the disc drive may contain a minimum command set in its nonvolatile memory and load its final firmware from the medium when it becomes ready. After it has loaded the firmware it may support more options and therefore return different supported options information in the Inquiry data.

## Disc drive inquiry data

The disc drive standard inquiry data contains 36 required bytes, followed by a number of bytes of disc drive specific data that is drive dependent. See individual drive's Product Manual, Volume 2. Refer to the standard Inquiry data in Table 102.

**Table 102. Disc drive inquiry data format**

Bit Byte	7	6	5	4	3	2	1	0
0	Peripheral Qualifier		Peripheral Device Type					
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	ANSI-Approved Version		
3	0 AENC	0 TRMIOP	0 NACA	0 HiSupport	Response Data Format			
4	Additional Length							
5	0	0	0	0	0	0	0	0
6	BQue	ENC SER	Port	Dual P	0	0	0	0
7	RelAdr	0	0	0	LINKED	0 TrnDis	CMD QUE	Soft Reset
8 : 15	Vendor Identification							
16 : 31	Product Identification							
32 : 35	Product Revision Level							
36 : 43	Drive Serial Number							
44 : 55	Unused Vendor-Specific Area (00h)							
56 : 95	Reserved (00h)							
96 : 143	Copyright Notice							

**Table  
number**

### Field definitions (listed alphabetically)

#### **102** Additional Length

Specifies the length (in bytes) of the parameters. If the allocation length of the command descriptor block is too small to transfer all of the parameters, the additional length is not adjusted to reflect the truncation.

#### **102** AENC (Asynchronous Event Notification Capability)

0 The disc drive does not support the asynchronous event notification capability.

#### **102** ANSI-Approved Version

2h Indicates this device complies with ANSI IX3.131-199x (SCSI-2) and the SCSI-3 features as described in this manual.

**102 BQue (Basic Queuing)**

The following BQue values are valid only when the CMD QUE bit = 0.

- 0 The device does not support tagged tasks (command queuing) for this logical unit. This value is always used if the CmdQue bit is 1.
- 1 The device supports, for this logical unit, the basic task management model defined by ANSI document SCSI3 Architectural Model-2, T10/1157.

**102 CMD QUE (Command Queuing)**

- 0 The disc drive does not support tagged command queuing.
- 1 The disc drive supports tagged command queuing.

**102 Copyright Notice**

The 48 bytes of ASCII data "Copyright (c) XXXX Seagate All rights reserved," where "XXXX" indicates the current year (for example: 1997).

**102 Drive Serial Number**

The 8 bytes of ASCII data containing 8-digit drive serial number.

**102 Dual P (Dual Port)**

- 0 The disc drive is not a dual port device.
- 1 The disc drive is a dual port device.

**102 ENCSER (Enclosure Services)**

- 0 The drive does not support the enclosure services diagnostic pages.
- 1 The drive supports the Enclosure Service Diagnostic pages (see Sections 12.25 and 12.36). The drive returns Enclosure Services Information (ESI) data as a result of a Receive Diagnostic Results command.

**102 HiSupport (Hierarchical Support)**

- 0 The target does not use the hierarchical addressing model to assign LUNs to logical units.
- 1 The target uses the hierarchical addressing model to assign LUNs to logical units. When the HiSupport bit is one, the device server supports the Report LUNs command.

**102 LINKED (Linked Command)**

- 0 The disc drive does not support linked commands.
- 1 The disc drive supports linked commands.

**102 NACA (Normal Auto Contingent Allegiance)**

- 0 Drives supported by this manual do not support ACA.

**102 Peripheral Qualifier and Peripheral Device Type**

00h A direct-access device (magnetic disc) is connected to this logical unit.

**102 Port**

This bit is only defined when the Dual Port (Dual P) bit = 1.

- 0 The disc drive received the Inquiry command on port A.
- 1 The disc drive received the Inquiry command on port B.

**102 Product Identification**

The ASCII data containing the drive model number. The data is left-aligned within this field.

**102 Product Revision Level**

The four bytes of ASCII data containing the last four digits of the firmware release number.

**102 RelAdr (Relative Addressing)**

- 0 This function is not supported by drives described in this manual.

**102 Reserved**

Byte 56 through byte 95 are filled with 00h.

**102 Response Data Format**

- 0 The Inquiry data format is as specified in the ANSI SCSI-1 standard.
- 1 Indicates compatibility with some products that were designed prior to the development of the ANSI SCSI-2 standard (i.e., CCS).
- 2 Indicates that the data is in the format specified in the SCSI-2 standard.
- > 2 Values greater than two are reserved.

**102 Soft Reset**

- 0 The drive responds to the Reset condition with the hard Reset alternative.
- 1 The drive responds to the Reset condition with the soft Reset alternative.

**102 TRMIOP (Terminate I/O Process)**

- 0 The disc drive does not support the Terminate I/O Process message.

**102 TrnDis (Transfer Disable)**

Not supported.

**102 Vendor Identification**

The ASCII data containing the vendor name ("SEAGATE").

### 12.6.1 Vital product data pages

The initiator requests the vital product data information by setting the EVPD bit to one and specifying the page code of the desired vital product data. If the disc drive does not implement the requested page it returns Check Condition status. The sense key is set to Illegal Request and the additional sense code is set to Invalid Field in CDB.

This section describes the vital product data page structure and the vital product data pages that are applicable to the disc drive. These pages are optionally returned by the Inquiry command and contain specific product information about the disc drive. The vital product data includes unit serial numbers, device operating definitions, firmware release numbers, servo ROM and RAM release numbers and the date code from the manufacturer's defect log.

**Table 103. Vital product data page**

Bit Byte	7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	Page Code (00h)							
2	0	0	0	0	0	0	0	0
3	Page Length							
4 : 8	Supported Page List							

Table number

#### Field definitions (listed alphabetically)

##### 103 Page Code

Page 00h provides a list of all supported vital product data pages. The Page Code field is set to the value of the Page Code field in the Inquiry command descriptor block. Page Code C3 is only returned by ASA-II firmware.

##### 103 Page Length

The length (in bytes) of the supported page list. If the allocation length is too small to transfer all of the page, the page length is not adjusted to reflect the truncation. The page length reported by ASA-1 firmware is 06. The page length reported by ASA-II firmware is 07. The total number of bytes returned (N) will be Page Length +4 in either case.

##### 103 Peripheral Qualifier and Peripheral Device Type

00h A direct-access device (magnetic disc) is connected to this logical unit.

##### 103 Supported Page List

Contains a list of all vital product data page codes implemented for the disc drive in ascending order beginning with Page Code 0h. See Table 104.

**Table 104. Vital product data page codes**

Page Code	Description
00h	Supported vital product data pages
80h	Unit Serial Number page
81h	Implemented Operating Definition page
83h	Device Identification page
C0h	Firmware Numbers page
C1h	Date Code page
C2h	Jumper Settings page
C3h	Device Behavior page



### 12.6.2 Unit Serial Number page (80h)

The Unit Serial Number page provides the product serial number for the drive.

**Table 105. Unit Serial Number page (80h)**

Bit Byte	7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	Page Code (80h)							
2	0	0	0	0	0	0	0	0
3	Page Length (08h)							
4 : 11	Product Serial Number							

**Table number** **Field definitions (listed alphabetically)**

**105 Page Code**

Page 80h provides the product serial number for the disc drive. See bytes 4–8 (Product Serial Number field).

**105 Page Length**

The length (in bytes) of the Unit Serial Number page. If the allocation length is too small to transfer all of the page, the page length is not adjusted to reflect the truncation.

**105 Peripheral Qualifier and Peripheral Device Type**

00h A direct-access device (magnetic disc) is connected to this logical unit.

**105 Product Serial Number**

Contains ASCII data. The least significant ASCII character of the serial number appears as the last byte of a successful data transfer. If the product serial number is not available, the disc drive returns ASCII spaces (20h) in this field.

### 12.6.3 Implemented Operating Definition page (81h)

Table 106. Implemented Operating Definition page (81h)

Bit Byte	7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	Page Code (81h)							
2	0	0	0	0	0	0	0	0
3	Page Length (04h)							
4	0	Current Operating Definition						
5	SAVIMP	Default Operating Definition						
6	SAVIMP	Supported Operating Definition						
7	SAVIMP	Supported Operating Definition						

#### Table number Field definitions (listed alphabetically)

##### 106 Current Operating Definition

Returns the value of the present operating definition. The default operating definition field returns the value of the operating definition the disc drive uses when power is applied if no operating definition is saved.

**Note.** The FC-AL drive always returns a value of 03h in the current and default fields.

00h Use current operating definition.

01h SCSI X3.131-1986 operating definition.

03h SCSI-2 X3.131-199x operating definition.

##### 106 Default Operating Definition

Returns the value of the default operating definition.

##### 106 Page Code

81h Defines the current operating definition, the default operating definition, and which operating definitions are implemented by the disc drive.

##### 106 Page Length

04h The length of the implemented operating definition data (in bytes).

##### 106 Peripheral Qualifier and Peripheral Device Type

00h A direct-access device (magnetic disc) is connected to this logical unit.

##### 106 SAVIMP (Save Implemented)

For each operating definition there is an associated Save Implemented (SAVIMP) bit. A SAVIMP bit of zero indicates that the corresponding operating definition parameter cannot be saved. A SAVIMP bit of one indicates that the corresponding operating definition parameter can be saved. The disc drive saves the default operating definition and all supported operating definitions.

##### 106 Supported Operating Definition

The operating definition supported by this device.

### 12.6.4 Device Identification page (83h)

The device identification page provides the Node Name for the drive.

**Table 107. Device Identification page (83h)**

Bit Byte	7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	Page Code (83h)							
2	Reserved							
3	Page Length (0Ch)							
<b>Identification descriptor list</b>								
4	Identification descriptor							
.								
.								
.								
15								

Table  
number

#### Field definitions (listed alphabetically)

##### **107** Identification Descriptor

Contains type information and a unique drive identification value.

**Table 108. Identification Descriptor**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	Code Set			
1	0	0	Association		Identifier Type			
2	0	0	0	0	0	0	0	0
3	Page Length (08h)							
4	MSB							
.	Identifier							
.								
11								

##### **108** Association

00h The Identifier field is associated with the addressed device.

##### **108** Code Set

01h The Identifier field contains binary values.

##### **108** Identifier

The 64-bit Node Name of the drive.

##### **108** Identifier Type

03h The Identifier field contains a unique 64-bit Fibre Channel Name\_Identifier.

##### **108** Page Length

08h The length of the Identification Descriptor page.

##### **107** Page Code

83h Provides the Node Name of the disc drive.

**107 Page Length**

The length (in bytes) of the Device Identification page. If the allocation length is too small to transfer all the page, the page length is not adjusted to reflect the truncation.

**107 Peripheral Qualifier and Peripheral Device Type**

00h A direct-access device (magnetic disc) is connected to this logical unit.

Each identification descriptor contains information identifying the logical unit. If the logical unit is accessible through any other path, it returns the same identification.

**Table 109. Identification Descriptor structure**

Bit Byte	7	6	5	4	3	2	1	0
0	Reserved				Code Set			
1	Reserved		Association		Identifier Type			
2	Reserved							
3	Identifier Length (n - 3)							
4	(MSB)							
:	Identifier							
n	(LSB)							

**Table number 109 Field definitions (listed alphabetically)****Association**

This field specifies the entity that the Identifier field is associated with.

00h Associated with the addressed physical or logical device.

01h Associated with the port that received the request.

02 - 03h Reserved.

**109 Code Set**

This field specifies the code set used for the identifier field. This field is an aid to software that displays the identifier field.

00h Reserved.

01h The Identifier field contains binary values.

02h The Identifier field contains ASCII graphic codes (i.e., code values 20h through 7Eh)

03 - 0Fh Reserved

**109 Identifier**

This field contains the identifier as described by the Identifier Type, Code Set, and Identifier Length fields.

**109 Identifier Length**

This field specifies the length, in bytes, of the Identifier.

**Note.** If the command descriptor block's allocation length is too small to transfer all of the identifier, the Identifier Length is not adjusted to reflect the truncation.

**109 Identifier Type**

This field specifies the format and assignment authority for the identifier.

00h No assignment authority was used and, consequently, there is no guarantee that the identifier is globally unique (the identifier is vendor-specific).

01h The first eight bytes of the Identifier field contain the Vendor ID. The organization associated with the Vendor ID is responsible for ensuring that the remainder of the Identifier field is unique. One recommended method of constructing the remainder of the Identifier field is to concatenate the Product Identification field from the standard Inquiry Data field and the product serial number field from the Unit Serial Number page.

- 
- 02h            The Identifier field contains an IEEE Extended Unique Identifier, 64-bit (EUI-64). In this case, the Identifier Length field is set to 8. Note that the IEEE guidelines for EUI-64 specify a method for unambiguously encapsulating an IEEE 48-bit identifier within an EUI-64.
- 04 - 0Fh      Reserved.

### 12.6.5 Firmware Numbers page (C0h)

Table 110. Firmware Numbers page (C0h)

Bit Byte	7	6	5	4	3	2	1	0
0	Peripheral Qualifier		Peripheral Device Type					
1	Page Code (C0h)							
2	0	0	0	0	0	0	0	0
3	Page Length (20h)							
4 : 11	Firmware Release Number							
12 : 19	Servo RAM Release Number							
20 : 27	Servo ROM Release Number							
28 : 31	Servo RAM Release Date in ASCII							
32 : 35	Servo ROM Release Date in ASCII							

#### Table number Field definitions (listed alphabetically)

##### 110 Firmware Release Number

Contain ASCII data. The least significant ASCII character of the drive firmware number appears as the last byte of a successful data transfer.

##### 110 Page Code

C0h Provides the firmware release numbers for the disc drive.

##### 110 Page Length

20h The length of the Firmware Numbers page (in bytes).

##### 110 Peripheral Qualifier and Peripheral Device Type

00h A direct-access device (magnetic disc) is connected to this logical unit.

##### 110 Servo RAM Release Date in ASCII

This field contains the servo RAM release data in ASCII format.

##### 110 Servo RAM Release Number

This field contains the servo RAM release number.

##### 110 Servo ROM Release Date in ASCII

This field contains the servo ROM release data in ASCII format.

##### 110 Servo ROM Release Number

This field contains the servo ROM release number.

### 12.6.6 Date Code page (C1h)

Table 111. Date Code page (C1h)

Bit Byte	7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	Page Code (C1h)							
2	0	0	0	0	0	0	0	0
3	Page Length (0Ch)							
4 : 9	Product Date Code							
10 : 15	Compile Date							

#### Table number Field definitions (listed alphabetically)

##### 111 Compile Date

Contains ASCII data. The least significant ASCII character of the compile date appears as the last byte of a successful data transfer. If the compile date is not available, the drive returns ASCII spaces (20h) in this field.

##### 111 Page Code

C1h Provides the date code from the disc drive defect list.

##### 111 Page Length

0Ch The length (in bytes) of the Date Code page.

##### 111 Peripheral Qualifier and Peripheral Device Type

00h A direct-access device (magnetic disc) is connected to this logical unit.

##### 111 Product Date Code

Contains ASCII data. The least significant ASCII character of the product date code appears as the last byte of a successful data transfer. If the product date code is not available, the drive returns ASCII spaces (20h) in this field.

### 12.6.7 Jumper Settings page (C2h)

Table 112. Jumper Settings page (C2h)

Bit Byte	7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	Page Code (C2h)							
2	0	0	0	0	0	0	0	0
3	Page Length (02h)							
4	S2	S1	Rsvd	Rsvd	Rsvd	Rsvd	Rsvd	Rsvd
5	Rsvd	Sel. ID						

**Table number** Field definitions (listed alphabetically)

**112** Page Code

C2h Provides the status of the option selections at the disc drive connector.

**112** Page Length

02h The length (in bytes) of the Jumper Settings page.

**112** Peripheral Qualifier and Peripheral Device Type

00h A direct-access device (magnetic disc) is connected to this logical unit.

**112** Sel. ID (Select-ID)

AL\_PA Select-ID mapping is shown on the next page (see Table 113).

**112** S2 (Start\_2), S1 (Start\_1)

Motor spinup options:

S2	S1	Function
----	----	----------

0	0	Motor spins up at power on.
---	---	-----------------------------

1	0	Remote motor spin up. A SCSI Start command is required to spin up the drive.
---	---	--

0	1	Delay motor spin up.
---	---	----------------------

1	1	Invalid selection or the drive is not completely plugged in.
---	---	--



Table 113. AL\_PA Select-ID mapping

AL_PA (hex)	Sel. ID (hex)	AL_PA (hex)	Sel. ID (hex)	AL_PA (hex)	Sel. ID (hex)
EF	00	A3	2B	4D	56
E8	01	9F	2C	4C	57
E4	02	9E	2D	4B	58
E2	03	9D	2E	4A	59
E1	04	9B	2F	49	5A
E0	05	98	30	47	5B
DC	06	97	31	46	5C
DA	07	90	32	45	5D
D9	08	8F	33	43	5E
D6	09	88	34	3C	5F
D5	0A	84	35	3A	60
D4	0B	82	36	39	61
D3	0C	81	37	36	62
D2	0D	80	38	35	63
D1	0E	7C	39	34	64
CE	0F	7A	3A	33	65
CD	10	79	3B	32	66
CC	11	76	3C	31	67
CB	12	75	3D	2E	68
CA	13	74	3E	2D	69
C9	14	73	3F	2C	6A
C7	15	72	40	2B	6B
C6	16	71	41	2A	6C
C5	17	6E	42	29	6D
C3	18	6D	43	27	6E
BC	19	6C	44	26	6F
BA	1A	6B	45	25	70
B9	1B	6A	46	23	71
B6	1C	69	47	1F	72
B5	1D	67	48	1E	73
B4	1E	66	49	1D	74
B3	1F	65	4A	1B	75
B2	20	63	4B	18	76
B1	21	5C	4C	17	77
AE	22	5A	4D	10	78
AD	23	59	4E	0F	79
AC	24	56	4F	08	7A
AB	25	55	50	04	7B
AA	26	54	51	02	7C
A9	27	53	52	01	7D
A7	28	52	53		
A6	29	51	54		
A5	2A	4E	55		

### 12.6.8 Device Behavior page (C3h)

The Device Behavior page (VPD page C3h) is used by regression tests to determine what behavior should be expected from a particular firmware package.

**Table 114. Device Behavior page (C3h)**

Bit Byte	7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	Page Code (C3h)							
2	Reserved							
3	Page Length							
4	Version Number							
5	Behavior Code							
6	Behavior Code Version Number							
7 : 22	ASCII Model Number (16 bytes)							
23	Maximum Interleave							
24	Default Number of Cache Segments							
25+	Feature flags and additional byte fields will go here but are undefined at this time.							

#### Table number Field definitions (listed alphabetically)

##### 114 ASCII Model Number

Identical to the Product Identification Number given in the standard Inquiry command data (see Table 102).

##### 114 Behavior Code and Behavior Code Version Number

Jointly assigned by the Firmware Engineering Managers of all SCSI design locations.

##### 114 Default Number of Cache Segments

Identical to the same parameter given in the Mode Caching page (see Table 148).

##### 114 Feature flags and additional byte fields...

These bytes are not yet defined.

##### 114 Maximum Interleave

The maximum value which the drive can support in the least significant byte of Interleave in the Format Unit command (see Table 93). The actual interleave which has been used during the last Format, providing it has not been changed by an intervening Mode Select command is reported in the Interleave bytes of the Format Device bytes of the Format Device page (see Table 145).

##### 114 Page Code

C3h Provides the behavior code information for the drive.

##### 114 Page Length

32h The length of the Device Behavior page (in bytes).

##### 114 Peripheral Qualifier and Peripheral Device Type

00h A direct-access device (magnetic disc) is connected to this logical unit.

##### 114 Version Number

A 1-byte short form notation for the 24-byte assignment in the Firmware Numbers page. Version Numbers are registered by engineering services.

## 12.7 Log Select command 4Ch

The Log Select command provides a means for an initiator to manage statistical information about the drive operation. This information is logged within the drive and can be sent to the initiator in response to a Log Sense command from the initiator. The Log Select command format is shown in Table 115. In the Data Out phase following the command, the initiator sends zero or more pages of control parameters in the Log Page format of Table 118. These log pages contain parameters that command the drive to change selected threshold, or cumulative values of any or all drive logs.

The following tables in Section 12.7 apply for the Log Select command as indicators of functions that command the drive to perform or enable for performance, control parameter bits the drive sets/resets/saves, log counts that are kept, etc. For the Log Sense command, these tables apply as indicators of functions the drive reports back to the host that it is enabled to perform, control parameter bits that are set/reset/saved, log counts that are being kept, etc. Though the language of the descriptions is for the Log Select case, the application to the Log Sense case should also be considered. Section 12.8 describes the Log Sense command, but the tables of this section that apply are not repeated there.

The drives represented by this Interface Manual do not support keeping independent sets of log parameters (one set for each initiator in the system). If at some point log parameters are changed (by a Log Select command) that affect initiators other than the initiator that sent the Log Select command, the drive generates a unit attention condition for those other initiators, but not for the one that issued the Log Select command. When the other initiators at a future time connect to the drive, the first command attempted would not execute and a check condition status would be issued by the drive. A Request Sense command would normally follow and a unit attention condition sense code be returned to these other initiators with an additional sense code of Log Parameters Changed (one by one as they connect to the drive). See Section 12.11.1, Unit Attention page.

**Table 115. Log Select command (4Ch)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	1	0	0	1	1	0	0
1	0	0	0	0	0	0	PCR	SP
	Reserved							
2	PC		Reserved					
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) _____							
8	Parameter List Length						_____ (LSB)	
9	Control							

### **Table number** Field definitions (listed alphabetically)

#### **115 Control**

See Control Bytes in Section 11.2.1.6.

#### **115 PC (Page Control)**

This field defines the type of log parameter the initiator selects to change with the Log Select command.

- 00b Log current threshold values
- 01b Log current cumulative values
- 10b Log default threshold values
- 11b Log default cumulative values

The drive only updates the cumulative values to reflect the number of events experienced by the drive, but the initiator can set the threshold or cumulative log (00 or 01) parameter values using the Log Select command with the PC field set as applicable.

The drive sets the current log values to default values in response to a Log Select command with the parameter list length set to zero and the PC field set to the applicable value (10b or 11b).

If an initiator attempts to change a current threshold value that is not available or not implemented for that log parameter, the drive terminates the Log Select command with a Check Condition status, the sense key set to Illegal Request and an additional sense code set to Invalid Field In Parameter List. The saving of current threshold parameters and the criteria for the current threshold being met are controlled by bits in the Parameter Control Byte (PCB) (byte 2 of each of the Log Parameter pages).

#### **115 PCR (Parameter Code Reset)**

- 1 And Parameter List Length value = 0—causes all implemented parameters to be set to the drive-defined default values (most likely zero).
- 1 And Parameter List Length value >0—causes the command to terminate with a Check Condition status. The sense key is set to Illegal Request and the additional sense code is set to Invalid Field in CDB.
- 0 The log parameters are not reset.

#### **115 Parameter List Length**

This specifies the length (in bytes) of the parameter list that is transferred from the initiator to the drive.

- 0 No pages are transferred. This condition is not considered an error.

If the initiator sends page codes or parameter codes within the parameter list that are reserved or not implemented by the drive, the drive terminates the Log Select command with Check Condition status. The sense key is set to Illegal Request and the additional sense code set to Invalid Field In Parameter List.

If a parameter list length results in the truncation of any log parameter, the drive terminates the command with Check Condition status. The sense key is set to Illegal Request and the additional sense code set to Invalid Field In CDB.

The initiator may send none, one, or more data pages, each of which is in the format specified in Table 118 and which contain control information pertaining to the management and reporting of various drive log parameters. If multiple pages are sent out following the command CDB, they must be sent in ascending page code value order. Also, log parameters in each log page must be sent in log parameter code ascending order (see Table 118). The Page code (byte 0) specifies which log the page pertains to. The page code assignments are listed in Table 121. Initiator cannot send page zero (0).

#### **115 SP (Save Parameters)**

- 1 After performing the specified log select operation, the drive saves to nonvolatile memory all log select parameters identified as savable by the DS bit in the log parameter sections of the log page (see Tables 118 and 119).
- 0 Specifies that parameters are not saved immediately.

Log parameters are also saved after each thermal calibration if the TSD bit in the Log Parameters page (see Table 119) is zero (0).

It is not an error to set the SP bit to one and to set the DS bit of a log parameter to one. In this case, the parameter value for that log parameter is not saved.

Table 116 summarizes the Log Select Command field settings used when updating the cumulative/threshold value settings and the resulting action that will occur based on these field settings.

**Table 116. Log Select Command field setting summary**

PCR	PC	Parameter List Length	Resulting action
1	xx	0	All cumulative counter and threshold log page values will be set to "zero" on all log pages.
0	11	0	All cumulative counter log page values will be set to "zero" on all log pages.
0	10	0	All threshold log page values will be set to "zero" on all log pages.
0	01	nn	The cumulative counter for a specific parameter code will be set to the stipulated value on a specified log page as found in the Log Parameter Page data.
0	00	nn	The threshold for a specific parameter code will be set to the stipulated value on a specified log page as found in the Log Parameter Page data.

The Log Select and Log Sense commands use the same log page format. See Section 12.8.

## 12.8 Log Sense command 4Dh

The Log Sense command provides a means for an initiator to retrieve statistical information maintained by the drive about the drive operation. It is a complementary command to the Log Select command. This information is stored in logs (counters) in the drive and is sent to the initiator as inbound data of the Log Sense command. The Log Sense command format that the initiator sends is shown in Table 117. The format of the data pages sent back by the drive is shown in Table 118.

**Table 117. Log Sense command (4Dh)**

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

### Table number **Field definitions (listed alphabetically)**

#### **117** Allocation Length

This field informs the drive of the amount of space available for returning log parameter data. If the allocation length is too small, the drive sends as much data as can fit in the allocation length without truncating a log parameter. The initiator can retrieve the rest of the log page information by setting the parameter pointer to the last returned parameter code and reissuing the log sense command. This process may be repeated as necessary to retrieve all the available information.

#### **117** Control

See Control Bytes in Section 11.2.1.6.

#### **117** Operation Code

4Dh The operation code for the Log Sense command.

#### **117** Page Code

The page of data requested by the command (see Table 121). If a page code is sent that is not implemented, the drive terminates the command with Check Condition status. The sense key is set to Illegal Request with the additional sense code set to Invalid Field In CDB.

Table 122 (Page Code 00h) returns the list of log pages that the drive supports. This page is not defined for the Log Select command.

#### **117** PC (Page Control)

This field defines the type of log parameter the initiator selects to change with the Log Select command.

- 00b Log current threshold values
- 01b Log current cumulative values
- 10b Log default threshold values
- 11b Log default cumulative values

The parameter values returned are from one of the following:

- The specified parameter values in the log counters as of the last update (updated by Log Select command, Log Sense command or done automatically by the drive for cumulative values).

- The saved values if an update has not occurred since last power-on, hard reset condition, or Bus Device Reset message (assumes saved values are available).
- If saved values are not available, the default values are sent if an update has not occurred since the last power-on, hard reset condition, or Bus Reset message.

**117 Parameter Pointer**

A parameter code (see Table 123) that specifies that log parameter data be returned to the initiator starting with the Parameter Pointer code and continuing to the maximum allocation length or to (and including) log parameter data of the maximum parameter code supported by the drive, whichever is less. If the value of the Parameter Pointer field is larger than the largest available parameter code that can be returned by the drive on the specified page, the drive terminates the command with a Check Condition status. The sense key is set to Illegal Request and the additional sense code is set to Invalid Field In CDB.

**117 PPC (Parameter Pointer Control)**

- 1 The drive returns a log page with only those log parameters that have changed since the last Log Select or Log Sense command. The drive returns log parameter codes according to (in ascending numerical order) the parameter code specified in the Parameter Pointer field (bytes 5 & 6).
  - 0 All of the log parameter data requested from the drive, whether changed or not, is sent and it begins with the log specified by the parameter code given in the Parameter Pointer field and returns the number of bytes specified by the allocation length field, in ascending order of parameter codes starting at the parameter code given in the Parameter Pointer field.
- A PPC bit of zero and a Parameter Pointer field of zero causes all available log parameters for the specified log page to be returned to the initiator subject to the allocation length.

**117 SP (Save Parameters)**

- 0 The drive performs the specified Log Sense command and does not save any log parameters to nonvolatile memory.
- 1 The drive first saves parameters identified as savable (by the DS bit in Table 119) to a nonvolatile location, and then performs the rest of the Log Sense command.

**Table 118. Log Page format**

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

**Log parameter structure(s)**

4 to x + 3	Log Parameter (First) (Length X bytes)
.	.
.	.
.	.
n-Y	Log Parameter (last) (Length Y bytes)

**Table number** **Field definitions (listed alphabetically)**

**118 Log Parameter**

Each Log Parameter structure begins with a four-byte parameter header followed by one or more bytes of parameter value data. Log Parameter structures are in the format given in Table 119.

**118 Log Parameter Structures**

Most log pages contain one or more special data structures called Log Parameters. Log Parameters may be data counters that record a count of a particular event (or events) or list parameters (strings) that contain a description of a particular event. List parameters are not currently supported by the drives represented by this manual.

**118 Page Code**

Valid page codes are listed in Table 121.

**118 Page Length**

The total number of bytes of Log Parameter structures that follow these first four control block bytes. If the initiator sends a page length that results in the truncation of any parameter, the target terminates the command with Check Condition status. The sense key is set to Illegal Request with the additional sense code set to Invalid Field In Parameter List.

**Table 119. Log Parameter structure**

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

**Table number** **Field definitions (listed alphabetically)****119 DS (Disable Save)**

- 0 The drive supports Log Select and Log Sense data saving for that log parameter. The drive saves the current cumulative and the current threshold parameter values in response to a Log Select or Log Sense command with a SP bit of one.
- 1 The drive does not support saving that log parameter in response to a Log Select or Log Sense command with a SP bit of one.

**119 DU (Disable Update)**

- 0 The drive updates the log parameter value to reflect all events that should be logged by that parameter.
- 1 The drive does not update the log parameter value except in response to a Log Select command that specifies a new value for the parameter.

For the Log Select command, this applies only to the cumulative log parameter values (indicated by 01 in the PC field of the Log Select and Log Sense command descriptor block).

The DU flag is set to one when the current cumulative value of the parameter counter it controls reaches its maximum value (see Parameter Length definition for this table). Upon reaching this maximum value, the data counter does not wrap around and start over at zero. Incrementing of other counters within the same log pages ceases. Counters do not restart automatically if the overflowed counter is re-initialized. If the data counter reaches its maximum value during the execution of a command, the drive completes the command. Drive counter updates are performed in the background. This means a counter may overflow long after a command has completed, so the drive must treat this condition as a Unit Attention with the additional sense code set to Log Counter at max for all initiators if RLEC=1 (Report Log exception condition bit of the Control Mode Page 0Ah).

Since the drive uses volatile memory to hold cumulative values, they will be lost when a power cycle occurs. Unless the initiator commands the drive to save them to nonvolatile memory using a Log Select or Log Sense command with the SP bit set to one.

The DU bit is not defined for threshold values (indicated by the PC field of the Log Sense command descriptor block) nor for list parameters (indicated by the LP bit). The drive ignores the value of DU bits in a Log Select command applicable to threshold values or list parameters.

**119 ETC (Enable Threshold Comparison)**

- 1 A comparison to the threshold value is performed whenever the cumulative value is updated.
- 0 The comparison is not performed. The value of the ETC bit is the same for both the threshold and cumulative parameters.



**119 LBIN (List Binary)**

- 0 The parameter list contains a string of ASCII characters.
- 1 The parameter list is in a binary format.

**119 LP (List Parameter)**

- 0 The parameter is a data counter.
- 1 The parameter is a list parameter.

This bit only has meaning for the Log Sense command Data In pages.

Data counters are associated with one or more events. The data counter is updated whenever one of these events occurs by incrementing the counter value, provided the DU bit is zero. See the DU field description above.

An LP bit of one indicates that the parameter is a list parameter. List parameters are not counters and thus the ETC and TMC fields are set to zero. A list parameter is a string of ASCII graphic codes (i.e., code values 20h through 73h). List parameters are not supported by the drive at this time.

**119 Parameter Code**

The specific parameter that is being transferred with the Log Page. These codes are listed and explained in the individual page code descriptions following Table 123.

Byte 2 is referred to as the Parameter Control byte. For a Log Select command these bits perform a control function, but on a Log Sense command they only report the drive settings of these bits in this same format on the data-in part of the Log Sense command.

**119 Parameter Length**

This field specifies the length (in bytes) of the parameter that follows. If the initiator sends a parameter length value that results in the truncation of the parameter value, the drive terminates the command with a Check Condition status. The sense key is set to Illegal Request with the additional sense code set to Invalid Field In Parameter List.

**119 Parameter Value**

This field uses one, two, four, or eight bytes to transmit an unsigned counter value. The initiator sends these counts to set the counter values in the drive. The initiator is responsible to issue a Log Sense command to learn the parameter length the target has selected.

When any counter in a log page reaches its maximum value, the drive ceases incrementing all counters in that log page. If the RLEC bit of the Control Mode page is one, then the drive reports the exception condition as described in Disable Update definition for this table.

**119 TMC (Threshold Met Criteria)**

This field defines the basis for comparison of the cumulative and threshold values. See Table 120 for meanings of values in this field. The TMC field is only valid when the ETC bit is one.

**Table 120. Threshold Met Criteria**

Code	Basis for Comparison
00b	Notify of every update of cumulative value
01b*	Cumulative value equal to threshold value
10b*	Cumulative value not equal threshold value
11b*	Cumulative value greater than threshold value

\* Comparison made at every update of cumulative value.

If the ETC bit is one\* and the result of the comparison is true, a unit attention condition is generated for all initiators. When reporting the unit attention condition the drive sets the sense key to Unit Attention, and the additional sense code to Threshold Condition Met.

\* The RLEC bit (Report Log Exception Condition) in Mode page 0AH (Table 149) must also be one.

**119 TSD (Target Save Disable)**

- 0 The drive saves frequently enough to insure statistical significance. The drive's method is to save after each thermal calibration, which is once every ten minutes.
- 1 The drive does not use its save method.

The page code assignments for the log pages are listed in Table 121. Detailed descriptions follow the table.

**Table 121. Log Page codes**

Page Code	Description	Section
37h	Cache Statistics page	12.8.5
10h	Device Self-test Results page	12.8.4
3Dh	Drive dump (contents are vendor unique)	
03h	Error Counter page (Read)	12.8.1
05h	Error Counter page (Verify)	12.8.1
02h	Error Counter page (Write)	12.8.1
3Eh	Factory Log page	
06h	Non-medium Error page	12.8.2
00h	Supported Log pages	
0Dh	Temperature page	12.8.3
08h-0Ah	Reserved	
0Ch	Reserved	
11h - 2Fh	Reserved	
3Fh	Reserved	
30h - 3Eh	Vendor-specific (37h, 3Dh, and 3Eh are used above)	

Table 122. Supported log pages

Bit Byte	7	6	5	4	3	2	1	0
0	Reserved		Page Code (00h)					
1	Reserved							
2	(MSB)		Page Length (n-3)				(LSB)	
3								
4 : n	Supported Page List							

**Table number** Field definitions (listed alphabetically)

**122** Page Code

00h Supported log pages page code.

**122** Page Length

The length (in bytes) of the Supported Log Pages page. If the allocation length is too small to transfer all of the page, the page length is not adjusted to reflect the truncation.

**122** Supported Page List

A list of all log page codes implemented by the target in ascending order beginning with Page Code 00h.

### 12.8.1 Error Counter pages, Write, Read, Read Reverse, and Verify (code 02, 03, 04, and 05h)

Table 123 defines the parameter code field for the write, read, read reverse, and verify error counter pages.

**Table 123. Write, Read, Read Reverse, and Verify Error Parameter Code field**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
1	Parameter Code							

#### Table number Field definitions (listed alphabetically)

##### 123 Parameter Code

Parameter codes 00h through 06h specify six counters each for write, read, read reverse, and verify errors (24 counters). A description of the type (category of error) counters specified by codes 00h through 06h are described following.

- 0000h Error Corrected Without Substantial Delay. An error correction was applied to get perfect data (like ECC on-the-fly). "Without substantial delay" means the correction did not postpone reading of later sectors (e.g., a revolution was not lost). The counter is incremented once for each logical block that requires correction. Two different blocks corrected during the same command are counted as two events.
- 0001h Error Corrected With Possible Delay. An error code or algorithm (e.g., ECC, checksum) is applied in order to get perfect data with substantial delay. "With possible delay" means the correction took longer than a sector time so that reading/writing of subsequent sectors was delayed (e.g, a lost revolution). The counter is incremented once for each logical block that requires correction. A block with a double error that is correctable counts as one event and two different blocks corrected during the same command count as two events.
- 0002h Total (e.g., re-writes or re-reads). This parameter code specifies the counter counting the number of errors that are corrected by applying retries. This counts errors recovered, not the number of retries. If five retries were required to recover one block of data, the counter increments by one, not five. The counter is incremented once for each logical block that is recovered using retries. If an error is not recoverable while applying retries and is recovered by ECC, it isn't counted by this counter; it will be counted by the counter specified by parameter code 01h – Error Corrected With Possible Delay.
- 0003h Total Errors Corrected. This counter counts the total of all correctable errors encountered. It is the sum of the counters specified by parameter codes 01h and 02h. There is no double counting of data errors among these two counters and all correctable data errors are counted in one of these counters.
- 0004h Total Times Correction Algorithm Processed. This parameter code specifies the counter that counts the total number of retries or the number of times the retry algorithm is invoked. If after five attempts a counter 02h type error is recovered, then five is added to this counter. If three retries are required to get a stable ECC syndrome before a counter 01h type error is corrected, then those three retries are also counted here. The number of retries applied to unsuccessfully recover an error (counter 06h type error) are also counted by this counter.
- 0005h Total Bytes Processed. This parameter code specifies the counter that counts the total number of bytes either successfully or unsuccessfully read, written, or verified (depending on the log page) from the drive. If a transfer terminates early because of an unrecoverable error, only the logical blocks up to and including the one with the unrecoverable error are counted.
- 0006h Total Uncorrected Errors. This parameter code specifies the counter that contains the total number of blocks for which an unrecoverable data error has occurred.

**12.8.2 Non-Medium Error page (code 06h)**

Log page code 06h specifies non-medium errors.

**Table 124. Non-Medium Error page (code 06h)**

Bit Byte	7	6	5	4	3	2	1	0
0	Page Code (06h)							
1	Parameter Code							

**Table number** **Field definitions (listed alphabetically)****124** **Page Code**

06h Non-Medium Error page code.

**124** **Parameter Code**

0000h The number of recoverable error events other than write, read, or verify errors (0000h is the only code supported for this page).

### 12.8.3 Temperature page (code 0Dh)

Log page code 0Dh provides the temperature of the drive and Fibre Channel link error and initialization counts.

**Table 125. Temperature log page (code 0Dh)**

Bit Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (06h)					
1	Reserved							
2 3	Page Length (92h)							

**Table number** **Field definitions (listed alphabetically)**

**125 Page Code**

06h Temperature page.

**125 Page Length**

92h Length of the page.

**125 PS (Parameter Savable)**

1 Page contains savable parameters.

0 None of the parameters within the page are savable.

**Table 126. Temperature Parameter Format**

Bit Byte	7	6	5	4	3	2	1	0
0 1	Parameter Code							
2	0	1	1	0	00		1	1
3	02h							
4 5	Temperature Data							

**Table number** **Field definitions (listed alphabetically)**

**126 Parameter Code**

0000h Temperature data. The temperature sensed in the device at the time the Log Sense command is performed is returned in the Parameter field defined by this parameter code. The one-byte binary value specified the temperature of the device in degrees Celsius. Temperatures equal to or less than zero degrees Celsius is indicated by a value of zero.

If the device server is unable to detect a valid temperature because of a sensor failure or other condition, the value returned is FFh. The temperature should be reported with an accuracy of plus or minus three Celsius degrees while the device is operating at a steady state within the environmental limits specified for the drive. No comparison is performed between the temperature value specified in parameter 0000h and the reference temperature specified in parameter 0001h.

0001h Reference temperature data. A reference temperature for the drive may optionally be provided by the drive using parameter code 0001h. If no reference temperature is provided, the parameter may not be provided in the log page or alternatively, the reference temperature value may be set to the value of FFh. The one-byte binary value reflects the maximum reported sensor temperature in degrees Celsius at which the drive will operate continuously without degrading the drive's operation or reliability outside the limits specified by the manufacturer of the drive. The reference temperature may change for vendor-specific reasons.

**Table 127. Command Initiate Parameter Format**

Bit Byte	7	6	5	4	3	2	1	0
0 1	Parameter Code (80FFh)							
2	0	1	1	0	00	1	1	
3	02h							
4	Reserved							
5	Reserved							CIP

Table  
number**Field definitions (listed alphabetically)****127 Parameter Code**

80FFh Command Initiate Port Code. This field identifies the port on the drive that receives the Log Sense command and requested transfer of this page.

0 = Port A.  
1 = Port B.

**Table 128. Fibre Channel Link Format**

Bit Byte	7	6	5	4	3	2	1	0
0 1	Parameter Code							
2	0	1	1	0	00	1	1	
3	04h							
4 5 6 7	Counter Data							

Table  
number**Field definitions (listed alphabetically)****128 Parameter Code**

Code	Length	Description
8100h	4 bytes	Link Failure Count, Port A. Count of the number of Loss of Sync conditions that have occurred on Part A which exceeded 100 msec in duration.
8101h	4 bytes	Loss of Synchronization Count, Port A. Count of the number of short (< 100 msec) Loss of Synchronization conditions that have occurred on Port A.
8104h	4 bytes	Invalid Transmission Word Count, Port A. Count of the number of invalid transmission words/Running Disparity errors that have been detected on Port A.
8105h	4 bytes	Invalid CRC Count, Port A. Count of the number of write data frames that have been received with invalid CRCs on port A. These errors are only detected when this drive is the target of the data transfer.
8106h	4 bytes	LIP F7 Initiated Count, Port A. Count of the number of LIP F7s (Initialize LIP) which the drive has initiated on Port A.
8107h	4 bytes	LIP F7 Received Count, Port A. Count of the number of LIP F7s (Initialize LIP) which the drive has received on Port A.
8108h	4 bytes	LIP F8 Initiated Count, Port A. Count of the number of LIP F8s (Failure LIP) which the drive has initiated on Port A.
8109h	4 bytes	LIP F8 Received Count, Port A. Count of the number of LIP F8s (Failure LIP) which the drive has received on Port A.

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8110h	4 bytes	Link Failure Count, Port B. Count of the number of Loss of Sync conditions that have occurred on Port B which exceeded 100 msec in duration.
8111h	4 bytes	Loss of Synchronization Count, Port B. Count of the number of short (< 100 msec) Loss of Synchronization conditions that have occurred on Port B.
8114h	4 bytes	Invalid Transmission Word Count, Port B. Count of the number of invalid transmission words/Running Disparity errors that have been detected on Port B.
8115h	4 bytes	Invalid CRC Count, Port B. Count of the number of write data frames that have been received with invalid CRCs on port B. These errors are only detected when this drive is the target of the data transfer.
8116h	4 bytes	LIP F7 Initiated Count, Port B. Count of the number of LIP F7s (Initialize LIP) which the drive has initiated on Port B.
8117h	4 bytes	LIP F7 Received Count, Port B. Count of the number of LIP F7s (Initialize LIP) which the drive has received on Port B.
8118h	4 bytes	LIP F8 Initiated Count, Port B. Count of the number of LIP F8s (Failure LIP) which the drive has initiated on Port B.
8119h	4 bytes	LIP F8 Received Count, Port B. Count of the number of LIP F8s (Failure LIP) which the drive has received on Port B.



### 12.8.4 Device Self-test Results Log page (code 10h)

This page provides the results from the 20 most recent device self-tests. Results from the most recent test or the test currently in progress is reported in the first self-test log parameter; results from the second most recent self-test is reported in the second self-test log structure parameter and so on. If fewer than 20 device self-tests have occurred, the unused entries are zero filled.

The following table describes the Device Self-test Results Log page returned by the device server upon request by the application client.

**Table 129. Self-test Results Log page format**

Bit Byte	7	6	5	4	3	2	1	0
0	Page Code (10h)							
1	Reserved							
2	(MSB) _____ Page Length (0190h) _____ (LSB)							
3								
Self-test Results Log Parameters								
4 . . . 23	First Self-test Results Log Parameter (Most Recent)							
. . .	(2nd through 19th Self-test Results Log Parameters)							
384 . . . 403	20th Self-test Results Log Parameter (Least Recent)							

**Table number** **Field definitions (listed alphabetically)**

**129 Page Code**

10h Self-test Results Log page code.

**129 Page Length**

0190h The length (in bytes) of the parameter list that is transferred from the device server to the application client.

**129 Self-test Results Log Parameter fields**

See Table 130 below.

**Table 130. Device Self-test Results Log parameter data format**

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB) _____							
1	Parameter Code (0001h to 0014h)							(LSB)
2	0 DU	0 DS	0 TSD	0 ETC	TMC		1 LBIN	1 LP
	Parameter Control Bits							
3	Parameter Length (10h)							
4	Self-test Code			Reserved	Self-test Results Value			
5	Self-test Segment Number							
6	(MSB) _____							
7	Timestamp							(LSB)
8	(MSB) _____							
.								
.	LBA of First Failure							
.								
15								(LSB)
16	Reserved				Sense Key			
17	Additional Sense Code							
18	Additional Sense Code Qualifier							
19	Vendor Specific							

**Table number Field definitions (listed alphabetically)****130 Additional Sense Code**

This field may contain a hierarchy of additional information relating to error or exception conditions that occurred during the self-test represented in the same format used by the sense data (see Request Sense command).

**130 Additional Sense Code Qualifier**

This field may contain a hierarchy of additional information relating to error or exception conditions that occurred during the self-test represented in the same format used by the sense data (see Request Sense command).

**130 LBA of First Failure**

This field contains information that helps you locate the failure on the media. If the logical unit implements logical blocks, the content of this field is the first logical block address where a self-test error occurred. This implies nothing about the quality of any other logical block on the logical unit, since the testing during which the error occurred may not have been performed in a sequential manner. This value does not change (e.g., as the result of block reassignment). The content of this fields will be FFFFFFFFFFFFFFFFh if no errors occurred during the self-test or if the error that occurred is not related to an identifiable media address.

**130 Parameter Code**

This field identifies the log parameter being transferred. The Parameter Code field for the results of the most recent self-test contains 0001h; the Parameter Code field for the results of the second most recent test contains 0002h, etc.

**130 Parameter Control Bits**

DU	0	Value provided by device server
DS	0	Device server supports saving of parameter
TSD	0	Device server manages saving of parameter

ETC	0	No threshold comparison is made on this value
TMC	xxx	Ignored when ETC is 0
LBIN	1	The parameter is in binary format
LP	1	The parameter is a list parameter

**130 Parameter Length**

10h This value is always 10h.

**130 Self-test Code**

This field contains the value in the Self-test Code field of the Send Diagnostics command that initiated this device self-test (see Send Diagnostics command).

**130 Self-test Results Value**

00h	The self-test routine completed without error.
01h	The background self-test routine was aborted by the application client using a Send Diagnostics command with the Self-test Code field set to 100b (Abort background self-test).
02h	The self-test routine was aborted by an application client using a method other than a Send Diagnostics command with the Self-test Code field set to 100b (e.g., by a task management function, by a reset, or by issuing an exception command).
03h	An unknown error occurred while the device server was executing the self-test routine and the device server was unable to complete the self-test routine.
04h	The self-test completed with a failure in a test segment, and the test segment that failed is not known.
05h	The first segment of the self-test failed.
06h	The second segment of the self-test failed.
07h	Another segment of the self-test failed.
08-0Eh	Reserved.
0Fh	Self-test is in progress.

**130 Self-test Segment Number**

This field identifies the number of the segment that failed during the self-test.

00h The segment that failed cannot or need not be identified.

**130 Sense Key**

This field may contain a hierarchy of additional information relating to error or exception conditions that occurred during the self-test represented in the same format used by the sense data (see Request Sense command).

**130 Timestamp**

This field contains the total accumulated power-on hours of the device server at the time the self-test operation was completed. If the test is still in progress, the content of this field is 0. If the power-on hours for the device server at the time the self-test operation was completed is greater than FFFFh, the content of this field is FFFFh.

### 12.8.5 Cache Statistics page (code 37h)

Log Page code 37h specifies Cache Statistics page.

**Table 131. Cache Statistics page**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
1	Parameter Code							

**Table number** **Field definitions (listed alphabetically)**

**131** **Parameter Code**

- 00h The number of logical blocks that have been sent to an initiator.
- 01h The number of logical blocks that have been received from an initiator.
- 02h The number of logical blocks read from the cache memory that have been sent to an initiator.
- 03h The number of read and write commands that had data lengths equal or less than the current segment size.
- 04h The number of read and write commands that had data lengths greater than the current segment size.

**12.8.6 Factory Log page (code 3Eh)**

Log Page code 3Eh specifies factory status parameters.

**Table 132. Factory Log page**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
1	Parameter Code							

**Table number** **Field definitions (listed alphabetically)**

**131** **Parameter Code**

- 0000h Power-on Time. The number of drive power-on minutes. Currently, the Power-on Time parameter is the only parameter in this Log Page that is visible to OEM/customers.
- 0008h The time, in minutes, to the next scheduled interrupt for a S.M.A.R.T. measurement.

## 12.9 Mode Select (6) command 15h

The Mode Select command provides a means for the initiator to specify medium, logical unit, or peripheral device parameters to the disc drive. The drive also implements the Mode Sense command (see 12.11). Initiators should issue Mode Sense prior to Mode Select to determine supported pages, page lengths, and other parameters.

The drive maintains a common set of mode parameters shared by all initiators. If an initiator sends a Mode Select command that changes any parameters, the drive generates a Unit Attention condition for all initiators except the one that issued the Mode Select command. The drive sets the additional sense code to Mode Parameters Changed.

**Table 133. Mode Select (6) command (15h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	1	0	1	0	1
1	0	0	0	Reserved	PF	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	Parameter List Length							
5	Control							

### Table number Field definitions (listed alphabetically)

#### 133 Control

See Control Bytes in Section 11.2.1.6.

#### 133 Parameter List Length

The length (in bytes) of the Mode Select parameter list that is transferred during the Data Out phase.

0 No data will be transferred. This condition is not considered an error.

#### 133 PF (Page Format)

1 The data sent by the initiator after the Mode Select header and the block descriptors (if any) complies with the Page Format mode.

0 The data sent by the initiator after the Mode Select header and the block descriptors (if any) are vendor unique. The disc drive does not interpret the PF bit. It assumes the Page Format mode.

#### 133 SP (Save Pages)

1 The disc drive saves the savable pages. The format related parameters in the block descriptor, pages 3 and 4 are saved during a Format command as well as a Mode Select command with SP = 1. The disc drive must update the Current mode values with parameters included with this command, save the Current values of the savable parameters, and report Good status only after the save operation is completed. The saved parameters are not changed if an error is detected during the Mode Select command.

0 The saved parameter values are not changed.

The Mode Select parameter list (Table 134) contains a four-byte header, followed by zero or one block descriptors, followed by the pages of Mode Select Parameters.

Acceptable values for the Mode Select parameter list for the disc drive are shown in Table 134.

The target terminates all the Mode Select commands with Check Condition status, sets the sense key to Illegal Request and sets the additional sense code to Invalid Field In Parameter List, and does not change any mode parameters for the following conditions:

- If the Strict mode is enabled (see Table 142) and the initiator attempts to change any field that is not changeable by the host as reported by the target. In this case, no parameters are changed by this command. The target compares the parameters against the values as they were prior to this Mode Select command. (The

host is not penalized by values not changeable by the host, which have a target “ripple change” as a result of this Mode Select).

- If the initiator attempts to send an unsupported value or, a nonzero value to a reserved field in the Mode Select header, block descriptor, or any page header.
- If an initiator attempts to send a page with a length not equal to the parameter length reported for that page by the Mode Sense command.
- If the initiator attempts to send a value for a changeable parameter that is outside the range supported by the target and rounding is not implemented for that parameter (see rounding bit in Table 142).
- If the initiator sends a page descriptor with an unsupported page code value and the Strict mode is enabled. (see Table 142).
- If the initiator sends a value in the Number of Blocks field (see Table 134) that is greater than the maximum Number of Blocks (rounding is used if the maximum Number of Blocks might change). This is also an exception for FFFFFFFFh.

If the initiator sends a value for a changeable parameter that is outside the range supported by the target and rounding is implemented for that parameter, the target will either:

- round the parameter to an acceptable value and if Round is one, terminate the command, or
- round the parameter to an acceptable value and if Round equals zero, terminate the command as if an acceptable value had been sent from the initiator.

A target may alter any mode parameter in any mode page (even parameters reported as nonchangeable) as a result of changes to other mode parameters.

.

Table 134. Mode Select (6) parameter list

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
	Reserved							
1	0	0	0	0	0	0	0	0
	Medium Type							
2	0	0	0	0	0	0	0	0
	Reserved							
3	Block Descriptor Length Either 00h or 08h							

**Block descriptor**

0	0	0	0	0	0	0	0	0
	Density Code							
1	0	0	0	0	0	0	0	0
	Number of Blocks (MSB)							
2	0	0	0	0	0	0	0	0
	Number of Blocks							
3	0	0	0	0	0	0	0	0
	Number of Blocks (LSB)							
4	0	0	0	0	0	0	0	0
5	Block Length (MSB)							
6	Block Length							
7	Block Length (LSB)							

**Parameter information**

0–n	Mode Select Page Headers And Their Parameters (see tables 135 and 141)
-----	--

**Table number** Field definitions (listed alphabetically)**134** Block Descriptor Length

The length (in bytes) of the Block Descriptor. It is equal to the number of bytes in the Block Descriptor (either 0 or 8) and does not include the page headers and mode parameters.

0 No block descriptors are included in the parameter list. This condition is not considered an error.

**134** Block Length

The length (in number of bytes) for each logical block described by the Block Descriptor. Set to desired sector size before a Format. Valid values are even numbered sizes from 180 (B4h) to 4,096 (1000h). Not all drives can format down to 180; some have a minimum of 256. A typical block length value is 512 (200h).

**134** Density Code

Must be 00h to define the default density of the medium.

**Note.** For drives with capacities over 5 Gbytes, this byte is used for the Most Significant Byte (MSB) of the Number of Blocks field.

**134** Medium Type

00h Define the default type direct access device.

**134** Mode Select Page Headers And Their Parameters

See Mode Sense command (see Section 12.11) for detailed descriptions.



**134 Number of Blocks**

This field contains the number of accessible logical blocks on the logical unit. The maximum Number of Blocks depends on the Block Length in the Block Descriptor, the Format parameters, and the Rigid Disc Drive Geometry parameters. A drive not having the capacity programming feature will ignore the Number of Blocks field and will always have the maximum Number of Blocks.

Drives that have the capacity programming feature set the Number of Blocks to the maximum value if the Number of Blocks field contains FFFFFFFFh. The Number of blocks field is taken to be zero if the Block Descriptor is omitted from the Parameter List. If the Number of Blocks field contains zero, the capacity of the drive will not change, unless the maximum Number of blocks change (due to changed Block Length, etc.) If the maximum Number of Blocks change, a zero in the Number of Blocks field is processed as FFFFFFFFh. If the value in the Number of Blocks field is not greater than the maximum, the drive will set its capacity to the value in the Number of Blocks field. A change in the Number of Blocks will not cause the Format Corrupt condition.

**Note.** For drives with capacities over 5 Gbytes, the Density Code field byte is used for the Most Significant Byte (MSB) of the Number of Blocks field.

The rest of the Mode Select parameters are organized into pages that group the parameters by function. The parameter definitions are the same as those described in the Mode Sense command (Section 12.11) and are not repeated here.

**Table 135. Mode Select page descriptor header**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	Page Code					
1	Page Length							
2–n	Mode Parameters							

Each page of mode parameters begins with a two-byte Page Descriptor header. The Page Code identifies the page of mode parameters that is being transferred (see Table 141). The Page Length indicates the number of additional bytes of mode parameters contained in this page. The number of additional bytes sent must always match the Page Length value.

The disc drive only verifies Mode Select data that is defined as changeable by the drive. The various disc drives support the following page codes.

**Note.** See individual drive's Product Manual, Volume 1, SCSI Interface commands supported section for a table showing the mode pages that a particular drive implements. The table shows the default parameters for pages that are implemented, and shows which mode parameters are changeable by that drive model.

The detailed information can be obtained by issuing the Mode Sense command requesting changeable values.

**Note.** There may be implicit associations between parameters defined in the pages and block descriptors. The block length affects the optimum values (the values that achieve best performance) for the sectors per track, bytes per physical sector, track skew factor, and cylinder skew factor fields in the format parameters page. In this case, the drive may change parameters not explicitly sent with the Mode Select command. A subsequent Mode Sense command would provide information on these changes.

**12.10 Mode Select (10) command** 55h

The Mode Select (10) command provides a means for the initiator to send a list of drive operating mode parameters to the drive.

**Table 136. Mode Select (10) command (55h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	1	0	1	0	1	0	1
1	0	0	0	PF	Reserved			SP
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) _____							
8	Parameter List Length						_____ (LSB)	
9	Control							

See the Mode Select (6) command (Section 12.9) for a description of the fields in this command. Initiators should issue Mode Sense prior to Mode Select to determine supported pages, page lengths, and other parameters.

**Table 137. Mode Select (10) parameter list**

Bit Byte	7	6	5	4	3	2	1	0	
0	(MSB) _____ Sense Data Length _____ (LSB)								
1									
2	0	0	0	0	0	0	0	0	
	Medium Type								
3	0	0	0	DPO-FUA	0	0	0	0	
	Reserved				Reserved				
4	Reserved								
5	Reserved								
6	(MSB) 0	0	0	0	0	0	0	0	
	Block Descriptor Length (8 decimal)								
7	0	0	0	0	1	0	0	0 (LSB)	
0–7		Block Descriptor Data (see Table 139)							
0–n		Mode Sense Page Headers and Their Parameters							

**Table number** **Field definitions (listed alphabetically)**

**157 Block Descriptor Data**

See Table 139.

**157 Block Descriptor Length**

The length (in bytes) of the block descriptor. It is equal to the number of bytes in the Block Descriptor (8) and does not include the page headers and mode parameters, if any. The disc drive sends one Block Descriptor.

Each Block Descriptor specifies the medium characteristics for all or part of a logical unit. Each Block Descriptor contains a Density Code, a Number of Blocks, and a Block Length.

**157 DPO-FUA (Disable Page Out–Force Unit Access)**

0 When used with the Mode Sense command, this value indicates that the target does not contain a cache memory or does not support the DPO and FUA bits.

1 The target supports the DPO and FUA bits.

**157 Medium Type**

00h Default medium. This is the only valid value.

**157 Mode Sense Page Headers and Their Parameters**

See Table 140.

**157 Sense Data Length**

The length (in bytes) of the Mode Sense data that is available to be transferred to the initiator. The Sense Data Length does not include itself.

### 12.11 Mode Sense (6) command 1Ah

The Mode Sense command provides a means for the disc drive to report its medium, logical unit, or peripheral device parameters to the initiator. It is a command complementary to the Mode Select command.

**Table 138. Mode Sense command (1Ah)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	1	1	0	1	0
1	0	0	0	0	DBD	0	0	0
	Reserved							
2	PCF		Page Code					
3	0	0	0	0	0	0	0	0
4	Allocation Length							
5	Control							

#### Table number Field definitions (listed alphabetically)

##### 138 Allocation Length

The number of bytes that the initiator has allocated for returned Mode Sense data. Any value other than zero indicates the maximum number of bytes transferred.

0 No Mode Sense data is transferred. This condition is not considered an error.

The disc drive terminates the data when allocation length bytes have been transferred or when all available Mode Sense data has been transferred to the initiator, whichever is less.

##### 138 Control

See Control Bytes in Section 11.2.1.6.

##### 138 DBD (Disable Block Descriptors)

0 The drive may return zero or more block descriptors in the returned Mode Sense data, at the drive's discretion. Seagate FC-AL products return one block descriptor if the DBD bit is zero.

1 The drive does not return any block descriptors in the returned Mode Sense data. The Block Descriptor Length field of the Mode Sense header contains 00h to indicate a block descriptor length of zero.

##### 138 Page Code

This field allows the initiator to select one or all of the pages of Mode parameters supported by the target. Page codes that may be supported by the disc drive are summarized in Table 141 on page 204 (also see the individual drive's Product Manual, Volume 1).

##### 138 PCF (Page Control Field)

The content of mode parameter bytes is determined by the value of this field. The disc drive returns the same Page Length for each supported page regardless of the value of PCF. The block descriptor contains its normal values regardless of the value of the PCF. Unsupported fields or bits within a page are returned as zeros for all PCF values. PCF is defined below.

Bit 7 Bit 6 Page control description

0 0 Return Current values. The Current values are the values currently being used by the disc drive to control its operation. After a Power On Reset, a hard Reset, or a Bus Device Reset message the Current values are equal to the Saved values (if Saved values can be retrieved) or the Default values (if Saved values cannot be retrieved). The Current value of a parameter is updated by a Mode Select command if the Mode Select command ends with Good status returned.

0 1 Return Changeable values. The changeable values of any page is a mask that indicates the parameters that are changed via a Mode Select command and the parameters that are not. Each returned parameter byte contains ones where a field or bit may be changed and zeros where a field or bit may not be changed.

1 0 Return Default values. The Default values are the values to which the disc drive sets the Current values after a reset condition unless valid Saved values are available.

- 
- 1 1 Return Saved values. The saved values are the values the disc drive stores in nonvolatile memory. The Saved values of any changeable parameter can be set to new values via a Mode Select command with the SMP bit set to 1. For nonchangeable parameters, the Default value is used.

Table 139. Mode Sense (6) parameter list

Bit Byte	7	6	5	4	3	2	1	0
0	Sense Data Length							
1	0	0	0	0	0	0	0	0
Reserved								
2	WP	0	0	DPO-FUA	0	0	0	0
		Reserved				Reserved		
3	0	0	0	0	0	0	0	0
Block Descriptor Length (8 decimal)								
<b>Block descriptor data</b>								
0	0	0	0	0	0	0	0	0
Number of Blocks (MSB)								
1	0	0	0	0	0	0	0	0
Number of Blocks								
2	0	0	0	0	0	0	0	0
Number of Blocks								
3	0	0	0	0	0	0	0	0
Number of Blocks (LSB)								
4	0	0	0	0	0	0	0	0
Reserved								
5	Block Length (MSB)							
6	Block Length							
7	Block Length (LSB)							
<b>Parameter information</b>								
0–n	Mode Sense Page Headers and Their Parameters							

**Table number** **Field definitions (listed alphabetically)**

**139** **Block Descriptor Length**

The length (in bytes) of the Block Descriptor. It is equal to the number of bytes in the Block Descriptor (8) and does not include the page headers and mode parameters, if any. The disc drive sends one Block Descriptor.

Each Block Descriptor specifies the medium characteristics for all or part of a logical unit. Each Block Descriptor contains a Density Code, a Number of Blocks, and a Block Length.

**139** **Block Length**

As defined after a format function, specifies the length (in bytes) of each logical block described by the Block Descriptor. Default is 512 if no Mode Select command is received before the Format command. The disc drive may be formatted from 180 to 4,096 bytes per sector in multiples of four bytes.

**139** **DPO-FUA (Disable Page Out–Force Unit Access)**

0 When used with the Mode Sense command, the target does not contain a cache memory or does not support the DPO and FUA bits.

1 The target supports the DPO and FUA bits.

**139** **Mode Sense Page Headers and Their Parameters**

See Table 140.

**139 Number of Blocks**

The number of logical blocks of the medium that meets the Block Length in the Block Descriptor.

0 All of the remaining logical blocks of the logical unit have the medium characteristics specified by the Block Descriptor.

**139 Sense Data Length**

The length (in bytes) of the following Mode Sense data that is available to be transferred to the initiator. The Sense Data Length does not include itself.

**139 WP (Write Protect)**

0 The medium is write enabled.

1 The medium is write protected.

**Mode Sense page descriptor header****Table 140. Mode Sense page descriptor header**

Bit Byte	7	6	5	4	3	2	1	0
0	PS	0	Page Code					
1	Page Length							
2–n	Mode Parameters							

Table  
number

**Field definitions (listed alphabetically)****140 Mode Parameters**

The contents of the mode pages being transferred. The number of bytes is indicated in the Page Length field.

**140 Page Code**

Each page of mode parameters (for the Mode Sense command) begins with a two-byte Page Descriptor Header. The Page Code identifies the page of mode parameters that is being transferred (see Table 141). The parameter bit values are left blank herein, because they may be different for each drive model.

**Note.** See the individual drive's Product Manual, Volume 1, for a table giving the Mode Sense parameter values that are applicable to the disc drive model of interest. The tables in Volume 1 also show which parameters are changeable in the drive model of interest and which are not.

Multiple pages of mode parameters may be transferred in one Mode Sense Data In phase (using Page Code 3Fh). If a non-supported page code is requested by the Initiator, the disc drive terminates the command with Check Condition status, sets the sense key to 05, Illegal Request, and sets the additional sense code to 24, Invalid Field In Parameter List.

Table 141. Mode sense page code section reference

Page code	Page description	Reference table
00h	Unit Attention page	142 (page 205)
01h	Error Recovery	143 (page 207)
02h	Disconnect/Reconnect Control	144 (page 210)
03h	Format Parameters	145 (page 212)
04h	Rigid Disc Drive Geometry	146 (page 215)
07h	Verify Error Recovery page	147 (page 217)
08h	Caching page	148 (page 219)
0Ah	Control Mode page	149 (page 222)
0Ch	Notch and Partition page	150 (page 224)
10h	XOR Control Mode page	151 (page 226)
19h	Fibre Channel Interface Control page	152 (page 228)
1Ah	Power Condition page	153 (page 230)
1Ch	Informational Exceptions Control page	154 (page 231)

**140 Page Length**

The length of the mode parameters that follow (in bytes). If the initiator does not set this value to the value that is returned for the page by the Mode Sense command, the drive terminates the command with Check Condition status. The sense key is set to Illegal Request with the additional sense code set to Invalid Field in Parameter List. The drive is permitted to implement a mode page that is less than the full page length defined by this specification, provided no field is truncated and the page length field correctly specifies the actual length implemented. If the Strict bit equals zero and if the page length specified by the initiator is shorter than the actual page length, then the parameters are transferred and the command ends with Good status if no other items cause the command to be rejected.

**Caution:** Data integrity may be adversely affected if an initiator uses this forgiving option without analyzing the impact of the truncation.

See the individual page code descriptions for specific page lengths.

**140 PS (Parameter Savable)**

- 1 Page contains savable parameters.
- 0 None of the parameters within the page are savable.

Since the parameters within pages 3 and 4 are always saved during Format commands (but not by a Mode Select command with the SMP bit set to 1), these pages return a 1 for the PS bit.



### 12.11.1 Unit Attention page (00h)

The Unit Attention page is the last page reported by the drive. See your individual drive's Product Manual, Volume 1, Mode Sense Data section, for a table showing codes that indicate which of these bits are changeable by the host using the Mode Select command.

**Table 142. Unit Attention page (00h)**

Bit Byte	7	6	5	4	3	2	1	0
0	PS	0	0	0	0	0	0	0
	Page Code (00h)							
1	Page Length (02h)							
2 Default	PM	0 Reserved	IL	Unit Attn	0	Rnd	Strict	SCSI-2
3 Default	Reserved							
4	Reserved				JIT3	JIT2	JIT1	JIT0
5	Reserved							
6	Reserved							
7	Reserved							

#### Table number Field definitions (listed alphabetically)

##### 142 IL (Inquiry Length)

- 1 The standard Inquiry data available to a host is limited to the 36 bytes required by the SCSI-2 specification.
- 0 148 bytes of standard Inquiry data are available. The Additional Length field in byte 4 of the Inquiry data is updated to reflect the actual number of additional bytes available.

##### 142 JIT (Just In Time)

These bits allow you to enable and disable certain seek speeds. JIT0 represents the fastest seek type used by the drive, JIT1 represents the second fastest, JIT2 represents the third fastest, and JIT3 represents the slowest seek type.

You can use these bits to reduce accoustics by disabling the fastest seeks. This can also reduce power consumption (from seek activity). These JIT settings only affect user read and write operations. Background drive operations and user seek commands will always use the fastest seek type.

- 1 The drive is allowed to use this seek type in its seek speed algorithm.
- 0 The drive is not allowed to use this seek type in its seek speed algorithm.

**Note.** If all JIT bits are set to zero, the drive enables JIT0 only.

##### 142 Page Code

00h Unit Attention page code.

##### 142 Page Length

02h The length of the Unit Attention page (in bytes).

##### 142 PM (Performance Mode)

This bit is used to control the drive's cache management algorithm to allow best performance in different types of systems. It is the initiator's responsibility to determine which setting is best for that system.

- 1 The number of cache segments is fixed to the value set in mode page 8.
- 0 The drive will optimize the number of segments depending on the command activity observed by the drive. The number of segments value (in mode page 8) is ignored.

**142 PS (Parameter Savable)**

This bit is only used with the Mode Sense command. This bit is not used with the Mode Select command.

- 1 The drive is capable of saving the page in a nonvolatile vendor-specific location.

**142 Rnd (Round)**

- 1 The drive treats and reports rounded parameters as described in Section 11.6.
- 0 The drive rounds the parameter and handles command completion reporting as if the parameter had not been rounded.

**142 SCSI-2**

- 1 The following SCSI-3 features are changed from their SCSI-3 definition to the SCSI-2 definition:
  - Control Mode Page (0Ah) Length from 0Ah to 06h.
  - Caching Page (08h) Length from 12h to 0Ah.
- 0 The SCSI-3 features remain as specified in other portions of this specification.

**142 Strict**

- 1 The drive checks for Initiator attempts to change unchangeable parameters. If the drive detects an attempt it rejects the command in the standard way, i.e., Check Condition status from drive, Request Sense from the Initiator, Illegal Request sense key (5h) back from the drive.
- 0 The drive ignores the values of the unchangeable parameters in a Mode Select command. The drive does not reject the command trying to change unchangeable parameters.

**142 Unit Attn (Unit Attention)**

- 1 Unit Attention is logged in sense only; no Check Condition status is presented following any reset.
- 0 Check Condition is presented for all affected Initiators following a reset until Request Sense is issued by each Initiator (as per current operation).

**Note.** Byte 3 is reserved for future compatibility with Seagate host adapters. Though presently may be changeable (see S2 field definition), this byte does not control anything unless the individual drive's Product Manual indicates that it does and defines its use in the Mode Sense Data section.

### 12.11.2 Error Recovery page (01h)

The disc drive Error Recovery page implementation is defined in Table 143. This table summarizes the function and default for each byte/bit.

See individual drive's Product Manual, Volume 1, section showing changeable values. A value of zero (0) means this bit function is not directly changeable by an initiator; a value of 1 means the bit function is directly changeable by an initiator (see Mode Select command).

**Table 143. Error Recovery page (01h)**

Bit Byte	7	6	5	4	3	2	1	0	
<b>Page descriptor header</b>									
0	1 PS	0	0	0	0	0	0	1 Page Code (01h)	
1	Page Length (0Ah bytes)								
<b>Error recovery parameters</b>									
2 Default	AWRE	ARRE	TB	RC	EER	PER	DTE	DCR	
3 Default	Read Retry Count								
4 Default	Correction Span (bits)								
5 Default	Head Offset Count								
6 Default	Data Strobe Offset Count								
7 Default	Reserved								
8 Default	Write Retry Count								
9 Default	Reserved								
10	(MSB)			Recovery Time Limit					
11								(LSB)	

**Table number** **Field definitions (listed alphabetically)**

**143 ARRE (Automatic Read Reallocation of defective data blocks Enabled)**

- 1 Allows the disc drive to automatically reallocate bad blocks detected during read operations. Automatic reallocation is performed only if the drive successfully recovers the data and is able to place it in the reallocated block.
- 0 The disc drive will not perform automatic reallocation but will create Check Condition status with sense key of Medium Error instead.

**143 AWRE (Automatic Write Reallocation of defective data blocks Enabled)**

- 1 Allows the disc drive to automatically reallocate bad blocks detected during write operations. The drive performs the automatic write reallocation only if the drive has the valid data (e.g., original data in the buffer or recovered from the medium). The valid data is placed in the reallocated block. This function doesn't apply to the Format Unit command.
- 0 The disc drive will not perform automatic reallocation but will create Check Condition status with sense key of Medium Error instead.

**143 Correction Span**

The size of the largest read data error (in bits) on which ECC correction is to be attempted. Errors longer than this span are reported as unrecoverable. This value is drive dependent. If this field is zero, the drive uses its default value.

**143 Data Strobe Offset Count**

0 Zero is the default value and is not changeable. This feature is not programmable by the initiator. Data Strobe Offsets are performed as part of the disc drive's retry algorithms.

**143 DCR (Disable Correction)**

1 ECC correction will not be applied to the data even if correction is possible.  
0 ECC correction will be applied if correction is possible.

**143 DTE (Disable Transfer on Error)**

The DTE bit is valid only when the PER bit is set to one.

1 The disc drive terminates data transfer even for recoverable errors (the drive will transfer the data for the recovered error before terminating the transfer).  
0 Data transfer continues if recoverable errors are encountered. Recoverable errors are reported after all data has been transferred.

**143 EER (Enable Early Recovery)**

1 The drive is allowed to apply maximum T level ECC correction on the fly before attempting other retry mechanisms. Seek error retries are not affected by this bit. Successful correction on the fly is not reported to the host as an error.  
0 The drive applies ECC correction before other retry mechanisms, but performs only normal T level ECC corrections on the fly (normal T level is product specific, but is typically max T - 1). The DCR bit must also be set to 0. Successful correction on the fly is not reported to the host as an error.

**143 Head Offset Count**

0 Zero is the default value and is not changeable. This feature is not programmable by the initiator. Head offsets are performed as part of the disc drive's retry algorithms.

**143 Page Code**

01h Error Recovery page code.

**143 Page Length**

0Ah The length of the Error recovery page (in bytes). If the allocation length is too small to transfer all of the page, the page length is not adjusted to reflect the truncation.

**143 PER (Post Error)**

1 The disc drive reports Check Condition status and appropriate sense key for any recovered errors encountered. Reporting of unrecoverable errors has priority over reporting of recoverable errors.  
0 Any errors recovered within the limits established by the other Error Recovery Flags are not reported. Any unrecoverable errors are reported.

**143 PS (Parameter Savable)**

This bit is not used with the Mode Select command.

1 Page 01h parameter data is savable.

**143 RC (Read Continuous)**

1 Requests the disc drive to transfer the requested data length without adding delays (for retries or ECC correction) that may be required to ensure data integrity. The disc drive may send erroneous data in order to maintain the continuous flow of data. This bit overrides the DTE bit if it is set. RC bit also has priority over EER, DCR, and PER bits.  
0 Recovery actions during data transfer are allowed.

**Note.** This bit is set to zero (0) and is not changeable in most, if not all, of the drive models covered by this manual. See individual drive's Product Manual, Volume 1, section showing changeable values.

**143 Read Retry Count**

The maximum number of times the disc drive attempts its read recovery algorithms. A Retry Count of zero inhibits non-ECC retries from being performed.

**143 Recovery Time Limit**

The maximum number of milliseconds that is allowed for recovery time. A hex FFFF indicates that the Recovery Time Limit is unlimited.

**143 TB (Transfer Block)**

- 1 The data block that is not recovered will be transferred to the initiator.
- 0 The failing data block will not be transferred.

**143 Write Retry Count**

The maximum number of times that the target attempts its recovery algorithm during write operations.

### 12.11.3 Disconnect/Reconnect Control page (02h)

The Disconnect/Reconnect Control page implementation is defined in Table 144. This table summarizes the function and defines the default values.

See individual drive's Product Manual, Volume 1, section showing changeable values. A value of zero (0) means this bit function is not directly changeable by an initiator; a value of 1 means the bit function is directly changeable by an initiator (see Mode Select command).

**Table 144. Disconnect/Reconnect Control page (02h)**

Bit Byte	7	6	5	4	3	2	1	0
<b>Page descriptor header</b>								
0	1 PS	0	0	0	0	0	1	0 Page Code (02h)
1	Page Length (0Eh)							
<b>Disconnect/reconnect control parameters</b>								
2 Default	Buffer Full Ratio							
3 Default	Buffer Empty Ratio							
4 Default	Bus Inactivity Limit (MSB)							
5 Default	Bus Inactivity Limit (LSB)							
6,7 Default	Disconnect Time Limit							
8,9 Default	Connect Time Limit							
10,11 Default	MSB Maximum Burst Size LSB							
12 Default	EMDP	0	0	0	DImm	DTDC		
13–15	Reserved							

**Table number** **Field definitions (listed alphabetically)**

**144 Buffer Empty Ratio**

This number is the numerator of a fractional multiplier that has 256 (100h) as its denominator. This field indicates, on Write commands, how empty the disc drive's buffer will be before attempting to arbitrate from control of the loop. The disc drive, rounds the requested ratio down to the nearest whole logical block. This value is changeable by an initiator.

**144 Buffer Full Ratio**

This number is the numerator of a fractional multiplier that has 256 (100h) as its denominator. This field indicates, on Read commands, how full the disc drive's buffer will be before attempting to arbitrate for control of the loop. The disc drive rounds the requested ratio up to the nearest whole logical block. This value is changeable by an initiator.

The buffer full ratio is taken to be a percentage of the smaller of:

- the buffer size
- or
- the remaining transfer length.

For example, if the buffer full ratio is 80h (128 Decimal) (indicating a 128/256 or 50% value), the transfer length of a read command is 20h blocks, and the buffer size is 30h blocks, the arbitration begins when 10h blocks (50% of the transfer length of 20h blocks) is in the buffer.

**144 Bus Inactivity Limit**

Not supported (bytes 4 and 5).

**144 Connect Time Limit**

Not supported (bytes 8 and 9).

**144 DImm (Disconnect Immediate)**

Not supported.

**144 Disconnect Time Limit**

Not supported (bytes 6 and 7).

**144 DTDC (Data Transfer Disconnect Control)**

Not supported.

**144 EMDP (Enable Modify Data Pointers)**

Not supported.

**144 Maximum Burst Size**

The maximum amount of data that the drive will transfer in a Fibre Channel sequence. For performance, the maximum burst size should be a size that fits in a cache segment.

The disc drive defaults to an integer multiple of 512 that is less than or equal to a segment size. The length of the sequence is an integer multiple of the frame size that is less than or equal to the maximum burst size.

This value is expressed in increments of 512 bytes (e.g., a value of one means 512 bytes, two means 1024 bytes, etc.). The data length for a command may span multiple sequences.

The disc drive accepts a value of zero (0) or  $\geq 5$ , the minimum size for the largest frame size. A value of zero indicates the sequence length is limited by the command or the sequence count, whichever is less.

**144 Page Code**

02h Disconnect/Reconnect Control page code.

**144 Page Length**

0Eh The length of the Disconnect/Reconnect Control page (in bytes). If the allocation length is too small to transfer all of the page, the page length is not adjusted to reflect the truncation.

**144 PS (Parameter Savable)**

This bit is not used with the Mode Select command.

1 The page 02h parameter data is savable.

### 12.11.4 Format Parameters page (03h)

The Format Parameters page implementation is defined in Table 145. This table summarizes the function and defines the default values for each bit. See the individual drive's Product Manual, Volume 1, Mode Sense Data section for changeable values.

The only time this page of parameters may be sent is immediately before sending a Format Unit command to the disc drive. The current parameters for this page are updated immediately but any changes between these current parameters and the existing media format are not in effect until after the Format Unit command is completed.

The actual implementation of reserving spare areas for defect management takes place during the Format Unit command.

**Note.** In Table 145, zone refers to defect management zone (one or more tracks), not a ZBR (variable track capacity recording) zone. ZBR zones are referred to as notches (page 0Ch is the Notch page).

**Table 145. Format Parameters page (03h)**

Bit Byte	7	6	5	4	3	2	1	0
<b>Page descriptor header</b>								
0	1 PS	0	0	0	0	0	1	1 Page Code (03h)
1	Page Length (16h)							
<b>Format parameters</b>								
2,3 Default	Tracks Per Zone (MSB)							
4,5 Default	Alternate Sectors Per Zone							
6,7 Default	Alternate Tracks Per Zone							
8,9 Default	Alternate Tracks Per Volume							
10,11 Default	Sectors Per Track							
12,13 Default	Data Bytes Per Physical Sector							
14,15 Default	Interleave							
16,17 Default	Track Skew Factor							
18,19 Default	Cylinder Skew Factor							
20 Default	SSEC	HSEC	RMB	SURF	Reserved			
		Drive Type						
21–23 Default	Reserved							

**Table number** **Field definitions (listed alphabetically)**

**145 Alternate Sectors Per Zone**

The number of spare sectors to be reserved for the defined defect management zone.



0 No sectors are to be reserved in each zone for defect management. This is to accommodate hosts that want to manage the defects themselves.

**145 Alternate Tracks Per Volume**

The number of spare tracks to be reserved at the end of the drive volume. The disc drive uses these locations for replacing defective sectors.

Typically the disc drive defaults to two times the number of read/write heads in the drive, which amounts to two spare cylinders. A value of zero (0) indicates that no spare tracks are to be reserved at the end of the unit for defect management. The initiator may change this value for a number between 0 and 255 that is a multiple of the total number of Data Read/Write heads installed.

**145 Alternate Tracks Per Zone**

The number of spare tracks to be reserved at the end of each defect management zone.

0 No spare tracks are to be reserved in each zone for defect management by the disc drive.

**145 Cylinder Skew Factor**

The average number of physical sectors between the last logical block of one cylinder and the first logical block of the next cylinder. A value of zero indicates no skew. Cylinder skew will be utilized by a disc drive but is not changeable by an initiator.

**145 Data Bytes Per Physical Sector**

The number of data bytes the disc drive allocates per physical sector. This value equals the block length reported in the Mode Sense block descriptor. The bytes per physical sector is not directly changeable by the initiator and is not verified on a Mode Select command.

**145 Drive Type**

The Hard Sectoring (HSEC) bit (bit 6) set to one indicates the disc drive uses hard sector formatting.

The Soft Sectoring (SSEC) bit (bit 7) when set to one indicates the drive uses soft sectoring.

Bits 0–5, and 7 are not implemented by the disc drive and are always zero. Bits 0 – 7 are not changeable.

**145 Interleave**

The interleave value sent to the disc drive during the last Format Unit command.

**Note.** This field is valid only for Mode Sense commands. The disc drive ignores this field during Mode Select commands.

**145 Page Code**

03h Format Parameters page code.

**145 Page Length**

16h The length of the Format Parameters page (in bytes).

**145 PS (Parameter Savable)**

This bit is not used with the Mode Select command.

1 The page 03h parameter data is savable.

**145 RMB (Removable)**

0 Indicates that the logical unit supports removable media.

1 Indicates that the logical unit does not support removable media.

The status of this bit is reflected in the Inquiry command, removable media bit (RMB).

**145 Sectors Per Track**

The average number of physical sectors the disc drive has per disc track. This value depends on the selected sector size and ZBR zones. The number of user accessible sectors per track may be fewer than the reported value, since sectors per track includes sectors set aside for defect management. This value cannot be used to calculate drive user-accessible capacity.

**Note.** The value cannot be directly selected with the Mode Select command, but is a report of how the drive is configured.

**145 SURF (Surface)**

0 The target allocates progressive addresses to all logical blocks within a cylinder prior to allocating addresses on the next cylinder

- 1 The target allocates progressive addresses to all logical blocks on a surface prior to allocating sector addresses on the next surface.

**145 Track Skew Factor**

The average number of physical sectors between the last logical block on one track and the first logical block on the next sequential track of the same cylinder. A value of zero indicates no skew.

**Note.** This value is not changeable by an initiator.

**145 Tracks Per Zone**

The number of tracks the disc drive allocates to each defect management zone. Seagate drives define a defect management zone as one track or one cylinder. A programmed value of 1 defines one track per zone (i.e. spare sectors per track). Any other recorded value results in the drive defining one cylinder as the defect management zone and the drive automatically inserts the number of read/write heads (i.e., number of tracks per cylinder) in this field. Default value is usually 1, but see individual drive's Product Manual, Volume 1.

**12.11.5 Rigid Disc Drive Geometry Parameters page (04h)**

The Rigid Disc Drive Geometry Parameters page implementation is defined in Table 146. This table summarizes the function and defines the default value.

See the individual drive's Product Manual, Volume 1, Mode Sense Data section, for changeable values.

**Table 146. Rigid Disc Drive Geometry Parameters page (04h)**

Bit	7	6	5	4	3	2	1	0	
Byte									
<b>Page descriptor header</b>									
0	1	0	0	0	0	1	0	0	
	PS		Page Code (04h)						
1	Page Length (16h)								
<b>Rigid disc drive geometry parameters</b>									
2 Default	Number of Cylinders (MSB)								
3 Default	Number of Cylinders								
4 Default	Number of Cylinders (LSB)								
5 Default	Number of Heads								
6–8 Default	Starting Cylinder–Write Precomp.								
9–11 Default	Starting Cylinder–Reduced Write Current								
12,13 Default	Drive Step Rate								
14–16 Default	Landing Zone Cylinder								
17 Default	0	0	0	0	0	0	RPL		
18 Default	Rotational Offset (XXh)								
19 Default	0	0	0	0	0	0	0	0	
	Reserved								
20	Medium Rotation Rate								
21									(MSB)
22 Default	0	0	0	0	0	0	0	0	
	Reserved								
23 Default	0	0	0	0	0	0	0	0	
	Reserved								

**Table number** Field definitions (listed alphabetically)

**146 Drive Step Rate**

Not applicable.

**146 Landing Zone Cylinder**

Not applicable.

**146 Medium Rotation Rate**

On Mode Sense commands, these bytes return drive nominal rotation rate in revolutions per minute for synchronous spindle operation. The bytes have no meaning for Mode Select.

**146 Number of Cylinders**

The number of physical cylinders used for data storage. This may or may not include spare cylinders set aside for flaw reallocation. See individual drive's Product Manual, Volume 1, which specifies what the drive reports.

The disc drive uses some additional cylinders for storing disc drive parameters, defect lists, or for diagnostic purposes. These are not accessible by the user.

**146 Number of Heads**

The maximum number of data (read/write) heads on the disc drive.

**146 Page Code**

04h Rigid Disc Drive Geometry Parameters page code.

**146 Page Length**

16h The length of the Rigid Disc Drive Geometry Parameters page (in bytes). If the allocation length is too small to transfer all of the page, the page length is not adjusted to reflect the truncation.

**146 PS (Parameter Savable)**

See applicable drive's Product Manual, Volume 1, for features supported. This bit is not used with the Mode Select command.

1 Page 04 parameter data is savable and is saved when a Format function is performed. In some drives an exception exists that applies to bytes 17 and 18. In the exception drives, bytes 17 and 18 are only saved if the SMP bit in the Mode Select command (Table 133) is 1.

**146 Rotational Offset**

Rotational skew in the lagging direction used for spindle synchronization.

XXh Represents a XXh/FFh fractional part of a revolution lagging offset. One revolution lag is maximum.

**146 RPL (Rotation Position Locking)**

Used for spindle synchronization.

00b Automatic spindle synchronization (automatic master arbitration is used to determine which device in the chain is to be the master).

01b The target operates as a synchronized spindle slave.

10b The target operates as a synchronized spindle master.

11b The target operates as a synchronized spindle master control (not supported by the disc drive).

**146 Starting Cylinder–Reduced Write Current**

Not applicable.

**146 Starting Cylinder–Write Precomp**

Not applicable.

**12.11.6 Verify Error Recovery page (07h)**

The Verify Error Recovery page specifies the error recovery parameters the target uses during the Verify command and the verify operation of the Write and Verify command.

**Table 147. Verify Error Recovery page (07h)**

Bit Byte	7	6	5	4	3	2	1	0
<b>Page descriptor header</b>								
0	1 PS	0 Reserved	Page Code (07h)					
1	Page Length (0Ah)							
<b>Verify error recovery parameters</b>								
2 Default	0	0	0	0	0	PER	DTE	DCR
	Reserved				EER			
3 Default	Verify Retry Count							
4 Default	Verify Correction Span (bits)							
5 Default	0	0	0	0	0	0	0	0
	Reserved							
6 Default	0	0	0	0	0	0	0	0
	Reserved							
7 Default	0	0	0	0	0	0	0	0
	Reserved							
8 Default	0	0	0	0	0	0	0	0
	Reserved							
9 Default	0	0	0	0	0	0	0	0
	Reserved							
10 Default	(MSB) 1	1	1	1	1	1	1	1
	Verify Recovery Time Limit							
11 Default	1	1	1	1	1	1	1	1 (LSB)
	Verify Recovery Time Limit							

**Table 147 Field definitions (listed alphabetically)****147 DCR (Disable Correction)**

- 1 ECC correction will not be applied to the data even if correction is possible.
- 0 ECC correction will be applied if correction is possible.

**147 DTE (Disable Transfer on Error)**

The DTE bit is valid only when the PER bit is set to 1.

- 1 The disc drive terminates data transfer even for recoverable errors (the drive will transfer the data for the recovered error before terminating the transfer).
- 0 Data transfer continues if recoverable errors are encountered. Recoverable errors are reported after all data has been transferred.

**147 EER (Enable Early Recovery)**

- 1 The disc drive applies on-the-fly T>1 ECC correction as soon as possible, before attempting other retry mechanisms, and without reporting successful corrections to the host as recovered error. Seek error retries and message system errors are not affected by this bit. When this bit is set to 1, the DCR bit must be zero (0).
- 0 The disc drive applies ECC correction before other retry mechanisms, but does not perform T>1 corrections on the fly; any successful correction will be reported to the host as a recovered error.

**147 Page Code**

07h Verify Error Recovery page code.

**147 Page Length**

0Ah This field specifies the length of the parameter that follows (in bytes).

**147 PER (Post Error)**

- 1 The disc drive reports Check Condition status and appropriate sense key for any recovered errors encountered. Reporting of unrecoverable errors has priority over reporting of recoverable errors.
- 0 Any errors recovered within the limits established by the other Error Recovery Flags are not reported. Any unrecoverable errors are reported.

**147 PS (Parameter Savable)**

Used only with the Mode Sense command. This bit is not used with the Mode Select command.

- 1 The target is capable of saving the page in a nonvolatile vendor-specific location.

**147 Verify Correction Span**

The size (in bits) of the largest burst data error for which data error correction may be attempted. If the drive does not implement this field, a value of zero (0) is returned in Mode Sense data.

**147 Verify Recovery Time Limit**

The maximum time (in increments of one millisecond) that the drive uses error recovery procedures to recover data for an individual logical block. If the verify retry count and the verify recovery time limit are both specified, the one that requires the least time for a data error recovery actions has priority. The drive may round this value.

**147 Verify Retry Count**

The number of times the drive will attempt its recovery algorithm during a verify operation. If the verify retry count and the verify recovery time limit are both specified, the one that requires the least time for data error recovery actions has priority.

### 12.11.7 Caching Parameters page (08h) for Mode Sense/Mode Select

The Caching Parameters page defines the parameters that affect the use of the cache.

**Table 148. Caching Parameters page (08h)**

Bit Byte	7	6	5	4	3	2	1	0
<b>Page descriptor header</b>								
0	PS	Reserved	Page Code (08h)					
1	Page Length (12h)							
2	IC	ABPF	CAP	DISC	SIZE	WCE	MF	RCD
3	Demand Read Retention Priority				Write Retention Priority			
4	(MSB) _____							
5	Disable Prefetch Transfer Length							(LSB)
6	(MSB) _____							
7	Minimum Prefetch							(LSB)
8	(MSB) _____							
9	Maximum Prefetch							(LSB)
10	(MSB) _____							
11	Maximum Prefetch Ceiling							(LSB)
12	FSW	LBCSS	DRA	Reserved				
13	Number of Cache Segments							
14	(MSB) _____							
15	Cache Segment Size							(LSB)
16	Reserved							
17	(MSB) _____							
18	Non-Cache Segment Size							(LSB)
19	(LSB)							

#### Table number Field definitions (listed alphabetically)

##### 148 ABPF (Abort Prefetch)

- 1 With the DRA bit equal to zero (0), requests that the SCSI device abort the prefetch upon selection. The ABPF set to 1 takes precedence over the Minimum Prefetch bytes.
- 0 With the DRA bit equal to zero (0), the termination of any active prefetch is dependent upon Caching Page bytes 4 through 11 and is operation and/or vendor specific.

##### 148 Cache Segment Size

The requested segment size (in bytes). This standard assumes that the Cache Segment Size field is valid only when the SIZE bit is 1.

##### 148 CAP (Caching Analysis Permitted)

- 1 Caching analysis enabled.
- 0 Caching analysis disabled.

Caching analysis results are placed in the SCSI Logging Information Table (Table 131).

##### 148 Demand Read Retention Priority

The cache replacement algorithm does not distinguish between retention in the cache of host-requested data and prefetch data. Therefore, this half byte is always zero (0).

**148 Disable Prefetch Transfer Length**

Prefetch is disabled for any SCSI Read command whose requested transfer length exceeds this value.

**148 DISC (Discontinuity)**

- 1 The SCSI device continues the prefetch across time discontinuities, such as across cylinders or tracks up to the limits of the buffer, or segment, space available for prefetch.
- 0 Prefetches are truncated at time discontinuities.

**148 DRA (Disable Read-Ahead)**

- 1 The target will not read any logical blocks into the buffer beyond the addressed logical block(s).
- 0 The target may continue to read logical blocks into the buffer beyond the addressed logical block(s).

**148 FSW (Force Sequential Write)**

- 1 Multiple block writes are to be transferred over the interface and written to the media in an ascending, sequential, logical block order.
- 0 The target is allowed to reorder the sequence of writing addressed logical blocks in order to achieve a faster command completion.

**148 IC (Initiator Control)**

- 1 Adaptive read look-ahead (ARLA) is disabled.
- 0 Adaptive read look-ahead (ARLA) is enabled.

Since Seagate drives covered by this manual never organize the cache according to size of segment, but rather by number of segments, this bit is used to enable or disable adaptive RLA.

**Note.** ARLA cannot be disabled in some Seagate drives using the ASA II code. See individual drive's Product Manual, Volume 1.

**148 LBCSS (Logical Block Cache Segment Size)**

Not used at this time.

**148 Maximum Prefetch**

The maximum number of logical blocks that may be prefetched. The prefetch operation may be aborted before the maximum prefetch value is reached, but only if the minimum prefetch value has been satisfied.

**148 Maximum Prefetch Ceiling**

The upper limit on the number of logical blocks computed as the maximum prefetch. If the Maximum Prefetch value is greater than the Maximum Prefetch Ceiling value, the value is truncated to the Maximum Prefetch Ceiling value.

**148 MF (Multiplication Factor)**

- 0 The Minimum Prefetch and Maximum Prefetch fields are interpreted as a number of logical blocks.
- 1 The target interprets the minimum and maximum prefetch fields to be specified in terms of a scalar number which, when multiplied by the number of logical blocks to be transferred for the current command, yields the number of logical blocks for each of the respective types of prefetch.

**148 Minimum Prefetch**

The minimum number of sectors to prefetch, regardless of the delay it may cause to other commands.

**148 Non-Cache Segment Size**

If the Non-Cache Buffer Size field (Bytes 17–19) is greater than zero (0), this field specifies to the target the number of bytes the initiator requests that the target allocate for a buffer function when all other cache segments are occupied by data to be retained. If the number is at least 1, caching functions in the other segments need not be impacted by cache misses to perform the SCSI buffer function.

If the Non-Cache Segment Size field = 0

or

the Non-Cache Segment Size field value + Cache Segment Size field > buffer size,

then

the vendor determines the cache function.

**148 Number of Cache Segments**

The number of segments into which the host requests the drive divide the cache.



**148 Page Code**

08h Caching Parameters page for Mode Sense/Mode Select page code.

**148 Page Length**

12h The length of the Caching Parameters page (in bytes). If the allocation length is too small to transfer all of the page, the page length is not adjusted to reflect the truncation.

**148 PS (Parameter Savable)**

This bit is not used with the Mode Select command.

- 1 Page 01h parameter data is savable and the bit function is directly changeable by an initiator (see Mode Select command).
- 0 This bit function is not directly changeable by an initiator, a value of 1 means the bit function is directly changeable by an initiator. See the individual drive's Product Manual, Volume 1, for changeable values.

**148 RCD (Read Cache Disable)**

- 0 SCSI Read commands may access the cache or the media.
- 1 SCSI Read commands must access the media. Data cannot come from the cache.

**148 SIZE (Size Enable)**

For Seagate drives covered by this manual, this bit is always zero (0).

- 1 The Cache Segment Size is to be used to control caching segmentation.
- 0 The Initiator requests that the Number of Cache Segments is to be used to control caching segmentation.

**148 WCE (Write Cache Enable)**

- 0 SCSI Write commands will not return Completion Status until all data has been written to the media.
- 1 SCSI Write commands may return Completion Status as soon as all data has been received from the host.

**148 Write Retention Priority**

The cache replacement algorithm does distinguish between retention in the cache of host-requested data and prefetch data. Therefore, this half byte is always 0.

**Note.** In addition to the caching control provided by the Caching Mode page, some 10-byte commands contain control bits DPO and FUA—the intent of which is to override the cache page control bits.

### 12.11.8 Mode Sense/Mode Select Control Mode page (0Ah)

The Control Mode page provides controls over several SCSI-2 features which are applicable to all device types such as tagged queuing, extended contingent allegiance, asynchronous event notification, and error logging.

See the individual drive's Product Manual, Volume 1, Mode Sense Data table for changeable values.

**Table 149. Control Mode page (0Ah)**

Bit Byte	7	6	5	4	3	2	1	0	
0	1 PS	Reserved	Page Code (0Ah)						
1	Page Length (0Ah)								
2 Default	0	0	0	0	0	0	GLTSD	RLEC	
3 Default	Queue Algorithm Modifier				0 Reserved		0	QErr	DQue
4 Default	Reserved	RAC	0	0	SWP	0	0	0 Not Supported	
5 Default	0	0	0	0	0	0	0	0	
6 & 7 Default	0	0	0	0	0	0	0	0	
8 & 9 Default	Busy Timeout Period								
10	MSB								
11	Extended Self-test Routine Completion Time								
	LSB								

#### Table number Field definitions (listed alphabetically)

##### 149 Busy Timeout Period

The maximum time, in 100 millisecond increments, that the initiator allows for the target to remain busy for unanticipated conditions that are not a routine part of commands from the initiator. This value may be rounded down as defined in Section 4.8 of this manual.

0000h Undefined.

FFFFh Unlimited period.

##### 149 DQue (Disable Queuing)

Drives supported by this manual require this bit to be set to zero (0).

1 Tagged queuing is disabled on the disc drive. This is not a valid value for the drives supported by this manual.

0 Tagged queuing is enabled.

##### 149 Extended Self-test Routine Completion Time

This field contains an advisory parameter that the application client may use to determine the time, in seconds, that the device server requires to complete the extended device self-test when the device server is not interrupted by an application client and no errors occur during execution of the device self-test. The application client should expect this time to increase significantly if other commands are sent to the logical unit while a test is in progress or if errors occur during execution of the test. Device servers supporting Self-test Code field values other than 000b for the Send Diagnostic command (see Section 12.36) support the Extended Self-test Completion Time field.

**149 GLTSD (Global Logging Target Save Disable)**

- 0 The target provides a target-defined method for saving log parameters (Logged to disk).
- 1 Either the target has disabled the target-defined method for saving log parameters or, when set by the initiator, specifies that the target-defined method will be disabled.

**149 Page Code**

0Ah Control Mode page code.

**149 Page Length**

0Ah The length of the Control Mode page (in bytes). If the allocation length is too small to transfer all of the page, the page length is not adjusted to reflect the truncation.

**149 PS (Parameter Savable)**

This bit is not used with the Mode Select command.

- 1 Page 0Ah parameter data is savable in nonvolatile memory.

**149 QErr (Queue Error Management)**

- 0 Commands still queued after the device has entered an auto contingent allegiance condition continue execution in a normal manner when that condition has terminated.
- 1 Commands still queued after the device has entered an auto contingent allegiance condition will be aborted when that condition has terminated. A unit attention condition is created for each initiator that had commands in the queue, but not for the initiator detecting the original error.

**149 Queue Algorithm Modifier**

Specifies restrictions on the algorithm used for reordering commands that are tagged with the Simple Queue Tag message.

- 0h Guarantee data integrity. The device must order the actual execution sequence of the queued command such that data integrity is guaranteed at any time. This requires that, if the data transmission of a command was halted at any time, the final value of all data must have exactly the same value it would have had if the command had been executed without queuing. The guaranteed data integrity value (0h) of the queue algorithm modifier bits is the usual default value.
- 1h Unrestricted reordering allowed. The device is allowed to order the actual execution sequence of the queued commands in any manner it selects. Any data integrity problems related to command sequence ordering are explicitly handled by the host operating system software.
- 2h–7h Reserved.
- 08h–Fh Vendor specific.

**149 RAC (Report A Check)**

Not used at this time.

**149 RLEC (Report Log Exception Condition)**

- 1 The drive reports log exception conditions.
- 0 The drive does not report log exception conditions.

**149 SWP (Software Write Protect)**

- 0 The medium is write enabled.
- 1 The medium is write protected.

### 12.11.9 Notch page (0Ch)

The Notch page contains parameters for direct access devices that implement a variable number of blocks per cylinder and support this page. Each section of the drive with a different number of blocks per cylinder is referred to as a notch.

**Note.** These values are not changeable.

**Table 150. Notch page (0Ch)**

Bit Byte	7	6	5	4	3	2	1	0
0	PS	0 Reserved	0	0	1	1	0	0
	Page Code (0Ch)							
1	Page Length (16h)							
2 Default	ND	0 LPN	0	0	0	0	0	0
	Reserved							
3 Default	0	0	0	0	0	0	0	0
	Reserved							
4,5 Default	(MSB)	Maximum Number of Notches						(LSB)
6,7 Default	(MSB)	Active Notch						(LSB)
8–11 Default	(MSB)	Starting Boundary						(LSB)
12–15 Default	(MSB)	Ending Boundary						(LSB)
16–23 Default	(MSB)	Pages Notched						(LSB)

#### Table number Field definitions (listed alphabetically)

##### 150 Active Notch

The notch to which this and subsequent Mode Select and Mode Sense commands refers, until the active notch is changed by a later Mode Select command. The value of the active notch is greater than or equal to zero (0) and less than or equal to the Maximum Number of Notches field value.

0 This and subsequent Mode Select and Mode Sense commands refer to the parameters that apply across all notches.

##### 150 Ending Boundary

The ending of the active notch or, if the active notch is zero (0), the ending of the drive. If the LPN bit is 1, then the four bytes represent the logical block address. If the LPN bit is zero (0), the three most significant bytes represent the cylinder number and the least significant byte represents the head number. When used with the Mode Select command this field is ignored.

Each notch will span a set of consecutive logical blocks on the drive, the notches will not overlap, and no logical block will be excluded from a notch.

##### 150 LPN (Logical or Physical Notch)

0 The notch boundaries are based on the physical parameters of the drive. The cylinder is considered most significant, the head least significant.

1 The notch boundaries are based on logical blocks on the drive.

##### 150 Maximum Number of Notches

The maximum number of notches supported by the drive.

**150 ND (Notched Drive)**

- 0 The device is not notched. All other parameters in this page will be returned as zero (0) by the drive.
- 1 The drive is notched. For each supported active notch value, this page defines the starting and ending boundaries of the notch.

**150 Page Code**

0Ch Notch page code.

**150 Page Length**

16h The length of the Notch page (in bytes). If the allocation length is too small to transfer all of the page, the page length is not adjusted to reflect the truncation.

**150 Pages Notched**

A bit map of the mode page codes that indicates which pages contain parameters that may be different for different notches. The most significant bit of this field corresponds to Page Code 3Fh and the least significant bit corresponds to Page Code 00h. If a bit is 1, the corresponding mode page contains parameters that may be different for different notches. If a bit is zero (0), the corresponding mode page contains parameters that are constant for all notches.

**150 PS (Parameter Savable)**

This bit is only used with the Mode Sense command. This bit is not used with the Mode Select command.

- 1 The drive is capable of saving the page in a nonvolatile vendor-specific location.

**150 Starting Boundary**

The beginning of the active notch or, if the active notch is zero (0), the beginning boundary of the drive. If the LPN bit is 1, then the four bytes represent a logical block address. If the LPN bit is zero (0), then the three most significant bytes represent the cylinder number and the least significant byte represents the head number. When used with the Mode Select command this field is ignored.

### 12.11.10 XOR Control Mode page (10h)

The XOR Control Mode page provides the initiator with the means to obtain or modify certain XOR target operating parameters..

**Table 151. XOR Control Mode page (10h)**

Bit Byte	7	6	5	4	3	2	1	0
0	PS	0 Reserved	0	1	0	0	0	0
	Page Code (10h)							
1	Page Length (16h)							
2	0	0	0	0	0	0	XORDis	Reserved
Default	Reserved							
3	0	0	0	0	0	0	0	0
Default	Reserved							
4–7	(MSB) _____							
Default	Maximum XOR Write Size						_____ (LSB)	
8–11	(MSB) _____							
Default	Reserved						_____ (LSB)	
12–15	(MSB) _____							
Default	Maximum Regenerate Size						_____ (LSB)	
16–19	(MSB) _____							
Default	Maximum Rebuild Read Size						_____ (LSB)	
20	(MSB) _____							
21	Reserved						_____ (LSB)	
22	(MSB) _____							
23	Rebuild Delay						_____ (LSB)	

#### Table number Field definitions (listed alphabetically)

##### 151 Maximum Rebuild Read Size

The maximum rebuild length (in blocks) that the target will use for Read commands during a rebuild operation. This field does not limit the rebuild size.

##### 151 Maximum Regenerate Size

The maximum regenerate length (in blocks) that the target accepts for the Regenerate command.

##### 151 Maximum XOR Write Size

The maximum transfer length (in blocks) that the target accepts for a single XDWrite Extended, XDWrite, or XPWrite command.

##### 151 Page Code

10h XOR Control Mode page code.

##### 151 Page Length

16h The length of the XOR Control Mode page (in bytes). If the allocation length is too small to transfer all of the page, the page length is not adjusted to reflect the truncation.

##### 151 PS (Parameter Savable)

This bit is only used with the Mode Sense command. This bit is not used with the Mode Select command.

1 The drive is capable of saving the page in a nonvolatile vendor-specific location.

**151 Rebuild Delay**

The minimum time (in milliseconds) between successive Read commands during a rebuild operation.

**151 XORDis**

This bit enables and disables XOR operations within a device.

- 0 Enables XOR operations.
- 1 Disables XOR operations. If an XOR command is sent to the target, the command is terminated with Check Condition status. The sense data will be set to Illegal Request: Invalid Command Operation Code.

### 12.11.11 Fibre Channel Interface Control page (19h)

The Fibre Channel Interface Control page controls options relevant to Fibre Channel protocol. It is intended for the control of features unique to Fibre Channel protocol that are not suitable for control by login or other techniques defined for Fibre Channel.

Mode page 19h, byte 3, bits 0 through 5 are changeable using the Mode Select command. When this byte is changed, the new value is stored in nonvolatile (flash) memory, not on disc, and is reported during a Mode Sense command when either the current or saved value is requested. There is no distinction between the current and saved values for this byte. The default value of this byte is 0.

Byte 3 may be modified using the Mode Select command up to 32 times. After 32 modifications, additional attempts to modify will result in a response of Illegal Request (05) with Error Code of 2600 (Invalid field in parameter list) and the Sense Key pointing to byte 3 as the offending parameter. Additional byte 3 updates may be accomplished by downloading new microcode that supports Fibre Channel Interface Control page 19h. After download, the byte may be updated 31 more times, or 32 more times if the value is 0 at the time of download. The current value of byte 3 is preserved through the download.

Updating mode page 19h, byte 3, results in the drive performing a reset similar to that performed following a microcode download.

**Table 152. Fibre Channel Interface Control page (19h)**

Bit Byte	7	6	5	4	3	2	1	0
0	1 PS	0 Reserved	0	1	1	0	0	1
	Page Code (19h)							
1	Page Length (06h)							
2 Default	0	0	0	0	0	0	0	0
	Reserved							
3 Default	DTFD	PLPB	DDIS	DLM	DSA	ALWLI	DTIPE	DTOLI
4 Default	0	0	0	0	0	0	0	0
	Reserved							
5 Default	0	0	0	0	0	0	0	0
	Reserved							
6 Default	0	0	0	0	0	0	0	0
	Reserved							
7 Default	0	0	0	0	0	0	0	0
	Reserved							

#### Table number Field definitions (listed alphabetically)

##### 152 ALWLI (Allow Login Without Loop Initialization)

- 1 The target uses the Select\_ID address available in the SCA connector and accepts logins without verifying the address with loop initialization.
- 0 The target must verify the address through loop initialization before accepting a login.

##### 152 DDIS (Disable Discovery)

- 1 The target does not require receipt of Address or Port Discovery ELS following loop initialization. The target resumes processing of tasks upon completion of loop initialization.
- 0 The target must wait to receive an Address or Port Discovery ELS before it resumes processing tasks for that initiator.



**152 DLM (Disable Loop Master)**

- 1 The target does not become loop master. The target only repeats the LISM frames it receives. This allows the initiator to become the loop master during loop initialization.
- 0 The target must wait to receive an Address or Port Discovery ELS before it resumes processing tasks for that initiator.

**152 DSA (Disable Soft Address)**

- 1 The target does not select a soft address if there is a conflict for the Select\_ID address available in the SCA connector during loop initialization. If there is a Select\_ID address conflict, the target enters the non-participation state. If the target detects loop initialization while in the non-participation state, the target again attempts to get the Select\_ID address.
- 0 The target attempts to obtain a soft address during loop initialization if the Select\_ID address is not available or if the Select\_ID address indicates the use of a soft address (7Fh).

**152 DTFD (Disable Target Fabric Discovery)**

- 1 The target attached by an FC-AL loop will not recognize the presence of a fabric loop port (FL\_Port) on the loop. The target will only perform the private loop functions defined for FC-PLDA targets.
- 0 The target attached by an FC-AL loop will discover the FL\_Port if present on the loop and will perform the public loop functions defined for FC-FLA targets. Targets attached to an N\_Port or to an F\_Port will ignore this bit.

**152 DTIPE (Disable Target Initiated Port Enable)**

- 1 The target waits for an initiator to send the Loop Port Enable primitive before inserting itself into the loop. The target uses the Select\_ID address available in the SCA connector to determine if primitives are addressed to it.

**Note.** Do not set the PLPB bit to one (1) and the DTIPE bit to one (1) at the same time as this is an illegal bit combination. When an illegal bit combination is sent by the application client, the device server returns Check Condition status and sets the sense key to Illegal Request with the additional sense code set to Invalid Field in the Parameter List.

- 0 After completing self test, the target enables the port in the loop without waiting for a Loop Port Enable primitive.

**152 DTOLI (Disable Target Oriented Loop Initialization)**

- 1 The target does not originate the initializing LIP following insertion into the loop. The target responds to an Initializing LIP when it is received. The target originates the Loop Failure LIP if it detects loop failure at its input. The target originates the Initializing LIP when the loop failure is corrected.
- 0 After completing self test, the target originates the Initializing LIP when it enables a port in a loop.

**153 Page Code**

- 19h Fibre Channel Interface Control page code.

**153 Page Length**

- 06h The length of the Fibre Channel Interface Control page (in bytes). If the allocation length is too small to transfer all of the page, the page length is not adjusted to reflect the truncation.

**153 PS (Parameter Savable)**

This bit is only used with the Mode Sense command. This bit is not used with the Mode Select command.

- 1 The drive is capable of saving the page in a nonvolatile vendor-specific location.

**152 PLPB (Prevent Loop Port Bypass)**

- 1 The target ignores any Loop Port Bypass (LPB) and Loop Port Enable (LPE) primitive sequences. The loop port remains enabled.

**Note.** Do not set the PLPB bit to one (1) and the DTIPE bit to one (1) at the same time as this is an illegal bit combination. When an illegal bit combination is sent by the application client, the device server returns Check Condition status and sets the sense key to Illegal Request with the additional sense code set to Invalid Field in the Parameter List.

- 0 The target allows the Loop Port Bypass and Port Bypass Enable primitive sequences to control the port bypass circuit.

### 12.11.12 Power Condition page (1Ah)

The Power Condition page provides the initiator the means to control the length of time a logical unit will delay before changing its power requirements. There is no notification to the initiator that a logical unit has entered into one of the power conditions. On receipt of this command, the device adjusts itself to the power condition which allows the command to execute. The timer which maps to this power condition and any lower power condition timers is reset on receipt of the command. The timer associated with this power condition is restarted when the condition that forces the change in power completes.

**Table 153. Power Condition page (1Ah)**

Bit Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (1Ah)					
1	Page Length (0Ah)							
2	Reserved							
3	Reserved						Idle	Standby
4	(MSB)							
5	Idle Condition Timer							
6								
7								
8	(MSB)							
9	Standby Condition Timer							
10								
11								

#### Table number Field definitions (listed alphabetically)

##### 153 Idle

- 1 The drive will use the Idle Condition Timer to determine the length of inactivity time to wait before entering the Idle condition.
- 0 The drive will not enter the Idle condition.

##### 153 Idle Condition Timer

The inactivity time (in 100 millisecond increments) that the logical unit will wait before entering the Idle condition. Minimum time is 500 milliseconds.

Not supported at this time.

##### 153 Page Code

1Ah Power Condition page code.

##### 153 Page Length

0Ah The length of the Power Condition page (in bytes). If the allocation length is too small to transfer all of the page, the page length is not adjusted to reflect the truncation.

##### 153 PS (Parameter Savable)

This bit is only used with the Mode Sense command. This bit is not used with the Mode Select command.

- 1 The drive is capable of saving the page in a nonvolatile vendor-specific location.

##### 153 Standby

Not supported at this time.

##### 153 Standby Condition Timer

Not supported at this time.

### 12.11.13 Informational Exceptions Control page (1Ch)

The Informational Exceptions Control page (see Table 154) defines the methods used by the target to control the reporting and the operations of specific informational exception conditions. This page only applies to informational exceptions that report an additional sense code of Failure Prediction Threshold Exceeded to the application client.

Informational exception conditions occur as the result of vendor specific events within a target. An information exception condition may occur asynchronous to any commands issued by an application client.

**Table 154. Informational Exceptions Control page (1Ch)**

Bit Byte	7	6	5	4	3	2	1	0
0	PS	Reserved	Page Code (1Ch)					
1	Page Length (0Ah)							
2	Perf	Reserved			DExcpt	Test	Reserved	LogErr
3	Reserved				MRIE			
4	(MSB)							
:	Interval Timer							
7								
8	(MSB)							
:	Report Count							
11								

**Table number** **Field definitions (listed alphabetically)**

**154 DExcpt (Disable Exception Control)**

- 0 Information exception operations are enabled and the Method of Reporting Informational Exceptions field determines the reporting of information exception conditions.
- 1 Information exception operations are disabled by target and the Method of Reporting Informational Exceptions field is ignored.

**154 Interval Timer**

Indicates the period (in 100 millisecond increments) for reporting that an informational exception condition has occurred. The target does not report informational exception conditions more frequently than the time specified by the Interval Timer field and as soon as possible after the timer interval has elapsed. After the informational exception condition has been reported, the Interval Timer is restarted.

0 Target only reports the informational exception condition one time.

FFFFFFFFh Timer interval is vendor specific.

Maintaining of the Interval Timer field's access power cycle and/or reset by the target is vendor specific.

**154 LogErr (Log Errors)**

0 The logging of informational exception conditions within a target is vendor specific.

1 The target logs informational exception conditions.

**154 MRIE (Method of Reporting Informational Exceptions)**

Indicates the methods that are used by the target to report informational exception conditions (see Table 155). The priority of reporting multiple information exceptions is vendor specific.

**Table 155. Method of Reporting Informational Exceptions field**

MRIE	Description
0h	No reporting of informational exception condition. This method instructs the target to not report information exception conditions.
1h	Asynchronous event reporting. This method instructs the target to report informational exception conditions by using the rules for asynchronous event reporting as described in the SCSI-3 Architecture Model and the relevant Protocol Standard. The sense key is set to Recovered Error and the additional sense code indicates the cause of the informational exception condition.
2h	Generate unit attention. This method instructs the target to report informational exception conditions by returning a Check Condition status on any command. The sense key is set to Unit Attention and the additional sense code indicates the cause of the informational exception condition. The command that has the Check Condition is not executed before the informational exception condition is reported.
3h	Conditionally generate recovered error. This method instructs the target to report informational exception conditions, dependent on the value of the per bit of the error recovery parameters mode page, by returning a Check Condition status on any command. The sense key is set to Recovered Error and the additional sense code indicates the cause of the informational exception condition. The command that has the Check Condition completes without error before any informational exception condition may be reported.
4h	Unconditionally generate recovered error. This method instructs the target to report informational exception conditions, regardless of the value of the per bit of the error recovery parameters mode page, by returning a Check Condition status on any command. The sense key is set to Recovered Error and the additional sense code indicates the cause of the information exception condition. The command that has the Check Condition completes without error before any informational exception condition may be reported.
5h	Generate no sense. This method instructs the target to report informational exception conditions by returning a Check Condition status on any command. The sense key is set to No Sense and the additional sense code indicates the cause of the informational exception condition. The command that has the Check Condition completes without error before any informational exception condition may be reported.
6h	Only report informational exception condition on request. This method instructs the target to preserve the informational exception information. To find out about information exception conditions, the application client polls the target by issuing an unsolicited Request Sense command. The sense key is set to No Sense and the additional sense code indicates the cause of the informational exception condition.
7h-Bh	Reserved.
Ch-Fh	Vendor specific.

**154 Page Code**

1Ch Informational Exceptions Control page code.

**154 Page Length**

0Ah The length of the Informational Exceptions Control page (in bytes). If the allocation length is too small to transfer all of the page, the page length is not adjusted to reflect the truncation.

**154 PS (Parameter Savable)**

This bit is not used with the Mode Select command.

**154 Perf (Performance)**

- 0 Informational exception operations that are the cause of delays are acceptable.
- 1 The target does not cause delays while doing informational exception operations. A Perf bit set to one may cause the target to disable some or all of the informational exceptions operations, thereby limiting the reporting of informational exception conditions.

**154 Report Count**

Indicates the number of times to report an informational exception condition to the application client. Maintaining of the Report Count field's access power cycle and/or reset by the target is vendor specific.

- 0 Indicates there is no limit on the number of times the target reports an informational exception condition.

**154 Test**

This field specifies whether the drive will create false drive failure notifications.

- 0 The drive does not create false drive failure notifications.
- 1 The drive creates false drive failures at the next interval time, provided that the DExcpt bit is not set. The MRIE and Report Count fields apply as specified in this document. A false drive failure will be reported as sense code/qualifier 5DFF (FF for false failure versus a true failure 5D00).

### 12.12 Mode Sense (10) command 5Ah

The Mode Sense (10) command provides a means for the drive to report drive operating mode parameters to the initiator. It is a complementary command to the Mode Select (10) command.

**Table 156. Mode Sense (10) command (5Ah)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	1	0	1	1	0	1	0
1	0	0	0	Reserved	DBD	Reserved		
2	PCF		Page Code					
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) _____							
8	Allocation Length						_____ (LSB)	
9	Control							

See the Mode Sense (6) command (Section 12.11) for a description of the fields in this command.

**Table 157. Mode Sense (10) data**

Bit Byte	7	6	5	4	3	2	1	0	
0	Sense Data Length								
1									(MSB)
2	0	0	0	0	0	0	0	0	
Medium Type									
3	WP	0	0	DPO-FUA	0	0	0	0	
		Reserved				Reserved			
4	Reserved								
5	Reserved								
6	Block Descriptor Length (8 decimal)								
7									(MSB) 0
		0	0	0	0	1	0	0	0 (LSB)
0–7		Block Descriptor Data (see Table 139)							
0–n		Mode Sense Page Headers and Their Parameters							

**Table number** **Field definitions (listed alphabetically)**

**157 Block Descriptor Data**

See Table 139.

**157 Block Descriptor Length**

The length (in bytes) of the block descriptor. It is equal to the number of bytes in the Block Descriptor (8) and does not include the page headers and mode parameters, if any. The disc drive sends one Block Descriptor.

Each Block Descriptor specifies the medium characteristics for all or part of a logical unit. Each Block Descriptor contains a Density Code, a Number of Blocks, and a Block Length.

**157 DPO-FUA (Disable Page Out–Force Unit Access)**

- 0 When used with the Mode Sense command, this value indicates that the target does not contain a cache memory or does not support the DPO and FUA bits.
- 1 The target supports the DPO and FUA bits.

**157 Medium Type**

00h (default medium). This is the only valid value.

**157 Mode Sense Page Headers and Their Parameters**

See Table 139.

**157 Sense Data Length**

The length (in bytes) of the Mode Sense data that is available to be transferred to the initiator. The Sense Data Length does not include itself.

**157 WP (Write Protect)**

- 0 The medium is write enabled.
- 1 The medium is write protected.

### 12.13 Persistent Reserve In command 5Eh

Use the Persistent Reserve In command to obtain information about persistent reservations and reservation keys that are active within a device server. Use this command in conjunction with the Persistent Reserve Out command (see Section 12.14).

**Note.** The actual length of the Persistent Reserve In parameter data is available in a parameter data field. The Allocation Length field in the CDB indicates how much space has been reserved for the returned parameter list. If the length is not sufficient to contain the entire parameter list, the first portion of the list is returned (this is not considered an error). If the remainder of the list is required, the application client should send a new Persistent Reserve In command with an Allocation Length field large enough to contain the entire list.

**Table 158. Persistent Reserve In command (5Eh)**

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

**Table number** **Field definitions (listed alphabetically)**

**158 Allocation Length**

The number of bytes reserved for the returned parameter list.

**158 Control**

See Control Byte in Section 11.2.1.6.

**158 Service Action**

- 00h Read keys. Reads all registered reservation keys. This service action requests that the device server return a parameter list containing a header and a list of each currently registered initiator's reservation key. If multiple initiators have registered with the same key, that key value is listed multiple times, once for each registration. See Section 12.13.1.
- 01h Read reservation. Reads all current persistent reservations. This service action requests that the device server return a parameter list containing a header and the persistent reservations, if any, present in the device server. Multiple persistent reservations may be returned only if element reservations are present. See Section 12.13.2.
- 02h-1Fh Reserved.



### 12.13.1 Persistent Reserve In parameter data for read keys

The format for the parameter data provided in response to a Persistent Reserve In command with the Read Keys service action is shown in Table 159.

**Table 159. Persistent Reserve In parameter data for read keys**

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB) _____ Generation _____ (LSB)							
3								
4	(MSB) _____ Additional Length (n - 7) _____ (LSB)							
7								
<b>Reservation key list</b>								
8	(MSB) _____ First reservation key _____ (LSB)							
15								
.	(MSB) _____ . . . (LSB)							
.								
.	(MSB) _____ Last reservation key _____ (LSB)							
n - 7								
:								
n								

#### Table number Field definitions (listed alphabetically)

##### 159 Additional Length

This field contains the number of bytes in the reservation key list. If the allocation length specified by the Persistent Reserve In command is not sufficient to contain the entire parameter list, only the bytes from 0 to the maximum allowed Allocation length are sent to the application client. The remaining incremental bytes are truncated, although the Additional length field will still contain the actual number of bytes in the reservation key list without consideration of any truncation resulting from an insufficient Allocation length (this is not considered an error).

##### 159 Generation

The Generation field is a 32-bit counter maintained by the device server. It is incremented every time a Persistent Reserve Out command requests the following service actions:

- Register
- Clear
- Preempt
- Preempt and Abort

The counter is not incremented by the following commands:

- Persistent Reserve In command
- Persistent Reserve Out command that performs a Reserve or Release service action
- Persistent Reserve Out command that is not performed due to an error or reservation conflict

**Note.** The Generation value is set to 0 as part of the power on reset process regardless of the APTPL bit value.

**159 Reservation keys (first through last)**

The Reservation key list contains all the 8-byte reservation keys for all initiators that have registered with the device server through all ports with the device server.

**12.13.2 Persistent Reserve In parameter data for read reservation**

The format for the parameter data provided in response to a Persistent Reserve In command with the Read Reservation service action is shown in Table 160.

**Table 160. Persistent Reserve In parameter data for read reservation**

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB)							
:	Generation							
3								
4	(MSB)							
:	Additional Length (n - 7)							
7								
8	(MSB)							
:	Reservation Descriptors (see Table 161)							
n								

**Table number** **Field definitions (listed alphabetically)****160 Additional Length**

This field contains the number of bytes to follow in Reservation descriptors. If the allocation length specified by the Persistent Reserve In command is not sufficient to contain the entire parameter list, only the bytes from 0 to the maximum allowed allocation length are sent to the application client. The remaining incremental bytes are truncated; however, the Additional Length field will still contain the actual number of Reservation Descriptor bytes and will not be affected by the truncation (this is not considered an error).

**160 Generation**

The Generation value is as defined for the Persistent Reserve In Read Keys parameter data. See Section 12.13.1, "Persistent Reserve In parameter data for read keys."

**160 Reservation Descriptors**

There is one read reservation descriptor for each persistent reservation, if any, present in the logical unit and a Reservation Descriptor for each element, if any, having a persistent reservation. If a persistent reservation is present in the logical unit that does not contain elements, there will be a single reservation descriptor in the list of parameter data returned by the device server in response to the Persistent Reserve In command with a Read Reservation service action. The Reservation descriptor for each reservation will contain the Reservation Key under which the persistent reservation is held. The Type and Scope of each persistent reservation as present in the Persistent Reserve out command that created the persistent reservation is returned.

If a persistent reservation is present in a logical unit that does contain elements, there will be a Reservation descriptor in the list of parameter data returned by the device server. This is in response to the Persistent Reserve In command with a Read Reservation service action for the logical unit persistent reservation that is held, if any, and each element persistent reservation that may be held. The Reservation descriptor contains the Reservation Key under which the persistent reservation is held. The Type and Scope of the persistent reservation as present in the Persistent Reserve out command that created the persistent reservation is returned.

If the Scope is an Element reservation, the Scope-specific Address field contains the element address, zero filled in the most significant bytes to fit the field. If the Scope is a Logical Unit reservation, the Scope-specific Address field is set to zero. The obsolete field (bytes 14 and 15) were defined in a previous standard and no longer used. The format of a single read reservation descriptor is provided in Table 161.

**Table 161. Persistent Reserve In Reservation Descriptor**

Bit Byte	7	6	5	4	3	2	1	0
0 : 7	(MSB) _____ Reservation Key _____ (LSB)							
8 : 11	(MSB) _____ Scope-specific Address _____ (LSB)							
12	Reserved							
13	Scope				Type			
14 : 15	(MSB) _____ Obsolete (no longer used) _____ (LSB)							

**161 Reservation Key**

The reservation key is the registered reservation key under which the reservation is held. If initiators use unique keys, the application should be able to associate the reservation key with the initiator that holds the reservation.

**161 Scope**

The value in this field specifies whether a persistent reservation applies to an entire logical unit or to an element.

**Code Name and Description**

0h	LU (logical unit). Persistent reservation applies to the full logical unit. The LU scope is implemented by all device servers that implement Persistent Reserve Out.
1h	Obsolete (no longer used).
2h	Element. Persistent reservation applies to the specified element of the logical unit defined by the Scope-specific Address field in the Persistent Reserve out parameter list. An element is defined by the SCSI-3 Medium Changer Command (SMC) standard. The Element scope is optional for all device servers that implement Persistent Reserve out.
3h-Fh	Reserved.

**161 Scope-specific Address**

If the Scope is an Element reservation (2h), this field contains the Element address, zero filled in the most significant bytes to fit the field. If the Scope is a Logical Unit reservation (0h), this field is set to 0.

**161** Type

This field determines the characteristics of the persistent reservation being established for all data blocks within the extent or logical unit. The required device server support descriptions below are divided into two paragraphs. The first paragraph defines the required handling for read operations. The second paragraph defines the required handling for write operations.

Type Code	Name	Description
0h	Obsolete (no longer used)	
1h	Write Exclusive	
	Reads Shared	Any application client on any initiator may execute tasks that request transfers from the storage medium or cache of the logical unit to the initiator.
	Writes Exclusive	All tasks from any initiator other than the initiator holding the persistent reservation that requests a transfer from the initiator to the storage medium or cache of the logical unit result in a reservation conflict.
2h	Obsolete (no longer used)	
3h	Exclusive Access	
	Reads Exclusive	All tasks from any initiator other than the initiator holding the persistent reservation that requests a transfer from the storage medium or cache of the logical unit to the initiator result in a reservation conflict.
	Writes Exclusive	All tasks from any initiator other than the initiator holding the persistent reservation that requests a transfer from the initiator to the storage medium or cache of the logical unit result in a reservation conflict.
4h	Obsolete (no longer used)	
5h	Write Exclusive, Registrants Only	
	Reads Shared	Any application client on any initiator may execute tasks that request transfers from the storage medium or cache of the logical unit to the initiator.
	Writes Exclusive	All tasks that request a transfer to the storage medium or cache of the logical unit from an initiator that is not currently registered with the device server result in a reservation conflict.
6h	Exclusive Access, Registrants Only	
	Read Exclusive	All tasks that requests a transfer from the storage medium or cache of the logical unit to an initiator that has not previously requested a Register service action with the device server result in a reservation conflict.
	Writes Exclusive	All tasks that requests a transfer to the storage medium or cache of the logical unit from an initiator that is not currently registered with the device server result in a reservation conflict.
7h - Fh	Reserved	

**12.14 Persistent Reserve Out command 5Fh**

The Persistent Reserve Out command is used to request service actions that reserve a logical unit or element for the exclusive or shared use of a particular initiator. This command is used in conjunction with the Persistent Reserve In command and should not be used with the Reserve and Release commands.

Initiators performing Persistent Reserve Out service actions are identified by a reservation key provided by the application client. An application client may use the Persistent Reserve In command to identify which initiators are holding a persistent reservation and use the Persistent Reserve Out command to preempt that reservation if required.

If a Persistent Reserve out command is attempted, but there are insufficient device server resources to complete the operation, the device server returns a Check Condition status. The sense key is set to Illegal Request and the additional sense data is set to Insufficient Registration Resources.

The Persistent Reserve Out command contains fields that specify a persistent reservation service action, the intended scope of the persistent reservation, and the restrictions caused by the persistent reservation. If a Scope field specifies a scope that is not implemented, the device server returns a Check Condition status. The sense key is set to Illegal Request and the additional sense data is set to Invalid Field in CDB.

Fields in the Persistent Reserve out parameter list specify the information required to perform a particular persistent reservation service action.

**Table 162. Persistent Reserve Out command (5Fh)**

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

**Table number** **Field definitions (listed alphabetically)****162 Control**

See Control Byte in Section 11.2.1.6.

**162 Parameter List Length**

24 (18h) If the parameter list length is set to something other than 24, the device server returns a Check Condition status, the sense key is set to Illegal Request, and the additional sense data is set to Parameter List Length Error.

**162 Scope**

See definition on page 239. If the Scope field specifies a scope that is not implemented, the device server returns a Check Condition status, the sense key is set to Illegal Request, and additional sense data is set to Invalid Field in CDB.

**162 Service Action**

When processing Persistent Reserve Out service actions, the device server increments the generation value as specified in Section 12.13.1 (see page 237).

00h Register. Register a reservation key with the device server.

01h Reserve. Create a persistent reservation with a specified scope and type.

02h	Release. Release a persistent reservation for the requesting initiator.
03h	Clear. Clear all reservation keys and all persistent reservations.
04h	Preempt. Preempt persistent reservations from another initiator.
05h	Preempt and Abort. Preempt persistent reservations from another initiator and abort the task set for the pre-empted initiator.
06h-1Fh	Reserved.

**162 Type**

See definition on page 239.

### 12.14.1 Persistent Reserve Out parameter list

The parameter list for the Persistent Reserve Out command is defined in Table 163. All fields are sent on all Persistent Reserve Out commands, even if the field is not required for the specified service action and scope values.

**Table 163. Persistent Reserve Out parameter list**

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB)							
:	Reservation Key							
7	(LSB)							
8	(MSB)							
:	Service Action Reservation Key							
15	(LSB)							
16	(MSB)							
:	Scope-specific Address							
19	(LSB)							
20	Reserved							APTPL
21	Reserved							
22	(MSB)							
:	Obsolete (no longer used)							
23	(LSB)							

Table  
number

#### Field definitions (listed alphabetically)

##### 163 APTPL (Activate Persist Through Power Loss)

The APTPL bit is valid only for the Register service action. In all other cases, the APTPL is ignored. Support for an APTPL bit equal to one is optional. If a device server that does not support the APTPL bit value of one receives that value in a Register service action, the device server returns a Check Condition status. The sense key is set to Illegal Request, and additional sense data is set to Invalid Field in the Parameter List.

If the last valid APTPL bit value received by the device server is zero, the loss of power in the target releases all persistent reservations for all logical units and removes all reservation keys.

If the last valid APTPL bit value received by the device server is one, the logical unit retains all persistent reservations that may be present and all reservation keys for all initiators even if power is lost and later returned.

Table 164 summarizes which fields are set by the application client and interpreted by the device server for each service action and scope value. Two Persistent Reserve Out parameters (Reservation Key and the APTPL bit) are not summarized below since they are discussed above.

Table 164. Persistent Reserve Out service actions and valid parameters

Service action	Allowed scope	Parameters		
		Type	Service action reservation key	Element or element parameters
Register	Ignored	Ignored	Valid	Ignored
Reserve	Logical Unit Element	Valid Valid	Ignored Ignored	Ignored Valid
Release	Logical Unit Element	Valid Valid	Ignored Ignored	Ignored Valid
Clear	Ignored	Ignored	Ignored	Ignored
Preempt	Logical Unit Element	Valid Valid	Valid Valid	Ignored Valid
Preempt and Clear	Logical Unit Element	Valid Valid	Valid Valid	Ignored Valid

**163 Reservation Key**

This field contains an 8-byte value provided by the application client to the device server to identify the initiator that is the source of the Persistent Reserve Out command. The device server verifies that the Reservation Key field in a Persistent Reserve Out command matches the registered reservation key for the initiator from which the task was received (except for the Register service action for an unregistered initiator which will have a reservation key value of zero). If a Persistent Reserve Out command specifies a Reservation Key field other than the reservation key registered for the initiator, the device server returns a Reservation Conflict status. The reservation key of the initiator will be verified to be correct regardless of the Service Action and Scope field values.

**163 Scope-specific Address**

If the scope is an Element reservation, the Scope-specific Address field contains the element address, zero filled in the most significant bytes to fit the field. If the service action is Register or Clear, or if the scope is a Logical Unit reservation, the Scope-specific Address field is set to zero.

**163 Service Action Reservation Key**

The Service Action Reservation key field contains information needed for the three service actions listed below:

Service action	Service action reservation key field contents
Register	The new reservation key to be registered.
Preempt	The reservation key of the persistent reservations that are being preempted.
Preempt and Abort	The reservation key of the persistent reservations that are being preempted.

**Note.** The Service Action Reservation Key is ignored for all service actions except those described above.



**12.15 Prevent/Allow Medium Removal command** 1Eh

Not implemented. If the drive receives this command, the drive terminates with Check Condition status and sets an Illegal Request sense key.

**12.16 Read command** 08h

The Read command requests the disc drive to transfer data to the initiator.

**Table 165. Read command (08h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0
1	0 0 0			(MSB)				
	Reserved			Logical Block Address				
2								
3								
	(LSB)							
4	Transfer Length							
5	Control							

**Table number** **Field definitions (listed alphabetically)****165 Control**

See Control Bytes in Section 11.2.1.6.

**165 Logical Block Address**

The logical block at which the read operation will begin.

**165 Transfer Length**

The number of contiguous logical blocks of data to be transferred. Any number other than 0 indicates the number of logical blocks that are transferred.

0 Transfer 256 logical blocks.

The data value most recently written in the addressed logical block is returned.

Read data transfers with the initiator do not begin until at least one full sector of data is available in the disc drive data buffer. For multiple sector reads, the transfer of data continues until the number of blocks specified in byte 4 of the CDB has been read and transferred or until an unrecoverable error is detected.

Data transfer could stop if the option to stop on recovered error is selected.

The initiator closes the loop after sending one or more commands. For a Read command, the disc drive arbitrates depending on the value of the Buffer Full Ratio Set in Page 2 of the Mode Select Data (see Section 12.9). After data transfer has been initiated with an initiator, the disc drive does not close the loop unless the buffer is empty or the transfer length is exhausted.

The initiator must accept all data presented to the initiator after sending this command until the disc drive sends Completion Status. (The disc drive may close the loop and re-arbitrate depending on the availability of data in the buffer while executing this command and the initiator may prematurely terminate this command by creating the Reset condition or by sending an Abort, Clear Queue, Target Reset, or Selective Reset).

Sense Data is valid after this command is executed and Completion Status is sent. If the Address Valid bit in the Sense Data is true (1), the Sense Data Logical Block Address (Information bytes) points to the last logical block accessed by the disc drive. If the Address Valid bit in the Sense Data is false (0), the Sense Data Logical Block Address bytes are not valid.

The disc drive contains a large buffer and implements an optional prefetch and segmented cache function whereby the requested Read data is read into the buffer, plus an additional amount, depending on the cache control parameters. See Prefetch and Multisegmented Cache Control section in the individual drive's Product Manual, Volume 1, for more information.

This command is terminated with a Reservation Conflict status and no data is read if any reservation access conflict (see Section 12.31) exists.

If any of the following conditions occur, this command is terminated with a Check Condition status, and if extended sense is implemented, the sense key is set as indicated in the following table. This table does not provide an exhaustive enumeration of all conditions that may cause the Check Condition status.

<b>Condition</b>	<b>Sense key</b>
Invalid logical block address	Illegal Request. Set the extended sense information bytes to the logical block address of the first invalid address.
Target reset since last command from this initiator	Unit Attention
Unrecoverable read error	Medium Error
Recovered read error	Recovered Error

### 12.17 Read Extended command 28h

The Read Extended command requests that the target transfer data to the initiator. This command is implemented with the drive-specific parameters shown in Table 166.

This command operates the same as the Read command (see Section 12.16) except that in the CDB for this command a four-byte logical block address and a two-byte transfer length may be specified.

The data value most recently written in the addressed logical block is returned to the Host.

This command terminates with a Reservation Conflict status if any reservation access conflict (see Section 12.31) exists, and no data is read.

**Table 166. Read Extended command (28h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	0	1	0	0	0
1	0	0	0	DPO	FUA	0	0	RelAdr
	Reserved							
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Transfer Length (MSB)							
8	Transfer Length (LSB)							
9	Control							

#### **Table number** Field definitions (listed alphabetically)

##### **166 Control**

See Control Bytes in Section 11.2.1.6.

##### **166 DPO (Disable Page Out)**

The DPO bit is used to control replacement of logical blocks in the cache memory when the host has information on the future usage of the logical blocks.

- 1 The disc drive assigns the logical blocks accessed by this command the lowest priority for being fetched into or retained by the cache. The host knows the logical blocks accessed by the command are not likely to be accessed again in the near future and should not be put in the cache memory nor retained by the cache memory.
- 0 The host expects that logical blocks accessed by this command are likely to be accessed again in the near future.

##### **166 FUA (Force Unit Access)**

- 1 The target accesses the media in performing the command prior to returning Good status. Read commands access the specified logical blocks from the media (i.e., the data is not directly retrieved from the cache). In the case where the cache contains a more recent version of a logical block than the media, the logical block is first written to the media.
- 0 The target satisfies the command by accessing the cache memory. For read operations, any logical blocks that are contained in the cache memory are transferred to the initiator directly from the cache memory.

##### **166 Logical Block Address**

The logical block at which the read operation begins, if RelAdr bit is zero (see RelAdr bit description).

##### **166 RelAdr (Relative Address)**

This function is not supported by drives described in this manual.

**166 Transfer Length**

The number of contiguous logical blocks of data transferred. A Transfer Length of zero (0) indicates that no logical blocks are transferred. This condition is not considered an error. Any other value indicates the number of logical blocks that are transferred.

If any of the following conditions occur, this command returns a Check Condition status and the sense key is set as indicated. This list does not provide an exhaustive enumeration of all conditions that cause the Check Condition status.

<b>Condition</b>	<b>Sense Key</b>
Invalid logical block address	Illegal Request. Set the extended sense information bytes to the logical block address of the first invalid address.
Target reset since last command from this initiator	Unit Attention
Unrecovered read error	Medium Error
Recoverable read error	Recovered Error

## 12.18 Read Data Buffer command 3Ch

The Read Buffer command is used in conjunction with the Write Buffer command as a diagnostic function for testing disc drive memory and the integrity of the FC-AL. This command will not alter the medium. Command format is shown in Table 167.

**Table 167. Read Buffer command (3Ch)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	0	0
1	0	0	0	0	0	Mode		
2	Buffer ID							
3	(MSB)							
4	Buffer Offset							
5								
6	(MSB)							
7	Allocation Length							
8								
9	Control							

### Table number Field definitions (listed alphabetically)

#### 167 Allocation Length

The number of bytes available for returning read buffer command data.

#### 167 Buffer ID

0

#### 167 Control

See Control Bytes in Section 11.2.1.6.

#### 167 Buffer Offset

0

#### 167 Mode

The interpretation of data bits 0–2 is given in the following table and in paragraphs following the table.

Bit 2	Bit 1	Bit 0	
0	0	0	Read combined descriptor header and data (Section 12.18.1)
0	1	0	Read data (Section 12.18.112.18.2)
0	1	1	Read descriptor (Section 12.18.312.18.1)

### 12.18.1 Read Combined Descriptor Header and Data mode (000b)

In this mode, a four-byte Read Buffer header followed by the data bytes are returned to the initiator in a data transfer. The Buffer ID and Buffer Offset fields are not used by drives supported by this manual, and must be zero.

**Table 168. Read Buffer header (000b)**

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

**Table number** Field definitions (listed alphabetically)

**168** Buffer Capacity

The number of bytes available in the read buffer.

### 12.18.2 Read Data mode (010b)

In this mode, the buffer data only is transferred with no header. The Buffer ID and Buffer Offset fields are not used.

### 12.18.3 Read Buffer descriptor mode (011b)

In this mode, a maximum of four bytes of Read Buffer descriptor information is returned. If there is no buffer associated with the specified buffer ID, the target returns all zeros in the Read Buffer descriptor. The Buffer Offset field is reserved in this mode. The allocation length should be set to four or greater. The target transfers the lesser of the allocation length or four bytes of Read Buffer descriptor. The Read Buffer descriptor is defined as shown in the following table.

Implementor's note: In a multi-tasking system, a buffer may be altered between the Write Buffer and Read Buffer commands by another task. Buffer testing applications may wish to insure that only a single task is active. Use of reservations (to all logical units on the device) may also be helpful in avoiding buffer alteration between these two commands.

**Table 169. Read Buffer descriptor mode (011b)**

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

**Table number** Field definitions (listed alphabetically)

**169** Buffer Capacity

The total number of data bytes that are available in the disc drive's data buffer (see 12.45.1 and 12.45.2). This number is not reduced to reflect the allocation length nor is it reduced to reflect the actual number of bytes written using the Write Buffer command. Following the Read Buffer header, the disc drive transfers data from its data buffer. The disc drive terminates the Data In phase when allocation length bytes of header plus data have been transferred or when all available header and buffer data have been transferred to the initiator, whichever is less.

**169 Offset Boundary**

This field contains the boundary alignment with the selected buffer for subsequent Write Buffer and Read Buffer commands. This is interpreted as a power of two.



**12.19 Read Capacity command** 25h

The Read Capacity command provides a means for the initiator to request the capacity of the disc drive information.

**Table 170. Read Capacity command (25h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	0	0	1	0	1
1	0	0	0	0	0	0	0	RelAdr
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	PMI
9	Control							

**Table number** **Field definitions (listed alphabetically)****170 Control**

See Control Bytes in Section 11.2.1.6.

**170 Logical Block Address**

The 32-bit address of the logical block affected by this command.

**170 PMI (Partial Medium Indicator)**

- 0 The information returned in the Read Capacity data is the Logical Block Address and Block Length (in bytes) of the last logical block of the logical unit. (This value is the same for all drives of the same model number, sector size and sparing scheme. It is the same regardless of the number of defective blocks the drive has.) The Logical Block Address in the Command Descriptor Block is set to zero (0) for this option.
- 1 The information returned is the Logical Block Address and Block Length (in bytes) of the last Logical Block Address after which a substantial delay (defined as approximately one millisecond for the typical disc drive) in data transfer is encountered. This returned Logical Block Address is greater than or equal to the Logical Block Address specified in the Command Descriptor Block. This reported Logical Block Address is the last block prior to a cylinder boundary.

**170 RelAdr (Relative Address)**

This function is not supported by drives described in this manual.

In response to the Read Capacity command, the drive returns eight bytes of Read Capacity Data to the host. The contents of the eight bytes are listed in Table 171.

**Table 171. Read Capacity data**

Byte	Description
0	Logical Block Address (MSB)
1	Logical Block Address
2	Logical Block Address
3	Logical Block Address (LSB)
4	Block Length (MSB)
5	Block Length
6	Block Length
7	Block Length (LSB)

**12.20 Read Defect Data (10) command 37h**

The Read Defect Data command requests that the target transfer the medium defect data to the initiator. If the drive is unable to access any medium defect data, it terminates the command with Check Condition status. The sense key is set to either Medium Error if a medium error occurred or No Sense if the list does not exist and the additional sense code is set to Defect List Not Found.

This command is implemented with the disc drive specific parameters listed in Table 172.

**Table 172. Read Defect Data command (37h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	1	0	1	1	1
1	0	0	0	0	0	0	0	0
	Reserved							
2	0	0	0	P	G	1	0	0 or
				CDB		1	0	1
						Defect List Format		
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	Allocation Length (MSB)							
8	Allocation Length (LSB)							
9	Control							

**Table number** **Field definitions (listed alphabetically)****172 Allocation Length**

The number of bytes the initiator has allocated for the returned defect data. An Allocation Length of zero indicates that no Read Defect Data is transferred. Any other value indicates the maximum number of bytes to be transferred. The disc drive terminates the Data In phase when the Allocation Length bytes have been transferred or when all available defect data has been transferred to the initiator, whichever is less.

**172 CDB (Command Descriptor Block)**

The disc drive interprets the P and G bits (bits 4 and 3 of byte 2 of the CDB) as follows:

Bit P   Bit G   Interpretation

0      0      Return Defect List header only. Target returns only the defect list header.

0      1      Return the growth "G" list only. This list reflects the grown or "G" list as defined in Section 12.5.

1      0      Return the manufacturer's original ETF list only. This list reflects the manufacturer's original ETF list. These defects may or may not have been reallocated, depending on the last Format command received (the last format may or may not have requested the P list flaws be reallocated during the format function).

1      1      Return all lists. The returned list contains all of the requested drive's defect lists (i.e., P, G, C, and D) regardless of whether these lists have been reallocated by the drive.

**172 Control**

See Section 11.2.1.6.

**172 Defect List Format**

Bits 2, 1, 0 in the CDB should be 1 0 0, respectively, to signify a defect list in the Bytes from Index format, or 1 0 1, respectively, to signify a defect list in the Physical Sector format. If neither of these two, the disc drive responds with the defect list in the drive's default format (physical sector) and creates the Check Condition status with Recovered Error sense key (1h) and additional sense error code (1C) at the end of the Read Defect Data transfer.

This command is intended to be used only with the Format Unit command (Section 12.5). The initiator should not interpret or act upon this list except to resend this list as defect data in a Format Unit command. It is not possible to relate actual physical locations to logical block addresses that are given in connection with other commands.

The format Defect Data header and Defect Data Descriptor bytes returned are shown in Table 173.

The first four bytes returned are the Defect List header. The P bit, G bit, and Defect List Format fields indicate the defect format actually returned by the disc drive. The definitions are the same as for byte 2 of the Read Defect Data Command Descriptor Block (Table 172).

The Defect List Length specifies the total length (in bytes) of all the defect descriptors available from the disc drive. If the Allocation Length of the CDB is too small to transfer all of the defect descriptors, the Defect List Length is not adjusted to reflect the truncation. The drive does not create the Check Condition status. The Defect Descriptors are not required to be in ascending order.

Table 173. Defect List Header description

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
	Reserved							
1	0	0	0	P	G	1	0	0 or
	Reserved			CDB		1	0	1
	Defect List Format							
2	Defect List Length (MSB) (Value is 8 times the number of defects)							
3	Defect List Length (LSB)							
4–n	Defect Descriptor Bytes							

**Table number** Field definitions (listed alphabetically)

**173 CDB (Command Descriptor Block)**

The disc drive interprets the P and G bits (bits 4 and 3 of byte 2 of the CDB) as follows:

Bit P Bit G Interpretation

0	0	Return Defect List header only. Target returns only the defect list header.
0	1	Return the growth “G” list only. This list reflects the grown or “G” list as defined in Section 12.5.
1	0	Return the manufacturer’s original ETF list only. This list reflects the manufacturer’s original ETF list. These defects may or may not have been reallocated, depending on the last Format command received (the last format may or may not have requested the P list flaws be reallocated during the format function).
1	1	Return all lists. The returned list contains all of the requested drive’s defect lists (i.e., P, G, C, and D) regardless of whether these lists have been reallocated by the drive.

**173 Defect List Format**

100 A list in the Bytes from Index format.

101 A list in the Physical Sector format.

**173 Defect List Length and Defect Descriptor Bytes**

If the P and G bits are 0 0, the Defect List Length will be 0 and no Defect Descriptor bytes are sent to the initiator. See Tables 99 and 100 for the format of Defect Descriptor bytes.

## 12.21 Read Defect Data (12) command B7h

The Read Defect Data (12) command requests that the target transfer the medium defect data to the initiator. If the logical unit is reserved, a reservation conflict occurs when a Read Defect Data (12) command is received from an initiator other than the one holding a logical unit reservation. This command is rejected with Reservation Conflict status if the reservation conflict is due to a logical unit reservation. Read Defect Data (12) commands with a reservation conflict are terminated with Reservation Conflict status. The Read Defect Data (12) command is not evaluated for extent reservation conflicts. For example, extent reservations do not conflict with the Read Defect Data (12) command.

This command is implemented with the disc drive specific parameters listed in Table 174.

**Table 174. Read Defect Data (12) command (B7h)**

Bit Byte	7	6	5	4	3	2	1	0
0	1	0	1	1	0	1	1	1
1	Logical Unit Number			P List	G List	Defect List Format		
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	MSB							
7	Allocation Length							
8								
9								
10	Reserved							
11	Control							

### Table number Field definitions (listed alphabetically)

#### 174 Allocation Length

The number of bytes the initiator has allocated for the returned defect data. An Allocation Length of zero indicates that no Read Defect Data is transferred. Any other value indicates the maximum number of bytes to be transferred. The disc drive terminates the Data In phase when the Allocation Length bytes have been transferred or when all available defect data has been transferred to the initiator, whichever is less.

#### 174 Control

See Section 11.2.1.6.

#### 174 Defect List Format

Bits 2, 1, 0 in the CDB should be 1 0 0, respectively, to signify a defect list in the Bytes from Index format, or 1 0 1, respectively, to signify a defect list in the Physical Sector format. If neither of these two, the disc drive responds with the defect list in the drive's default format (physical sector) and creates the Check Condition status with Recovered Error sense key (1h) and additional sense error code (1C) at the end of the Read Defect Data transfer.

#### 174 P List and G List bits

The disc drive interprets the P and G bits as follows:

Bit P	Bit G	Interpretation
-------	-------	----------------

0	0	Return Defect List header only. Target returns only the defect list header.
---	---	---

0	1	Return the growth "G" list only. This list reflects the grown or "G" list as defined in Section 12.5.
---	---	---

1	0	Return the manufacturer's original ETF list only. This list reflects the manufacturer's original ETF list. These defects may or may not have been reallocated, depending on the last Format command received (the last format may or may not have requested the P list flaws be reallocated during the format function).
---	---	--

- 1 1 Return all lists. The returned list contains all of the requested drive's defect lists (i.e., P, G, C, and D) regardless of whether these lists have been reallocated by the drive.

This command is intended to be used only with the Format Unit command (Section 12.5). The initiator should not interpret or act upon this list except to resend this list as defect data in a Format Unit command. It is not possible to relate actual physical locations to logical block addresses that are given in connection with other commands.

The format Defect Data header and Defect Data Descriptor bytes returned are shown in Table 173.

The first four bytes returned are the Defect List header. The P bit, G bit, and Defect List Format fields indicate the defect format actually returned by the disc drive. The definitions are the same as for byte 2 of the Read Defect Data Command Descriptor Block (Table 172).

The Defect List Length specifies the total length (in bytes) of all the defect descriptors available from the disc drive. If the Allocation Length of the CDB is too small to transfer all of the defect descriptors, the Defect List Length is not adjusted to reflect the truncation. The drive does not create the Check Condition status. The Defect Descriptors are not required to be in ascending order.

Table 175. Defect List (12) Header description

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
	Reserved							
1	0	0	0	P	G	1	0	0 or
	Reserved			CDB		Defect List Format		
2	Reserved							
3	Reserved							
4	(MSB)							
5	Defect List Length							
6								
7								
0–n	Defect Descriptor Bytes							

**Table number** Field definitions (listed alphabetically)

**175** CDB (Command Descriptor Block)

The disc drive interprets the P and G bits (bits 4 and 3 of byte 2 of the CDB) as follows:

Bit P	Bit G	Interpretation
-------	-------	----------------

0	0	Return Defect List header only. Target returns only the defect list header.
0	1	Return the growth “G” list only. This list reflects the grown or “G” list as defined in Section 12.5.
1	0	Return the manufacturer’s original ETF list only. This list reflects the manufacturer’s original ETF list. These defects may or may not have been reallocated, depending on the last Format command received (the last format may or may not have requested the P list flaws be reallocated during the format function).
1	1	Return all lists. The returned list contains all of the requested drive’s defect lists (i.e., P, G, C, and D) regardless of whether these lists have been reallocated by the drive.

**175** Defect List Format

- |     |  |
|-----|--|
| 100 | A list in the Bytes from Index format. |
| 101 | A list in the Physical Sector format.  |

**175** Defect List Length and Defect Descriptor Bytes

If the P and G bits are 0 0, the Defect List Length will be 0 and no Defect Descriptor bytes are sent to the initiator. See Tables 99 and 100 for the format of Defect Descriptor bytes.



**12.22 Read Long command** 3Eh

The Read Long command requests that the target transfer data to the initiator. The data passed during the Read Long command includes the data bytes, followed by the ECC bytes of the single logical block addressed by the command.

**Table 176. Read Long command (3Eh)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	1	0
1	0	0	0	0	0	0	CORRECT	RelAdr
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Byte Transfer Length (MSB)							
8	Byte Transfer Length (LSB)							
9	Control							

**Table  
number****Field definitions (listed alphabetically)****176 Byte Transfer Length**

The number of bytes of data that will be transferred. A transfer length of zero indicates that no bytes are transferred. This condition is not considered an error.

The byte transfer length requested must be equal to the current block size plus all ECC bytes for a data transfer to occur. If an incorrect number of bytes is stated in the command block, this command terminates with a Check Condition status. The correct number of bytes can be determined from the information returned in the extended sense data bytes after issuing the Request Sense command. The Request Sense command results in the Illegal Field In CDB condition with the Illegal Request sense key. The extended sense ILI bit is set. The extended sense information bytes contain the difference (residue) of the requested length minus the actual length (in bytes). (Negative values are indicated by two's complement notation.)

**176 Control**

See Control Bytes in Section 11.2.1.6.

**176 CORRECT (Corrected)**

0 A logical block will be read without any correction made by the target.

1 The data will be corrected by ECC, if necessary, before being transferred to the initiator.

If the DCR bit of the Read-Write Error Recovery page is equal to 1 and the CORRCT bit equals 1, the Read Long command terminates with Check Condition status and the sense key is set to Illegal Request with an additional sense code of Invalid Field in CDB.

**176 Logical Block Address**

The logical block at which the read operation will occur. The most recent data written in the addressed logical block is returned.

**176 RelAdr (Relative Address)**

This function is not supported by drives described in this manual.

### 12.23 Reassign Blocks command 07h

The Reassign Blocks command requests the target to reassign the defective logical blocks to an area on the logical unit reserved for this purpose.

After sending the Reassign Blocks command, the initiator transfers a defect list that contains the logical block addresses to be reassigned. The disc drive reassigns the physical medium used for each logical block address in the list. The data contained in the logical blocks specified in the defect list is not preserved, but the data in all other logical blocks on the medium is preserved. It is recommended that the initiator recover the data from the logical blocks to be reassigned before issuing this command. After completion of this command, the initiator can write the recovered data to the same logical block addresses.

The effect of specifying a logical block to be reassigned that has previously been reassigned is to reassign the block again. Thus, over the life of the medium, a logical block can be assigned to multiple physical addresses (until no more spare locations remain on the medium).

This command should be used by an initiator to immediately reallocate any block (sector) which requires the disc drive to recover data by data correction via ECC if the automatic reallocation feature of the disc drive is not enabled, see Mode Select command (Section 12.9).

**Table 177. Reassign Blocks command (07h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	1	1
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	Control							

**Table number** **Field definitions (listed alphabetically)**

**177** **Control**

See Control Byte in Section 11.2.1.6.

### Reassign Blocks defect list

The Reassign Blocks defect list contains a four-byte header followed by one or more defect descriptors. The length of each defect descriptor is four bytes.

If the logical unit has insufficient capacity to reassign all of the defective logical blocks, the command terminates with a Check Condition status and the sense key is set to Hardware Error and the additional sense code set to No Defect Spare Location Available. The logical block address of the first logical block not reassigned is returned in the information bytes of the sense data. If information about the first defect descriptor not reassigned is not available, or if all the defects have been reassigned, this field is set to FFFFFFFh.

If the Reassign Blocks command failed due to an unexpected unrecoverable read error that would cause the loss of data in a block not specified in the defect list, the logical block address of the unrecoverable block is returned in the information field of the sense data and the valid bit is set to one.

Implementor's Note: If the Reassign Blocks command returns Check Condition status and the sense data command-specific information field contains a valid logical block address, the initiator removes all defect descriptors from the defect list prior to the one returned in the command-specific information field. If the sense key is Medium Error and the valid bit is one (the information field contains the valid block address) the initiator inserts that new defective logical block address into the defect list and reissues the Reassign Blocks command with the new defect list. Otherwise, the initiator performs any corrective action indicated by the sense data and then reissues the Reassign Blocks command with the new defect list.

**Table 178. Reassign Blocks defect list**

Bit Byte	7	6	5	4	3	2	1	0
<b>Defect list header</b>								
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	Defect List Length (MSB)							
3	Defect List Length (LSB)							
<b>Defect descriptors</b>								
0	Defect logical block address (MSB)							
1	Defect logical block address							
2	Defect logical block address							
3	Defect logical block address (LSB)							

**Table number** **Field definitions (listed alphabetically)**

**178 Defect Logical Block Address**

Specifies a four-byte defect logical block address that contains the defect. The defect descriptors are in ascending order.

**178 Defect List Length**

The total length (in bytes) of the defect descriptors that follow. The Defect List Length is equal to four times the number of defect descriptors.

## 12.24 Rebuild command 81h

The Rebuild command requests that the target write the xor data generated from the specified source devices to the media. The target, acting as a temporary initiator, issues Read commands to retrieve the specified data.

**Note.** The target that receives the Rebuild command can not be one of the source devices. If only one source is specified, an xor operation does not occur. This case can occur in disc mirroring applications.

If the command terminates with Check Condition status, the sense data contains the logical block address of the failed block with the lowest logical block address. All logical blocks affected by the command and having a logical block address lower than that of the reported failing block will be rebuilt and written to the media.

**Table 179. Rebuild command (81h)**

Bit Byte	7	6	5	4	3	2	1	0
0	1	0	0	0	0	0	0	1
1	Reserved			DPO	FUA	IntData	Port Control	
2	Logical Block Address							
3								
4								
5								
6	Rebuild Length							
7								
8								
9								
10	Parameter List Length							
11								
12								
13								
14	Reserved							
15	Control							

### Table number **Field definitions (listed alphabetically)**

#### **179 Control**

See Section 11.2.1.6.

#### **179 DPO (Disable Page Out)**

The DPO bit is used to control replacement of logical blocks in the cache memory when the host has information on the future usage of the logical blocks.

- 1 The disc drive assigns the logical blocks accessed by this command the lowest priority for being fetched into or retained by the cache. The host knows the logical blocks accessed by the command are not likely to be accessed again in the near future and should not be put in the cache memory nor retained by the cache memory.
- 0 The host expects that logical blocks accessed by this command are likely to be accessed again in the near future.

#### **179 FUA (Force Unit Access)**

- 1 The target accesses the media in performing the command prior to returning Good status. Read commands access the specified logical blocks from the media (i.e., the data is not directly retrieved from the cache). In the case where the cache contains a more recent version of a logical block than the media, the logical block is first written to the media.
- 0 The target satisfies the command by accessing the cache memory. For read operations, any logical blocks that are contained in the cache memory are transferred to the initiator directly from the cache memory.

**179 IntData (Intermediate Data)**

The length of the intermediate data is calculated as follows:

$$\text{intermediate data} = \text{rebuild length} * \text{block size.}$$

This data is treated as an additional source, and an xor operation performed with it and the data from the specified sources.

0 The intermediate data is not sent with the rebuild parameter list. See Table 180.

1 The rebuild parameter list includes intermediate data.

**179 Logical Block Address**

The first logical block address on the target device that will contain xor result data.

**179 Parameter List Length**

The length, in bytes, of the parameter list that is transferred from the initiator to the target. See Table 180.

**179 Port Control**

This field determines which ports are used for the target transfers.

00 The target transfers the data using the same port that received the command.

01 The target transfers the data using a different port than that which received the command. If the target is not a multiple port device, the command terminates with a Check Condition status and the sense data is set to Illegal Request: Invalid Field in CDB.

10 The target transfers the data using one port of the target's choice.

11 The target transfers the data using one or more ports of the target's choice.

**179 Rebuild Length**

The number of blocks to be written to the medium and the number of blocks that are read from each source.

**Table 180. Rebuild parameter data**

Bit Byte	7	6	5	4	3	2	1	0
0	Number of Source Descriptors							
1	Reserved							
2	Source Descriptor/Pad Length (MSB)							
3	Source Descriptor/Pad Length (LSB)							

**Source descriptors (if any)**

4 . . 19	Source Descriptor (first)							
16x – 12 16x + 3	Source Descriptor (last)							
16x + 4 16x+y+3	Pad (if any) (y = length)							
16x+y+4 16x+y+z +3	(MSB)							Intermediate Data (if any) (z = length)
								(LSB)

**Table number** **Field definitions (listed alphabetically)**

**180 Intermediate Data**

The data from the specified source devices used in the xor operation. The length of the data is equal to the rebuild length multiplied by the block size.

**180 Number of Source Descriptors**

The number of source descriptors in the parameter data.

**180 Pad**

Provision for the Pad field is included to accommodate initiators which require the intermediate data to be aligned on a particular memory boundary. The Pad field does not contain valid data and is ignored.

**180 Source Descriptor/Pad Length**

The sum of the lengths (in bytes) of all of the source descriptors and the pad.

**180 Source Descriptor**

This field identifies the source device target identifiers and starting logical block addresses on the devices for the rebuild operation. See Table 181 for the source descriptor format.

**Table 181. Source descriptor format**

Bit Byte	7	6	5	4	3	2	1	0
0	Source Device Address							
1								
2								
3								
4								
5								
6								
7								
8	Reserved							
9								
10								
11								
12	Source Starting Logical Block Address							
13								
14								
15								

**Table number** **Field definitions (listed alphabetically)****181 Source Device Address**

The SAM-compliant target identifier of the data source device.

**181 Source Starting Logical Block Address**

The starting logical block address to use when reading data from the source specified in the Source Device Address field.

## 12.25 Receive Diagnostic Results command 1Ch

The Receive Diagnostic Results command requests analysis data after completion of a Send Diagnostic command or SCSI-3 Enclosure Services (SES) pages be sent to the initiator. The disc drive supports the optional Page format, wherein the initiator sends additional pages after a Send Diagnostic command. These additional pages have a page code that specifies to the disc drive the format of the data to be returned after it receives a Receive Diagnostic Results command.

If the Send Diagnostic command requested either page 00h or page 40h (the only two optional, non-ESI, pages supported by the disc drive), data returned is in the format shown in Table 184 or 187, respectively. If the Send Diagnostic Self Test bit is set, the data returned is described in Table 190.

If the Send Diagnostic command requested the Supported Diagnostic Pages list (PF bit = 1), the disc drive returns data in the format shown in Table 184 after receiving the Receive Diagnostic Results command. It lists all of the diagnostic pages supported by the disc drive.

If the Receive Diagnostic command is sent with the PCV bit set to a 1, the drive sends back the page selected by the Page Code field (see Table 183). It is not necessary to have first issued a Send Diagnostic command to receive these pages.

**Table 182. Receive Diagnostic Results command (1Ch)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	0	0
1	0	0	0	0	0	0	0	PCV
	Reserved							
2	Page Code							
3	Allocation Length (in bytes) (MSB)							
4	Allocation Length (in bytes) (LSB)							
5	Control							

### Table number Field definitions (listed alphabetically)

#### **182 Allocation Length**

The number of bytes the initiator has allocated for returned data.

0 No data is transferred.

Any other value indicates the maximum number of bytes that will be transferred. The disc drive terminates the data transfer when allocation length bytes have been transferred or when all available data has been transferred to the initiator, whichever is less.

#### **182 Control**

See Control Bytes in Section 11.2.1.6.

**182 Page Code**

The Page Code number of the Diagnostic page to be received. See Table 183 for page code numbers and descriptions.

**Table 183. Receive Diagnostics page code descriptions**

Page Code	Description	Reference Table
00h	List of Supported Diagnostic Pages	184
01h - 0Fh	SCSI Enclosure Services Pages	186
40h	Address Translation Page	187
none	Default Self Test Diagnostic Results	190

**182 PCV (Page Code Valid)**

- 0 The Page Code is ignored. The data received is the page of data prepared by the drive as the result of the most recently completed Send Diagnostic command. This data could also be the Self Test Diagnostic results which has no Page Code number, but is described in Table 190.
- 1 The Page Code in the Page Code field is valid. The contents of the Page Code field defines the data returned by this command.

**Table 184. Supported Diagnostic Pages format**

Bit Byte	7	6	5	4	3	2	1	0
0	Page Code (00h)							
1	Reserved							
2	(MSB)							
3	Page Length (n-3)						(LSB)	
4	Supported Page List							
:								
n								

**Table number Field definitions (listed alphabetically)****184 Page Code**

00h Provides the supported diagnostic pages information for the drive.

**184 Page Length**

n - 3 The length (in bytes) of the Supported Diagnostic page.

**184 Supported Page List**

A list of all diagnostic page codes implemented by the disc drive in ascending order beginning with page code 00h. The disc drive presently supports the pages listed in Table 185.

**Table 185. Supported Send Diagnostic pages**

Page Code	Description	Reference
00h	Supported Diagnostic pages	Table 184
01h - 0Fh	SCSI Enclosure Services Information (ESI) pages	Table 186
40h	Translate Address page	Table 187



### Enclosure Services Information (ESI)

The drives supported by the manual do not process the contents of the SCSI Enclosure Service (SES) pages. The drive attempts to transfer the page contents to or from the enclosure using the Enclosure Services Interface (ESI) as directed by the command. Errors detected in the transfer are returned to the initiator in response to the command. See ANSI document X3T10 NCITS 305-199x regarding the SCSI-3 Enclosure Services Command Set (SES) for descriptions of the data presented in the SES pages.

**Table 186. SCSI Enclosure Services Information (ESI) page format**

Bit Byte	7	6	5	4	3	2	1	0
0	Page Code (01h - 0Fh)							
1	Page Specific							
2	(MSB)							
3	Page Length (n - 3)							
n	(LSB)							
n	Page Specific							

#### Table number Field Definitions (listed alphabetically)

##### 186 Page Code

01h - 0Fh Enclosure Services Information (ESI) pages.

##### 186 Page Length

n - 3

##### 186 Page Specific

Content defined in the SCSI-3 Enclosure Services (SES) standard.

## Translate Address page

The Translate Address page allows the initiator to translate a logical block address into a physical sector address or a physical sector address to a logical block address. The address to be translated is passed to the target during the data transfer associated with the Send Diagnostic command and the results are returned to the initiator during the Data In phase following the Receive Diagnostic Results command. The translated address is returned in Translate Address page–Receive Diagnostic.

**Table 187. Translate Address page–Receive Diagnostic**

Bit Byte	7	6	5	4	3	2	1	0
0	Page Code (40h)							
1	Reserved							
2	(MSB)							
3	Page Length (000Ah) (LSB)							
4	Reserved					Supplied Format		
5	RAREA	ALTSEC	ALTRK	Rsvd	Rsvd	Translated Format		
6 : 13	Translated Address (see Tables 188 and 189)							

### Table number Field definitions (listed alphabetically)

#### 187 ALTSEC (Alternate Sector)

- 1 The translated address is physically located in an alternate sector of the medium. If the disc drive cannot determine if all or part of the translated address is located in an alternate sector it sets this bit to zero.
- 0 No part of the translated address is located in an alternate sector of the medium or that the disc drive is unable to determine this information.

#### 187 ALTRK (Alternate Track)

- 1 All or part of the translated address is located on an alternate track of the medium or the disc drive cannot determine if all or part of the translated address is located on an alternate track.
- 0 No part of the translated address is located on an alternate track of the medium.

#### 187 Page Code

40h Translate Address page–Receive Diagnostic page code.

#### 187 Page Length

000Ah The length (in bytes) of the Translate Address–Receive Diagnostic page. If the allocation length is too small to transfer all of the page, the page length is not adjusted to reflect the truncation.

#### 187 RAREA (Reserved Area)

- 1 All or part of the translated address falls within a reserved area of the medium (e.g. speed tolerance gap, alternate sector, vendor reserved area, etc.). If the entire translated address falls within a reserved area the target may not return a translated address.
- 0 No part of the translated address falls within a reserved area of the medium.

#### 187 Supplied Format

The value from the Send Diagnostic command supplied format field (see Table 209).

#### 187 Translated Address

The address the target translated from the address supplied by the initiator in the Send Diagnostic command. This field is in the format specified in the translate format field. The supported formats are shown in Tables 188 and 189.

**187 Translated Format**

The value from the Send Diagnostic command translate format field (see Table 209). The values are 000 (Logical block format) or 101 (Physical sector address format).

**Table 188. Address field logical block address format**

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Logical Block Address							
2								
3								
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0

**Table number** Field definitions (listed alphabetically)

**188 Logical Block Address**

The 32-bit address of the logical block.

**Table 189. Address field physical sector address format**

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Cylinder Number							
2								
3	Head Number							
4	Sector Number							
5								
6								
7								

**Table number** Field definitions (listed alphabetically)

**189 Cylinder Number**

This field contains the drive cylinder number.

**189 Head Number**

This field contains the drive head number.

**189 Sector Number**

This field contains the drive sector number.

Table 190. Default Self-test diagnostic data bytes

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB) _____							
1	Additional Length							(LSB)
2	FRU Code (most probable)							
3	FRU Code							
4	FRU Code							
5	FRU Code (least probable)							
6	(MSB) _____							
7	Error Code							(LSB)
8 - n	Additional Vendor-unique Fault Information							

**Table number** Field definitions (listed alphabetically)

**190** Additional Length

This 2-bytes value indicates the number of additional bytes included in the diagnostic data list. For example, if no product-unique byte (byte 7) is available, this value would be 0006h.

000h There are no additional bytes.

The most significant byte (MSB) is typically 000h or 0006h. The least significant byte (LSB) is typically 02AEh or nnnh.

**190** Additional Vendor-unique Fault Information

Vendor-unique data.

**190** FRU Code (Field Replaceable Unit Code)

These bytes identify an assembly that may have failed. The codes will be listed in probability order, with the most probable assembly listed first and the least probable listed last.

00h There is no FRU information. Seagate drives return this value in these bytes.

01h The entire unit should be replaced.

**190** Error Code

This value designates which part of a diagnostic operation has failed. These bytes are vendor-unique.

0081h Buffer RAM diagnostic error.

00C1h Data miscompare while doing drive diagnostics.

**12.26 Regenerate command** 82h

The Regenerate command requests that the target write the xor data generated from its' own media and the specified source devices to the buffer. The target, acting as a temporary initiator, issues Read commands to retrieve the specified data. The resulting xor data is retained in the target's buffer until it is retrieved by an XDread command with a starting logical block address and transfer length that match, or is a subset of the logical block address and regenerate length of this command.

The parameter data for the Regenerate command describes the other devices that are sources for the regenerate operation. The target receiving the Regenerate command is implicitly a source, and is not included in the parameter data.

**Table 191. Regenerate command (82h)**

Bit Byte	7	6	5	4	3	2	1	0
0	1	0	0	0	0	0	1	0
1	Reserved			DPO	FUA	IntData	Port Control	
2	Logical Block Address							
3								
4								
5								
6	Regenerate Length							
7								
8								
9								
10	Parameter List Length							
11								
12								
13								
14	Reserved							
15	Control							

**Table number** **Field definitions (listed alphabetically)****191 Control**

See Section 11.2.1.6.

**191 DPO (Disable Page Out)**

The DPO bit is used to control replacement of logical blocks in the cache memory when the host has information on the future usage of the logical blocks.

- 1 The disc drive assigns the logical blocks accessed by this command the lowest priority for being fetched into or retained by the cache. The host knows the logical blocks accessed by the command are not likely to be accessed again in the near future and should not be put in the cache memory nor retained by the cache memory.
- 0 The host expects that logical blocks accessed by this command are likely to be accessed again in the near future.

**191 FUA (Force Unit Access)**

- 1 The target accesses the media in performing the command prior to returning Good status. Read commands access the specified logical blocks from the media (i.e., the data is not directly retrieved from the cache). In the case where the cache contains a more recent version of a logical block than the media, the logical block is first written to the media.
- 0 The target satisfies the command by accessing the cache memory. For read operations, any logical blocks that are contained in the cache memory are transferred to the initiator directly from the cache memory.

**191 IntData (Intermediate Data)**

The length of the intermediate data is calculated as follows:

$$\text{intermediate data} = \text{rebuild length} * \text{block size.}$$

This data is treated as an additional source, and an xor operation performed with it and the data from the specified sources.

- 0 The intermediate data is not sent with the regenerate parameter list. See Table 180.
- 1 The regenerate parameter list includes intermediate data.

**191 Logical Block Address**

The first logical block address on the target device that will contain xor result data.

**191 Parameter List Length**

The length, in bytes, of the parameter list that is transferred from the initiator to the target. See Table 192.

**191 Port Control**

This field determines which ports are used for the target transfers.

- 00 The target transfers the data using the same port that received the command.
- 01 The target transfers the data using a different port than that which received the command. If the target is not a multiple port device, the command terminates with a Check Condition status and the sense data is set to Illegal Request: Invalid Field in CDB.
- 10 The target transfers the data using one port of the target's choice.
- 11 The target transfers the data using one or more ports of the target's choice.

**191 Regenerate Length**

The length (in logical blocks) of the resulting xor data. This field also specifies the number of logical blocks to be transferred from each of the specified sources.

**Table 192. Regenerate parameter data**

Bit Byte	7	6	5	4	3	2	1	0
0	Number of Source Descriptors							
1	Reserved							
2	Source Descriptor/Pad Length (MSB)							
3	Source Descriptor/Pad Length (LSB)(MSB)							

**Source descriptors (if any)**

4 . . 19	Source Descriptor (first)								
16x - 12 16x + 3	Source Descriptor (last)								
16x + 4 16x+y+3	Pad (if any) (y = length)								
16x+y+4 16x+y+z +3	(MSB)							Intermediate Data (if any) (z = length)	(LSB)

**Table number Field descriptions (listed alphabetically)**

**192 Intermediate Data**

The data from the specified source devices used in the xor operation. The length of the data is equal to the regenerate length multiplied by the block size.

**192 Number of Source Descriptors**

The number of source descriptors in the parameter data.

**192 Pad**

Provision for the Pad field is included to accommodate initiators which require the intermediate data to be aligned on a particular memory boundary. The Pad field does not contain valid data and is ignored.

**192 Source Descriptor/Pad Length**

The sum of the lengths (in bytes) of all of the source descriptors and the pad.

**192 Source Descriptor**

This field identifies the source device target identifiers and starting logical block addresses on the devices for the rebuild operation. See Table 193 for the source descriptor format.

**Table 193. Source descriptor format**

Bit Byte	7	6	5	4	3	2	1	0
0	Source Device Address							
1								
2								
3								
4								
5								
6								
7								
8	Reserved							
9								
10								
11								
12	Source Starting Logical Block Address							
13								
14								
15								

**Table number** **Field descriptions (listed alphabetically)**

**193 Source Device Address**

The SAM-compliant target identifier of the data source device.

**193 Source Starting Logical Block Address**

The starting logical block address to use when reading data from the source specified in the Source Device Address field.

**12.27 Release (6) command** 17h

The 6-byte Reserve and Release commands provide the basic mechanism for contention resolution in multiple-initiator systems. The Release (6) command is used to release a previously reserved logical unit, or, if the extent release option is implemented, to release previously reserved extents within a logical unit. It is not an error for an initiator to attempt to release a reservation that is not currently valid. In this case, the drive returns Good status without altering any other reservation. See also the 10-byte Reserve and Release commands.

The Release (6) command is implemented by the drive for an Entire Unit Release with Third Party Release supported and with the drive-specific parameters list in the table below.

**Table 194. Release (6) command (17h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	1	0	1	1	1
1	0	0	0	3rdPty	Third Party Device ID			0 Extent
2	Reservation Identification							
3	Reserved							
4	Reserved							
5	Control							

**Table number** **Field definitions (listed alphabetically)****194 Control**

See Control Bytes in Section 11.2.1.6.

**194 Extent (Extent Release)**

Not supported and must be zero (0).

**195 Reservation Identification**

Not supported.

**195 3rdPty (Third-Party)**

0 Bits 3, 2, and 1 are zeros.

1 Bits 3, 2, and 1 identify the SCSI bus ID of the device that reserves the drive.

**195 Third-Party Device ID**

Not supported.



**12.28 Release (10) command** 57h

The Reserve and Release commands provide the basic mechanism for contention resolution in multiple-initiator systems. The Release (10) command is used to release a previously reserved logical unit, or, if the extent release option is implemented, to release previously reserved extents within a logical unit. It is not an error for an initiator to attempt to release a reservation that is not currently valid. In this case, the drive returns Good status without altering any other reservation.

**Table 195. Release (10) command (57h)**

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (57h)							
1	0	0	0	3rdPty	0	0	Long ID	0 Extent
2	Reservation Identification							
3	Third-Party Device ID							
4	Reserved							
5	Reserved							
6	Reserved							
7	Parameter List Length							
8								
9	Control							

**Table number** **Field definitions (listed alphabetically)****195 Control**

See Control Bytes in Section 11.2.1.6.

**195 Extent (Extent Release)**

Not supported and must be zero (0).

**195 Long ID**

1 The ID of the third-party device is obtained by a parameter transfer. The parameter list length is specified by bytes 7 and 8 and must be 08h. See Section 12.32.

**195 Operation Code**

57h The operation code for the Release (10) command.

**195 Parameter List Length**

The length (in bytes) of the parameter list that is transferred during the data transfer.

The parameter list length will be either 00h, 04h or 0Eh (14 Decimal). No other pages are supported by the disc drive. If the initiator transfers more bytes than the disc drive supports, the disc drive rejects the command.

00h No additional parameter pages to be sent with this command (this is not considered an error).

04h The length value sent when the initiator sends Page 00h (see Table 208).

0Eh The value sent when Page 40h is sent (see Table 209).

**195 Reservation Identification**

Not supported.

**195 3rdPty (Third-Party)**

0 Bits 3, 2, and 1 are zeros.

1 Bits 3, 2, and 1 identify the SCSI bus ID of the device that reserves the drive.

**195 Third-Party Device ID**

Not supported.

**12.29 Report Device Identifier command** A3h

The Report Device Identifier command (see Table 196) requests that the drive send device identification information to the initiator.

**Table 196. Report Device Identifier command (A4h)**

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (A3h)							
1	Reserved			Service Action (05h)				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Allocation Length							
7								
8								
9								
10	Reserved							
11	Control							

**Table 196. Field definitions (listed alphabetically)****196 Allocation Length**

This field indicates how much space has been reserved for the returned parameter data. If the Length is not sufficient to contain all the parameter data, the first portion of the data is returned. This is not considered an error. The actual length of the parameter data is available in the Identifier Length field in the parameter data. If the remainder of the parameter data is required, the initiator should send a new Report Device Identifier command with an Allocation Length field large enough to contain all the data.

**196 Control**

See Section 11.2.1.6.

**196 Operation Code**

A3h The operation code for the Report Device Identifier command.

**196 Service Action**

05h The action defined in the SCC-2 standard (SCSI Controller Command set T10/1225), the Report Device Identifier command is the Report Peripheral Device/Component Device Identifier service action of the Maintenance In command (also Op. code A3h, but for initiators). Additional Maintenance In service actions (that apply to SCC-2 devices and devices that set the SCCS bit in their Standard Inquiry data) are defined in SCC-2.

The data returned from this command is formatted as described in the Report Device Identifier parameter list (see Table 197).

### Report Device Identifier Parameter List

This list contains the length (in bytes) of the parameter list and the logical unit's identifier.

The execution of a Report Device Identifier command may require you to enable nonvolatile memory within the logical unit. If the nonvolatile memory is not ready, the device server returns Check Condition status rather than wait for the device to become ready. The sense key is set to Not Ready and the additional sense data is set as described in the Test Unit Ready command. This information should allow the application client to determine the action required to cause the device server to become ready.

**Table 197. Report Device Identifier parameter list**

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB)							
1	Identifier Length (n - 4)							
2								
3								
4 : n	Identifier							

**Table number** **Field definitions (listed alphabetically)**

**197 Identifier**

This field contains a vendor-specific value. The value reported is the last value written by a successful Set Device Identifier command. The value of the identifier is changed only by a Set Device Identifier command. The identifier value persists through resets, power cycles, media format operations, and media replacement. The target returns the same identifier to all initiators on all ports.

**197 Identifier Length**

This field specifies the length (in bytes) of the Identifier field. If the Allocation Length field in the CDB is too small to transfer all of the identifier, the length is not adjusted to reflect the truncation. The identifier length is initially equal to zero and is changed only by a successful Set Device Identifier command.

**12.30 Request Sense command** 03h

The Request Sense command requests that the disc drive transfer sense data to the initiator in the format shown in Table 198. The sense data is valid after a Check Condition status returned on the prior command. Sense data is returned in the Fibre Channel Protocol Response frame with the Check Condition bypassing the need for the Request Sense command. Sense data must be cleared upon execution of any subsequent command. For Fibre Channel, data returned in response to a Request Sense command is only valid if commands are not queued in the drive.

If a disc drive sends a Check Condition status as a response to a Request Sense command being in error, it will do so only if the error was a fatal error. For example:

1. The disc drive receives a nonzero reserved bit in the command descriptor block.
2. A disc drive malfunction prevents return of sense data.

If any nonfatal error occurs during execution of Request Sense, the disc drive returns sense data with Good status. Following a fatal error on a Request Sense command, sense data may be invalid.

The disc drive terminates the data when the number of bytes indicated in the Allocation Length field have been transferred or when all available sense data have been transferred to the initiator, whichever is less. The disc drive always returns sense data in the extended sense data format shown in Section 11.5.1.

**Table 198. Request Sense command (03h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	1
1	0	0	0	0	0	0	0	0
	Reserved							
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	Allocation Length (in bytes)							
5	Control							

**Table  
number**

**Field definitions (listed alphabetically)****198 Allocation Length**

The allocation length in byte four of the format shown specifies the number of bytes the initiator has allocated for returned sense data. The allocation length should always be at least 18 bytes for disc drive devices for the initiator to receive all of the disc drive sense data. Any other value indicates the maximum number of bytes that will be transferred.

**198 Control**

See Control Bytes in Section 11.2.1.6.

### 12.31 Reserve (6) command 16h

The Reserve and Release commands provide the basic mechanism for contention resolution in multiple-initiator systems. The Reserve (6) command is used to reserve a logical unit or, if the extent reservation option is implemented, extents within a logical unit. The third-party reservation allows logical units or extents to be reserved for another specified SCSI device. See also the 10-byte Reserve and Release commands.

**Table 199. Reserve (6) command (16h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	1	0	1	1	0
1	0		0	0	3rdPty	Third Party Device ID		Extent
2	Reservation Identification							
3	(MSB) _____							
4	Extent List Length _____							
5	(LSB)							
5	Control							

**Table number** **Field definitions (listed alphabetically)**

**199 Control**

See Control Bytes in Section 11.2.1.6.

**199 Extent (Extent Release)**

Must be zero (0). Extent is not supported by the drive.

**199 Reservation Identification**

Not supported.

**199 3rdPty (Third-Party)**

0 The disc drive will be reserved for the device issuing the command if the command completes successfully.

1 Third-party reserve is used and Long ID byte 1, bit 1 must be a 1.

**199 Third-Party Device ID**

Not supported.

**12.32 Reserve (10) command** 56h

The Reserve and Release commands provide the basic mechanism for contention resolution in multiple-initiator systems. The Reserve (10) command is used to reserve a logical unit or, if the extent reservation option is implemented, extents within a logical unit. The third-party reservation allows logical units or extents to be reserved for another specified SCSI device.

**Table 200. Reserve (10) command (56h)**

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (56h)							
1	0	0	0	3rdPty	0	0	Long ID	Extent
	Reserved				Reserved			
2	Reservation Identification							
3	Third-Party Device ID							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) _____							
8	Parameter List Length						_____ (LSB)	
9	Control							

**Table number** **Field definitions (listed alphabetically)****200 Control**

See Control Bytes in Section 11.2.1.6.

**200 Extent (Extent Release)**

Must be zero (0). Extent is not supported by the drive.

**200 Long ID**

1 The Third Party ID is obtained by a parameter list transfer. The length is specified by bytes 7 and 8. The length must be 08h.

**200 Operation Code**

56h The operation code for the Reserve (10) command.

**200 Parameter List Length**

08h If the Long ID bit = 1, the Third Party ID is obtained by a parameter list transfer. The length must be 08h.

**200 Reservation Identification**

Not supported.

**200 3rdPty (Third-Party)**

0 The disc drive will be reserved for the device issuing the command if the command completes successfully.

1 Third-party reserve is used and Long ID byte 1, bit 1 must be a 1.

**200 Third-Party Device ID**

Not supported.

### 12.32.1 Logical unit reservation

When the Extent bit is zero, this command requests the entire disc drive to be reserved for exclusive use of the initiator until the reservation is superseded by another valid Reserve command from the initiator that made the reservation, released by a Release command from the same initiator, by a LIP Reset from any initiator, or be a hard Reset condition. A logical unit reservation is not granted if the logical unit is reserved by another initiator. It is permissible for an initiator to reserve a logical unit that is currently reserved by the initiator. If the Extent bit is zero (0), the Reservation Identification and the Extent List Length are ignored. If the Extent bit is a 1, the disc drive generates Check Condition status and sets the sense key to Illegal Request.

If, after honoring the reservation, any other initiator subsequently attempts to perform a command other than a Release command (which will be ignored), or an Inquiry command (which will be executed), or a Request Sense command (which will be executed), the command is rejected with Reservation Conflict status.

### 12.32.2 Third-party reservation

The third-party reservation option of the Reserve command allows an initiator to reserve a logical unit for another SCSI device. If the drive supports the third-party Reserve command, the disc drive also implements the third-party Release option (see Section 12.28). This feature is intended for use in multiple-initiator systems that use the Copy command.

If the third-party (3rdPty) bit is zero (0), the third-party reservation option is not requested. If the 3rdPty bit is one, the Reserve command reserves the specified logical unit for the SCSI device specified in the parameter list. The disc drive preserves the reservation until it is superseded by another valid Reserve command from the initiator which made the reservation or until it is released by the same initiator, by a LIP Reset from any initiator, or a hard Reset condition. The disc drive ignores any attempt to release the reservation made by any other initiator.

### 12.32.3 Superseding reservations

An initiator which holds a current reservation may modify that reservation by issuing another Reserve command to the same logical unit. The superseding Reserve command releases the previous reservation state when the new reservation request is granted. The previous reservation is not modified if the new reservation request cannot be granted.



### 12.32.4 Parameter list format for third-party addressing

The parameter list for the ten-byte Reserve and Release commands. Third-party addressing is eight bytes in length. The following table defines the format for the parameter list.

**Table 201. Parameter list format for third-party addressing**

Bit Byte	7	6	5	4	3	2	1	0
0	Reserved							PA_VAL
1	FCP_Port Identifier							(LSB)
2								
3								
4	Process Associator							(LSB)
5								
6								
7								

**Table number** **Field definitions (listed alphabetically)**

**201 FCP\_Port Identifier (Fibre Channel Protocol Port Identifier)**

Bytes 1–3, the 24-bit address used in the D\_ID and S\_ID fields of the Fibre Channel frame header.

**201 PA\_VAL (Process Associator Valid)**

The disc drive does not support process associators and requires this bit to be zero (0). This field indicates whether the Process Associator field (bytes 4–7) is valid.

**201 Process Associator**

Not supported and not checked.

### 12.33 Rezero Unit command 01h

The Rezero Unit command requests that the disc drive set its logical block address to zero (0) and return the disc drive read/write heads to the track (or cylinder) containing logical block zero (0). This command is intended for systems which disable retries and the initiator performs error recovery. It is longer than a seek to logical block address zero (0) and should be utilized if seek errors are encountered.

A Rezero Unit command also causes a thermal compensation to occur (on drives requiring thermal compensation) and resets the thermal compensation cycle timer back to its start, thus allowing the host to know when to expect the next thermal compensation to occur. The host can thus prevent critical data transfer operations from being interrupted at an undesirable time.

The Rezero Unit command will also save log counters to the media and reset the log save timer back to its start.

**Table 202. Rezero Unit command (01h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0	0
	Reserved							
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	Control							

**Table number** **Field definitions (listed alphabetically)**

**202 Control**

See Control Bytes in Section 11.2.1.6.

**12.34 Seek command** 0Bh

The Seek command requests that the disc drive seek to the specified logical block address. The initiator closes after sending one or more commands. The use of this command is infrequent since all commands involving data transfer to/from the disc drive media contain implied seek addresses. The disc drive arbitrates for the loop to send the Completion status.

**Table 203. Seek command (0Bh)**

Bit	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1
1	0	0	0	(MSB) Logical Block Address (LSB)				
	Reserved							
2								
3								
4	0	0	0	0	0	0	0	0
5	Control							

**Table number** **Field definitions (listed alphabetically)****203 Control**

See Control Bytes in Section 11.2.1.6.

**203 Logical Block Address**

The maximum logical block address that may be specified for a Seek command is defined in Read Capacity Data, Section 12.19.

### 12.35 Seek Extended command 2Bh

The Seek Extended command requests that the disc drive seek to the specified Logical Block Address. This command is implemented with the disc drive specific parameters listed in Table 204.

**Table 204. Seek Extended command (2Bh)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	0	1	0	1	1
1	0	0	0	0	0	0	0	0
	Reserved							
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	Control							

**Table number** **Field definitions (listed alphabetically)**

**204 Control**

See Control Bytes in Section 11.2.1.6.

**204 Logical Block Address**

This command operates the same as the Seek command (Section 12.34) except that a four-byte Logical Block Address is specified.

**12.36 Send Diagnostic command** 1Dh

This command requests that the disc drive perform diagnostic tests on itself, or perform other optional operations. Table 205 shows the format of the Send Diagnostic command as implemented by the disc drive. When the Self Test bit is zero, this command is usually followed by a Receive Diagnostic Results command and a subsequent data transfer that returns data to the initiator. Using this latter procedure of Send Diagnostic/Receive Diagnostic Results commands the initiator can ask the drive to return a list of optional operations it supports (see Table 208) and then request a supported additional operation. The disc drive supports the pages listed in Table 185 (see page 268).

For systems which support disconnection, the disc drive will disconnect while executing this command.

**Table 205. Send Diagnostic command (1Dh)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	0	1
1	Self-test Code			PF	Rsvd	Self-test	DEVOFL	Unit OFL
2	Reserved							
3	(MSB) _____							
4	Parameter List Length							(LSB)
5	Control							

**Table number** **Field definitions (listed alphabetically)****205 Control**

See Control Bytes in Section 11.2.1.6.

**205 DEVOFL (SCSI Device Off Line)**

- 1 Enables diagnostic operations that may adversely affect operations to other Logic Units on the same target. This bit is not interpreted by the disc drive.

**205 Parameter List Length**

The length (in bytes) of the parameter list that is transferred during the data transfer.

The parameter list length will be either 00h, 04h, 06h, or 0Eh (14 Decimal). No other pages are supported by the disc drive. If the initiator transfers more bytes than the disc drive supports, the disc drive rejects the command.

00h No additional parameter pages to be sent with this command (this is not considered an error).

04h The length value sent when the initiator sends Page 00h (see Table 208).

06h The value sent from page A0h (see Table 210).

0Eh The value sent from Page 40h is sent (see Table 209).

**205 PF (Page Format)**

- 1 The data returned by the subsequent Receive Diagnostic Results command use the diagnostic page format described in the ANSI SCSI-2 specification. See Tables 208 and 209 which show formats of the two pages supported by disc drive.

**205 Self-test**

- 0 Requests that the device server perform the Device Self-test operation specified by the Self-test Code field or in the parameter list. The diagnostic operation might or might not require the device server to return parameter data that contains diagnostic results. If the return of parameter data is not required, the return of Good status indicates successful completion of the diagnostic operation. If the return of parameter data is required, the device server either:
- performs the requested diagnostic operation, prepare the parameter data to be returned and indicate completion by returning Good status. The application client issues a Receive Diagnostic Results command to recover the parameter data; or
  - accept the parameter list, and if no errors are detected in the parameter list, return Good status. The requested diagnostic operation and the preparation of the parameter data to be returned are performed upon receipt of a Receive Diagnostic Results command.

- 1 Directs the device server to complete the target's Default Self-test. If the test passes successfully, the command is terminated with Good status; otherwise, the command is terminated with Check Condition status and the sense key is set to Hardware Error.

#### 205 Self-test Code

- 0 The contents of the Self-test Code field are as specified below:

Value	Function name	Description
000b	N/A	This value is used when the Self Test bit is 1 or if one of the other supported diagnostic pages is being transferred.
001b	Background Short Self-test	The device server starts its short self-test (see Section 13.2.2) in the background mode (see Section 13.2.3.2). The Parameter List Length field contains 0.
010b	Background Extended Self-test	The device server starts its extended self-test (see Section 13.2.2) in the background mode (see Section 13.2.3.2). The Parameter List Length field contains 0.
011b	Reserved.	
100b	Abort Background Self-test	The device server aborts the current self-test running in background mode. The Parameter List Length field contains 0. This value is only valid if a previous Send Diagnostic command specified a background self-test function and that self-test has not completed. If either of these conditions is not met, the device server returns a Check Condition status with a Sense Key of Illegal Request and an Additional Sense Code of Invalid Field in CDB.
101b	Foreground Short Self-test	Not supported.
110b	Foreground Extended Self-test	Not supported.
111b	Reserved	Reserved.

- 1 The Self-test Code field contains 000b.

#### 205 Unit OFL (Logical Unit Off Line)

- 0 Disables write operations on user medium or operations that affect user visible medium positioning. This bit is not interpreted by the disc drive.

**12.37 Set Device Identifier command** A4h

The Report Device Identifier command (see Table 206) requests that the device identifier information in the logical unit be set to the value received in the Set Device Identifier parameter list. On successful completion of the command, a Unit Attention is generated for all initiators except the one that issued the service action. When reporting the Unit Attention condition, the additional sense code is set to Device Identifier Changed.

**Table 206. Set Device Identifier command (A4h)**

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code (A4h)							
1	Reserved			Service Action (06h)				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Parameter List Length							
7								
8								
9								
10	Reserved							
11	Control							

**Table number** **Field definitions (listed alphabetically)****206 Control**

See Control Bytes in Section 11.2.1.6.

**206 Parameter List Length**

This field indicates the length in bytes of the identifier that will be transferred from the initiator to the drive. The maximum value for this field is 512 bytes. A parameter list length of zero indicates that no data will be transferred and that subsequent Report Device Identifier commands will return an identifier length of zero. Logical units that implement this command will be capable of accepting a parameter list length of 64 bytes or less. If the parameter list length exceeds 64 bytes and the logical unit is not capable of storing the requested number of bytes, the device server returns Check Condition status with the sense key set to Illegal Request and an additional sense code of Invalid Field in CDB.

**206 Operation Code**

A4h The operation code for the Report Device Identifier command.

**206 Service Action**

06h The Set Peripheral Device/Component Device Identifier.

The Set Device Identifier parameter list contains the identifier to be set by the addressed logical unit (see Table 197).

**Set Device Identifier Parameter List****Table 207. Report Device Identifier parameter list**

Bit Byte	7	6	5	4	3	2	1	0
0 : n	Identifier							

**Table number** **Field definitions (listed alphabetically)****197** **Identifier**

This field contains the vendor-specific value to be returned in Report Device Identifier commands.



### 12.37.1 Supported Diagnostic page–Send Diagnostic

This page instructs the disc drive to make available the list of all supported diagnostic pages to be returned by a subsequent Receive Diagnostic Results command. The definition of this page for the Send Diagnostic command includes only the first four bytes (Receive Diagnostic version given in Table 184). If the page length field is not zero, the disc drive terminates the Send Diagnostic command with a Check Condition status. The Sense Key will be set to Illegal Request with an additional sense code of Invalid Field Parameter List.

**Table 208. Supported Diagnostic Pages page**

Bit Byte	7	6	5	4	3	2	1	0
0	Page Code (00h)							
1	Reserved							
2	(MSB)							
3	Page Length (0000h) (LSB)							

**Table number** **Field definitions (listed alphabetically)**

**208 Page Code**

00h Supported Diagnostic Pages code.

**208 Page Length**

0000h Must be zero.

### 12.37.2 Translate Address page—Send Diagnostic

The translate address page allows the initiator to translate a logical block address into a physical sector address or a physical sector into a logical block address. The address to be translated is passed to the disc drive with Send Diagnostic command and the results are returned to the initiator during the data in phase following the Receive Diagnostic Results command. The translated address is returned in the Translate Address page returned after the Receive Diagnostic Results command (see Table 182).

**Table 209. Translate Address page—Send Diagnostic command**

Bit Byte	7	6	5	4	3	2	1	0
0	Page Code (40h)							
1	Reserved							
2	(MSB) _____							
3	Page Length (000Ah)						_____ (LSB)	
4	Reserved				Supplied Format			
5	Reserved				Translate Format			
6 : 13	Address To Translate							

#### Table number Field definitions (listed alphabetically)

##### 209 Address To Translate

A single address the initiator is requesting the disc drive to translate. The format of this field is defined by the Supplied Format Field. The supported formats are shown in Table 188 and Table 189.

##### 209 Page Code

40h Translate Address page—Send Diagnostic command page code.

##### 209 Page Length

000Ah The length (in bytes) of the Translate Address—Send Diagnostic page.

##### 209 Supplied Format

The format of the address to translate field. If the disc drive does not support the requested format, it terminates the Send Diagnostic command with Check Condition status. The sense key is set to Illegal Request and an additional sense code is set to Invalid Field In Parameter List.

000b Logical block address format.

101b Physical sector address format.

##### 209 Translate Format

The format to which the initiator would like the address to be translated. The Translate Format field must be different than the Supplied Format field. If the disc drive does not support the requested format it terminates the command with Check Condition status. The sense key is set to Illegal Request and an additional sense code is set to Invalid Field In Parameter List.

000b Logical block address format.

101b Physical sector address format.

### 12.37.3 Diagnostic page—Send Diagnostic

The Diagnostic page instructs the drive to turn the drive fault LED on or off. This page is used only by the Send Diagnostic command (see Table 210).

**Table 210. Diagnostic page—Send Diagnostic command**

Bit Byte	7	6	5	4	3	2	1	0
0	Page Code (A0h)							
1	Reserved							
2	(MSB) _____ Page Length (0002h) _____ (LSB)							
3								
4	Reserved							
5	Reserved							SBDL

**Table number** **Field definitions (listed alphabetically)**

**210 Page Code**

A0h Diagnostic page-Send Diagnostic command page code.

**210 Page Length**

000Ah The length (in bytes) of the Diagnostic—Send Diagnostic page.

**210 SBDL (Set Bad Device Light)**

1 Turn on the drive fault LED.

0 Turn off the drive fault LED.

**12.38 Start/Stop Unit command** 1Bh

The Start/Stop Unit command requests that the target enable the logical unit for further operations (start), or stop spindle rotation (stop).

The disc drive is able to execute the following commands when the drive spindle is not rotating, or in a simulated stopped condition.

- Test Unit Ready
- Reserve
- Receive Diagnostic Results
- Request Sense
- Release
- Write Data Buffer
- Inquiry
- Motor Start
- Read Data Buffer

The remaining commands (see SCSI Interface commands supported section in individual drive's Product Manual for list of all commands supported) cannot be executed until after the drive has spindled up. If the disc drive receives one of these commands before it can be executed, a Check Condition status is returned (with sense key of Not Ready). The initiator closes the loop after a Start Unit is commanded. The disc drive arbitrates for the loop when the unit is up to speed and Ready or when operation is initiated if the Immed bit is 1.

**Table 211. Start/Stop Unit command (1Bh)**

Bit Byte	7	6	5	4	3	2	1	0	
0	0	0	0	1	1	0	1	1	
1	0	0	0	0	0	0	0	Immed	
	Reserved								
2	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	Start	
5	Control								

**Table number** **Field definitions (listed alphabetically)****211 Control**

See Control Bytes in Section 11.2.1.6.

**211 Immed (Immediate)**

- 0 Status is returned after the operation is completed.
- 1 Status is returned as soon as the operation is initiated.

**211 Start**

- 1 Requests that the logical unit be made ready for use.
- 0 Requests that the drive to either actually stop the spindle or to simulate the drive spindle stopped condition. In this latter situation the drive spindle actually continues to spin and the drive reports Not Ready in response to media access commands. Power consumption is as when in idle mode. The type of stop implemented is given in the drive Product Manual.

**12.39 Synchronize Cache command** 35h

The Synchronize Cache command ensures that logical blocks in the cache memory, within the specified range, have their most recent data value recorded on the physical medium. If a more recent data value for a logical block within the specified range exists in the cache memory than on the physical medium, then the logical block from the cache memory is written to the physical medium. Logical blocks are not necessarily removed from the cache memory as a result of the synchronize cache operation.

**Table 212. Synchronize Cache command (35h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	1	0	1	0	1
1	0	0	0	0	0	0	0	0
	Reserved						Immed	RelAdr
2	Logical Block Address							
:								
5								
6	Reserved							
7	Number of Blocks							
8								
9	Control							

**Table number** **Field definitions (listed alphabetically)****212 Control**

See Control Bytes in Section 11.2.1.6.

**212 Immed (Immediate)**

- 1 The drive returns status as soon as the command descriptor block has been validated.
- 0 The status is not returned until the operation has been completed.
- 1 If the target does not support it, the command terminates with Check Condition status. The sense key is set to Illegal Request and the additional sense code is set to Invalid Field in CDB.

**212 Logical Block Address**

The logical block at which the Synchronize Cache operation begins.

**212 Number of Blocks**

The total number of contiguous logical blocks within the range. A number of blocks of zero indicates that all remaining logical blocks on the logical unit are within the range.

A logical block within the specified range that is not in cache memory is not considered an error. Multiple locks may be in effect from more than one initiator. Locks from different initiators may overlap. An unlock of an overlapped area does not release the lock of another initiator.

**212 RelAdr (Relative Address)**

This function is not supported by drives described in this manual.

### 12.40 Test Unit Ready command 00h

The Test Unit Ready command provides a means to verify the logical unit is ready. This is not a request for a self test. If the logical unit (drive) can accept an appropriate medium access command without returning Check Condition status, the drive returns a Good status.

If the drive cannot become operational or is in a state such that an initiator action (e.g., Start command) is required to make the unit ready, the drive returns Check Condition status with a sense key of Not Ready. One of several possible additional sense codes indicates the reason for the Not Ready condition.

**Table 213. Test Unit Ready command (00h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
	Reserved							
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	Control							

**Table number** **Field definitions (listed alphabetically)**

**213** **Control**

See Control Bytes in Section 11.2.1.6.

**12.41 Verify command** 2Fh

The Verify command requests that the target verify the data written on the medium. This command is implemented with the disc drive specific parameters listed in Table 214. The drive disconnects while this command is being executed if the initiator supports disconnect/reconnect.

**Table 214. Verify command (2Fh)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	0	1	1	1	1
1	Reserved			DPO	0	0	BytChk	RelAdr
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Verification Length (MSB)							
8	Verification Length (LSB)							
9	Control							

**Table number** **Field definitions (listed alphabetically)****214 BytChk (Byte Check)**

- 0 The verification will be a medium verification (CRC, ECC, etc.).
- 1 A byte-by-byte compare of data on the medium and the data transferred from the initiator. If the compare is unsuccessful, the command terminates with a Check Condition status and the sense key is set to Miscompare.

**214 Control**

See Control Bytes in Section 11.2.1.6.

**214 DPO (Disable Page Out)**

The DPO bit is used to control replacement of logical blocks in the cache memory when the host has information on the future usage of the logical blocks.

- 1 The target assigns the logical blocks accessed by this command the lowest priority for being fetched into or retained by the cache. The logical blocks accessed by the command are not likely to be accessed again in the near future and should not be put in the cache memory nor retained by the cache memory.
- 0 Logical blocks accessed by this command are likely to be accessed again in the near future.

**214 Logical Block Address**

The logical block at which the verify operation begins, if RelAdr is zero (0).

**214 RelAdr (Relative Address)**

This function is not supported by drives described in this manual.

**214 Verification Length**

The number of contiguous logical blocks of data that are verified. A Verification Length of zero indicates that no logical blocks are verified (an Implied Seek is still performed). This condition is not considered an error. Any other value indicates the number of logical blocks that are verified.

## 12.42 Write command 0Ah

The Write command requests that the disc drive write the data transferred by the initiator to the medium (discs).

**Table 215. Write command (0Ah)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0
1	Reserved			(MSB)				
2	Logical Block Address					(LSB)		
3								
4	Transfer Length							
5	Control							

### Table number Field definitions (listed alphabetically)

#### 215 Control

See Control Bytes in Section 11.2.1.6.

#### 215 Logical Block Address

The logical block at which the write operation begins.

#### 215 Transfer Length

The number of contiguous logical blocks of data to be transferred. Any value other than 0 indicates the number of logical blocks that are transferred.

0 Transfer 256 logical blocks

The disc drive closes the loop when any internal error recovery procedure is required, or if the disc drive's internal data buffer is full. After the disc closes, the initiator must re-arbitrate to send the remaining data.

The initiator must send requested write data to the drive until the drive sends Completion status or until the initiator resets/aborts the command or clears the queue. (The initiator may close and re-arbitrate at any time while executing this command).

Sense Data is valid after this command is executed and Completion status is sent (refer to the Read Command description in Section 12.16).

If the RCD bit is set to zero on the Caching Mode page 08h (cache is enabled), the data that is written by this command remains in the cache buffer, if no write errors are encountered. This allows a Read command to access the same data from the cache buffer instead of accessing the media, if the same LBA is requested by the Read command.

This command is terminated with a Reservation Conflict status and no data is written if any reservation access conflict (see Section 12.31) exists.

If any of the following conditions occur, this command is terminated with a Check Condition status, and if extended sense is implemented, the sense key is set as indicated in the following table. This table does not provide an exhaustive enumeration of all conditions that may cause the Check Condition status.

#### Condition

Invalid logical block address

Target reset since last command from this initiator

#### Sense key

Volume Overflow. Set the extended sense information bytes to the logical block address of the first invalid address.

Unit Attention.



**12.43 Write Extended command** 2Ah

The Write Extended command requests that the disc drive write to the medium the data transferred by the initiator. This command is implemented with the disc drive specific parameters listed in Table 216. Refer also to the Write Caching section in the individual drive's Product Manual, Volume 2, for information on write cache control.

**Table 216. Write Extended command (2Ah)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	0	1	0	1	0
1	Reserved			DPO	FUA	0	0	RelAdr
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Transfer Length (MSB)							
8	Transfer Length (LSB)							
9	Control							

**Table number** **Field definitions (listed alphabetically)****216 Control**

See Control Bytes in Section 11.2.1.6.

**216 DPO (Disable Page Out)**

- 1 No data is cached. The DPO bit is only meaningful if the RCD bit of Mode Select page 08h is set false (caching enabled).

**216 FUA (Force Unit Access)**

- 1 The Write command will not return Good status until the logical blocks have actually been written on the media. The FUA bit is only meaningful if the WCE bit of Mode Sense page 08h is true.

**216 Logical Block Address**

The logical block at which the write operation begins, if RelAdr bit is zero (see RelAdr bit definition).

**216 RelAdr (Relative Address)**

This function is not supported by drives described in this manual.

**216 Transfer Length**

The number of contiguous logical blocks of data that are transferred. A Transfer Length of zero (0) indicates no logical blocks are transferred. This condition is not considered an error and no data is written. Any other value indicates the number of logical blocks that are transferred.

This command operates the same as the Write command (Section 12.42) except that in the CDB for this command a four-byte logical block address and a two-byte transfer length may be specified.

This command terminates with a Reservation Conflict status if any reservation access conflict (see Section 12.31) exists, and no data is written.

If any of the following conditions occur, this command terminates with a Check Condition status and the sense key is set as indicated in the following table. This table does not provide an exhaustive enumeration of all conditions that cause the Check Condition status.

<b>Condition</b>	<b>Sense Key</b>
Invalid logical block address	Volume Overflow. Set the extended sense information bytes to the logical block address of the first invalid address.
Target reset since last command from this initiator	Unit Attention

**12.44 Write and Verify command** 2Eh**Table 217. Write and Verify command (2Eh)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	0	1	1	1	0
1	0 0 0 Reserved			0 DPO	0	0	BytChk	RelAdr
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Transfer Length (MSB)							
8	Transfer Length (LSB)							
9	Control							

**Table number** **Field definitions (listed alphabetically)****217 BytChk (Byte Check)**

- 0 Verification will be a medium verification (ECC) with no data comparison.
- 1 A byte-by-byte compare of data written on the peripheral device and the data transferred from the initiator. If the compare is unsuccessful, the command terminates with a Check Condition status and the sense key is set to Miscompare.

**217 Control**

See Control Bytes in Section 11.2.1.6.

**217 DPO (Disable Page Out)**

The DPO bit is used to control replacement of logical blocks in the cache memory when the host has information on the future usage of the logical blocks.

- 1 The target assigns the logical blocks accessed by this command the lowest priority for being fetched into or retained by the cache. The logical blocks accessed by the command are not likely to be accessed again in the near future and should not be put in the cache memory nor retained by the cache memory.
- 0 The logical blocks accessed by this command are likely to be accessed again in the near future.

**217 Logical Block Address**

The logical block at which the write operation begins if RelAdr bit is zero (see description of RelAdr bit for the Write Extended command).

**217 RelAdr (Relative Address)**

Drives supported by this manual do not implement this option.

**217 Transfer Length**

The number of contiguous logical blocks of data that are transferred. A transfer length of zero indicates that no logical blocks are transferred. This condition is not considered an error and no data is written. Any other value indicates the number of logical blocks that are transferred.

For systems that support disconnection, the disc drive disconnects during the execution of this command.

### 12.45 Write Data Buffer command 3Bh

The Write Buffer command may be used in conjunction with the Read Buffer command as a diagnostic function for testing the disc drive's data buffer memory and the FC-AL integrity. When used in a diagnostic mode, the medium is not accessed during the execution of this command. Additional modes are provided for downloading and saving executable microcode. The function of this command and the meaning of the fields within the Command Descriptor Block depend on the Mode field.

**Table 218. Write Data Buffer command (3Bh)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	1	1	0	1	1
1	0	0	0	0	0	Mode		
2	Buffer ID							
3	(MSB)							
4	Buffer Offset							
5								
6	(MSB)							
7	Byte Transfer Length							
8								
9	Control							

**Table number** **Field definitions (listed alphabetically)**

**218 Buffer ID**

Implemented only by drives that support modes 110b and 111b.

**218 Buffer Offset**

Implemented only by drives that support modes 110b and 111b.

**218 Byte Transfer Length**

Use a Read Data Buffer command with mode bits set to 011b to get the drive buffer capacity to use with the Write Buffer command.

**218 Control**

See Control Bytes in Section 11.2.1.6.

**218 Mode**

Defined in the following table and in the referenced sections.

Check with your drive's Product Manual, Volume 1, to see which modes are supported by the drive.

Table 219. Mode definitions

Bit 2	Bit 1	Bit 0	Mode Definition
0	0	0	Write combined header and data (Section 12.45.1)
0	1	0	Write data (Section 12.45.2)
1	0	0	Download microcode
1	0	1	Download microcode and save (Section 12.45.3)
1	1	0	Download microcode with offsets
1	1	1	Download microcode with offsets and save (Section 12.45.4)

### 12.45.1 Combined Header and Data mode (000b)

In this mode, data to be written to the disc drive's data buffer is preceded by a four-byte header.

The Byte Transfer Length includes a four-byte header and the Write Buffer data. A transfer length of zero indicates that no data transfer takes place. This condition does not create the Check Condition status. If the transfer length is greater than the Buffer Capacity reported by the Read Buffer header, the disc drive creates the Check Condition status with the sense key of Illegal Request. In this case no data is transferred from the initiator.

It is not considered an error to request a transfer length less than the Buffer Capacity.

Buffer ID and Buffer Offset fields are all zero.

The write data following the Write Buffer CDB consists of a four-byte Write Buffer header (which always precedes the data) plus the data to be written to the data buffer as follows:

**Table 220. Write Buffer header**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4 - n	Data to be written into disc drive buffer							

### 12.45.2 Write Data Only mode (010b)

The byte transfer length specifies the maximum number of bytes that are transferred and stored in the drive buffer. No header bytes are included. The Buffer ID and Buffer Offset fields are all zero.

### 12.45.3 Download Microcode and Save mode (101b)

In this mode, vendor-unique executable microcode (which is not preceded by a four-byte header) is transferred to the control memory space of the target and, if the download is completed successfully, will also be saved. The downloaded code is then effective after each power cycle and reset until it is replaced using another download microcode and save operation. When the download microcode and save command has been completed successfully, the target generates a Unit Attention condition for all initiators with an extended sense of Power On, Reset, or Bus Device Reset Occurred (Sense Data Error Code 29 03h). Following the downloading of new microcode, the drive may need to be reformatted before it can perform properly.

For this mode (101b) the command bytes of Table 218 are interpreted as shown below:

#### Buffer ID and Buffer Offset fields (CDB bytes 2–5):

These bytes are all zero.

#### Byte Transfer Length (CDB bytes 6, 7 and 8):

The transfer length (in bytes) of the downloadable code. This value must be the exact length of the download data. A value of one signifies one byte of download data, etc.

#### Control Bytes (CDB byte 9):

All bits zero.

### 12.45.4 Download Microcode with Offsets and Save mode (111b)

In this mode, the initiator may split the transfer of the vendor-specific microcode or control information over two or more write buffer commands. If the logical unit cannot accept this command because of some device condition, the logical unit terminates each write buffer command with this mode (111b) with a Check Condition status, a sense key of Illegal Request, and sets the additional sense code to Command Sequence Error.

If the last write buffer command of a set of one or more commands completes successfully, the microcode or control information is saved in a nonvolatile memory space (semiconductor, disk or other). The saved downloaded microcode or control information is then effective after each power-cycle and reset until it is supplanted by another download microcode with save operation or download microcode with offsets and save operation. In this mode, the data transfer contains vendor-specific, self-describing microcode or control information.

Since the downloaded microcode or control information may be sent using several commands, when the logical unit detects the last download microcode with offsets and save Write Buffer command has been received, the logical unit performs any logical unit required verification of the complete set of downloaded microcode or control information prior to returning Good status for the last command. After the last command completes successfully, the logical unit generates a unit attention condition for all initiators except the one that issued the set of write buffer commands. When reporting the unit attention condition, the logical unit sets the additional sense code to Microcode Has Been Changed.

If the complete set of write buffer commands required to effect a microcode or control information change (one or more commands) are not received before a reset or power-on cycle occurs, the change is not effective and the microcode or control information is discarded.

The Buffer ID field identifies a specific buffer within the logical unit. The vendor assigns buffer ID codes to buffers within the logical unit. A Buffer ID field value of zero is supported. If more than one buffer is supported, additional buffer ID codes are assigned contiguously, beginning with one. If an unsupported buffer ID code is identified, the logical unit returns Check Condition status and sets the sense key to Illegal Request with an additional sense code of Invalid Field In CDB.

The microcode or control information are written to the logical unit buffer starting at the location specified by the buffer offset. The initiator conforms to the offset boundary requirements. If the logical unit is unable to accept the specified buffer offset, it returns Check Condition status and it sets the sense key to Illegal Request with an additional sense code of Invalid Field In CDB.

The parameter list length specifies the maximum number of bytes that are transferred during the data transfer to be stored in the specified buffer beginning at the buffer offset. The initiator attempts to ensure that the parameter list length plus the buffer offset does not exceed the capacity of the specified buffer. If the Buffer Offset and Parameter List Length fields specify a transfer that would exceed the buffer capacity, the logical unit returns Check Condition status and sets the sense key to Illegal Request with an additional sense code of Invalid Field In CDB.

## 12.46 Write Long command 3Fh

The Write Long command requests that the target write to the medium the data transferred by the initiator. The data passed during the Write Long command includes the data bytes and all ECC bytes to be written to the single logical block addressed in the command. The Read Long command is usually issued before issuing a Write Long command. The Write Long data passed must be in the same order and must be the same number of bytes as the Read Long command.

**Table 221. Write Long command (3Fh)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	1	1	1	1	1
1	0	0	0	0	0	0	0	RelAdr
	Reserved							
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	0	0	0	0	0	0	0	0
7	Byte Transfer Length (MSB)							
8	Byte Transfer Length (LSB)							
9	Control							

### Table number Field definitions (listed alphabetically)

#### 221 Byte Transfer Length

The number of bytes of data that will be transferred. A transfer length of zero (0) indicates that no bytes will be transferred. This condition is not considered an error.

The byte transfer length requested must be equal to the current block size plus all ECC bytes for a data transfer to occur. If an incorrect number of bytes is stated in the command block, this command terminates with a Check Condition status. The correct number of bytes can be determined from the information returned in the extended sense data bytes after issuing the Request Sense command. The Request Sense command results in the Illegal Field In CDB condition with the Illegal Request sense key. The extended sense ILI bit will be set. The extended sense information bytes contain the difference (residue) of the requested length minus the actual length (in bytes). (Negative values are indicated by two's complement notation.)

#### 221 Control

See Control Bytes in Section 11.2.1.6.

#### 221 Logical Block Address

The 32-bit address of the logical block affected by this command.

#### 221 RelAdr (Relative Address)

This function is not supported by drives described in this manual.



**12.47 Write Same command** 41h

The Write Same command requests that the target write the single block of data transferred by the initiator to the medium multiple times..

**Table 222. Write Same command (41h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	1	0	0	0	0	0	1
1	Reserved			Reserved		PBdata	LBdata	RelAdr
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	Reserved							
7	Number of Blocks (MSB)							
8	Number of Blocks (LSB)							
9	Control							

**Table number** **Field definitions (listed alphabetically)****223 Control**

See Section 11.2.1.6.

**223 LBdata (Logical Block data)**

Seagate fibre channel drives do not support this bit.

**223 Logical Block Address**

The 32-bit address of the logical block affected by this command.

**223 Number of Blocks**

The number of contiguous logical blocks to be written.

0 A value of 0 requests that all the remaining logical blocks on the medium be written.

**223 PBdata (Physical Block data)**

Seagate fibre channel drives do not support this bit.

**222 RelAdr (Relative Address)**

This function is not supported by drives described in this manual.

**12.48 XDread command** 52h

The XDread command requests that the target transfer the xor data generated by an XDwrite or Regenerate command to the initiator.

If the logical unit is reserved, a reservation conflict occurs when a XDread command is received from an initiator other than the one holding the logical unit reservation. The command is rejected with Reservation Conflict status if the reservation conflict is due to a logical unit reservation. The XDread command is evaluated for extent reservation conflicts. XDread commands with a reservation conflict is terminated with Check Condition status and the sense key is set to Data Protect if any part of the XDread operation is prohibited by an extent reservation.

The xor data transferred is identified by the logical block address and transfer length. The logical block address and transfer length is the same as, or a subset of, those specified in a prior XDwrite or Regenerate command. If a match is not found, the command is terminated with a Check Condition status. The sense data is set to Illegal Request: Invalid Field in CDB.

**Table 223. XDread command (52h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	1	0	1	0	0	1	0
1	Reserved							
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	Reserved							
7	Byte Transfer Length (MSB)							
8	Byte Transfer Length (LSB)							
9	Control							

**Table number** **Field definitions (listed alphabetically)****223** **Byte Transfer Length**

The number of bytes of data that will be transferred. A transfer length of zero (0) indicates that no bytes will be transferred. This condition is not considered an error.

**223** **Control**

See Section 11.2.1.6.

**223** **Logical Block Address**

The 32-bit address of the logical block affected by this command.

**12.49 XDwrite command** 50h

The XDwrite command requests that the target xor the data transferred with the data on the medium. The resulting xor data is stored by the target until it is retrieved by an XDread command.

The resulting xor data is retrieved by an XDread command with starting logical block address and transfer length fields that match, or is a subset of, the starting logical block address and transfer length of this command.

If the logical unit is reserved, a reservation conflict occurs when a XDwrite command is received from an initiator other than the one holding the logical unit reservation. The command is rejected with Reservation Conflict status if the reservation conflict is due to a logical unit reservation. The XDwrite command is evaluated for extent reservation conflicts. XDwrite commands with a reservation conflict are terminated with Check Condition status and the sense key is set to Data Protect if any part of the XDwrite operation is prohibited by an extent reservation.

**Table 224. XDwrite command (50h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	1	0	1	0	0	0	0
1	Reserved			DPO	FUA	Disable Write	Reserved	
2	Logical Block Address (MSB)							
3								
4								
5								
6	Reserved							
7	Transfer Length (MSB)							
8	Transfer Length (LSB)							
9	Control							

**Table number** **Field definitions (listed alphabetically)****224 Control**

See Section 11.2.1.6.

**224 Disable Write**

- 0 The data transferred from the initiator is written to the medium after the xor operation is complete.
- 1 The data is not written to the medium.

**224 DPO (Disable Page Out)**

- 0 The priority is determined by the retention priority fields in the caching page. All other aspects of the algorithm implementing the cache memory replacement strategy are not defined.
- 1 The device server assigns the logical blocks accessed by this command the lowest priority for being fetched into or retained by the cache. This value overrides any retention priority specified in the caching page.

**224 FUA (Force Unit Access)**

- 0 The device server may satisfy the command by accessing the cache memory.  
For read operations, any or all of the logical blocks that are contained in the cache memory may be transferred to the application client directly from the cache memory.  
For write operations, logical blocks may be transferred directly to the cache memory. Good status may be returned to the application client prior to writing the logical blocks to the medium. Any error that occurs after the Good status is returned is a deferred error, and information regarding the error is not reported until a subsequent command.

- 1 The device server accesses the media in performing the command prior to returning Good status.  
Read commands access the specified logical blocks from the media (the data is not directly retrieved from the cache). In the case where the cache contains a more recent version of a logical block than the media, the logical block writes to the media first.  
Write commands do not return Good status until the logical blocks have actually been written on the media (the data is not write cached).

**224 Logical Block Address**

The starting logical block address of the data to be affected by the xor operation.

**224 Transfer Length**

The number of logical blocks that will be transferred to the XDwrite target and the number of logical blocks that will be affected by the xor operation.

**12.50 XDwrite Extended command** 80h

The XDwrite command requests that the target xor the data transferred with the data on the medium. The resulting xor data may then be sent to a secondary device using an XPwrite command. The xor data transfer to the secondary target is performed using an XPwrite command. The XPwrite command is sent to the device specified in the secondary address field. The secondary logical block address field value is placed in the logical block address field of the XPwrite command.

If the logical unit is reserved, a reservation conflict occurs when a XDwrite Extended command is received from an initiator other than the one holding the logical unit reservation. The command is rejected with Reservation Conflict status if the reservation conflict is due to a logical unit reservation. The XDwrite Extended command is evaluated for extent reservation conflicts. XDwrite Extended commands with a reservation conflict are terminated with Check Condition status and the sense key is set to Data Protect if any part of the XDwrite Extended operation is prohibited by an extent reservation.

**Table 225. XDwrite Extended command (80h)**

Bit Byte	7	6	5	4	3	2	1	0
0	1	0	0	0	0	0	0	0
1	Table Address	Reserved	Reserved	DPO	FUA	Disable Write	Port Control	
2	Logical Block Address (MSB)							
3								
4								
5								
6	Secondary Logical Block Address (MSB)							
7								
8								
9	Secondary Logical Block Address (LSB)							
10	Transfer Length (MSB)							
11	Transfer Length							
12	Transfer Length							
13	Transfer Length (LSB)							
14	Secondary Address							
15	Control							

**Table number** **Field definitions (listed alphabetically)****225 Control**

See Section 11.2.1.6.

**225 Disable Write**

- 0 The data transferred from the initiator is written to the medium after the xor operation is complete.
- 1 The data is not written to the medium.

**225 DPO (Disable Page Out)**

- 0 The priority is determined by the retention priority fields in the caching page. All other aspects of the algorithm implementing the cache memory replacement strategy are not defined.
- 1 The device server assigns the logical blocks accessed by this command the lowest priority for being fetched into or retained by the cache. This value overrides any retention priority specified in the caching page.

**225 FUA (Force Unit Access)**

- 0 The device server may satisfy the command by accessing the cache memory.  
For read operations, any or all of the logical blocks that are contained in the cache memory may be transferred to the application client directly from the cache memory.  
For write operations, logical blocks may be transferred directly to the cache memory. Good status may be returned to the application client prior to writing the logical blocks to the medium. Any error that occurs after the Good status is returned is a deferred error, and information regarding the error is not reported until a subsequent command.
- 1 The device server accesses the media in performing the command prior to returning Good status.  
Read commands access the specified logical blocks from the media (the data is not directly retrieved from the cache). In the case where the cache contains a more recent version of a logical block than the media, the logical block writes to the media first.  
Write commands do not return Good status until the logical blocks have actually been written on the media (the data is not write cached).

**225 Logical Block Address**

The starting logical block address of the data to be affected by the xor operation.

**225 Port Control**

This field determines which ports are used for the target transfers.

- 00 The target transfers the data using the same port that received the command.
- 01 The target transfers the data using a different port than that which received the command. If the target is not a multiple port device, the command terminates with a Check Condition status and the sense data is set to Illegal Request: Invalid Field in CDB.
- 10 The target transfers the data using one port of the target's choice.
- 11 The target transfers the data using one or more ports of the target's choice.

**225 Table Address**

- 0 The secondary address field contains the target identifier of the target to which the xor data is transferred. The implied logical unit number of the secondary target is zero. If the transport protocol requires more than one byte for the target identifier and the table address bit is set to zero, the secondary address field specifies the least significant byte of the secondary target identifier. The upper bytes of the secondary target identifier is equal to the upper bytes of the target identifier of the XDwrite Extended target.
- 1 The secondary address field contains a pointer to a lookup table of SAM compliant target identifiers. The lookup table is reserved for future definition.

**225 Transfer Length**

The number of logical blocks that will be transferred to the XDwrite Extended target and to the XPwrite target.

**12.51 XPwrite command** 51h

The XDread command requests that the target transfer the xor data transferred with the data on the medium and then write the xor data to the medium.

If the logical unit is reserved, a reservation conflict occurs when a XPwrite command is received from an initiator other than the one holding the logical unit reservation. The command is rejected with Reservation Conflict status if the reservation conflict is due to a logical unit reservation. The XPwrite command is evaluated for extent reservation conflicts. XPwrite commands with a reservation conflict is terminated with Check Condition status and the sense key is set to Data Protect with the appropriate additional sense code for the condition if any part of the XPwrite operation is prohibited by an extent reservation.

**Table 226. XPwrite command (51h)**

Bit Byte	7	6	5	4	3	2	1	0
0	0	1	0	1	0	0	0	1
1	Reserved			DPO	FUA	Reserved		
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	Reserved							
7	Byte Transfer Length (MSB)							
8	Byte Transfer Length (LSB)							
9	Control							

**Table number** **Field definitions (listed alphabetically)****226** **Byte Transfer Length**

The number of bytes of data that will be transferred. A transfer length of zero (0) indicates that no bytes will be transferred. This condition is not considered an error.

**226** **Control**

See Section 11.2.1.6.

**226** **DPO (Disable Page Out)**

The DPO bit is used to control replacement of logical blocks in the cache memory when the host has information on the future usage of the logical blocks.

- 1 The disc drive assigns the logical blocks accessed by this command the lowest priority for being fetched into or retained by the cache. The host knows the logical blocks accessed by the command are not likely to be accessed again in the near future and should not be put in the cache memory nor retained by the cache memory.
- 0 The host expects that logical blocks accessed by this command are likely to be accessed again in the near future.

**226** **FUA (Force Unit Access)**

- 1 The target accesses the media in performing the command prior to returning Good status. Read commands access the specified logical blocks from the media (i.e., the data is not directly retrieved from the cache). In the case where the cache contains a more recent version of a logical block than the media, the logical block is first written to the media.
- 0 The target satisfies the command by accessing the cache memory. For read operations, any logical blocks that are contained in the cache memory are transferred to the initiator directly from the cache memory.

**226** **Logical Block Address**

The 32-bit address of the logical block affected by this command.





## 13.0 Drive features

This section describes several features included for disc drives. Refer to the individual drive's product manual to determine if your drive supports these features.

### 13.1 Self-Monitoring Analysis and Reporting Technology

Self-Monitoring Analysis and Reporting Technology (S.M.A.R.T.) is designed to recognize conditions that indicate imminent drive failure and provide sufficient warning to the host system of impending failure. The host system may use the information provided to trigger it to perform diagnostic, preventative, and/or protective functions (e.g., data backup).

The initiator sets up the parameters for S.M.A.R.T. operation using Mode Select Informational Exceptions Control page 1Ch. The drive reports information about S.M.A.R.T. operation using Request Sense Additional Sense Code 5D 00 and Mode Sense data page 1Ch. Refer to sections 12.9, 12.10, 12.11, and 12.12 for descriptions of the Mode Select and Mode Sense commands. Refer to Section 12.11.13 for details on the Informational Exceptions Control page. Refer to the individual drive's product manual to determine if your particular drive supports S.M.A.R.T. and the extent of its implementation of the S.M.A.R.T. system.

### 13.2 Self-test operations

Default Self-test (DST) technology is part of a system to recognize drive fault conditions that qualify it for return to Seagate. If the drive fails the test, remove it from service.

#### 13.2.1 Default self-test

The default self-test is mandatory for all device types that support the Send Diagnostics command. The response is simply a Good status if the test is successful or a Check Condition status if the test fails. Additional status is available in the Default Self-test Diagnostics Results page by using the Receive Diagnostic Results command (see Section 12.25).

#### 13.2.2 Short and extended device self-tests

There are two optional types of device self-test that may be invoked using the Self-test Code field in the Send Diagnostics command: a short test and an extended test. The goal of the short device self-test is to quickly identify if the logical unit is faulty. A goal of the extended device self-test routine is to simplify factory testing during integration by having logical units perform more comprehensive testing without application client intervention. A second goal of the extended device self-test is to provide a more comprehensive test to validate the results of a short device self-test if its results are judged by the application client to be inconclusive.

The criteria for the short device self-test are that it has one or more segments and completes in two minutes or less. The criteria for the extended device self-test are that it has one or more segments and that the completion time is vendor-specific. Any tests performed in the segments are vendor-specific.

The following are examples of segments:

- a. An electrical segment wherein the logical unit tests its own electronics. The tests in this segment are vendor specific, but some examples of tests that might be included are: a read/write circuitry test and/or a test of the read/write head elements;
- b. A seek/servo segment wherein a device tests its capability to find and servo on data tracks; and
- c. A read/verify scan segment wherein a device performs read scanning of some or all of the medium surface.

The tests performed in the segments may be the same for the short and extended device self-tests. The time required by a logical unit to complete its extended device self-test is reported in the Extended Self-test Completion Time field in the Control Mode page (see Section 12.11.8).

#### 13.2.3 Device self-test modes

There are two modes for short and extended self-tests: a foreground mode and a background mode. These modes are described in the following sections.

### 13.2.3.1 Foreground mode

When a device server receives a Send Diagnostics command specifying a self-test to be performed in the foreground mode, the device server returns status for that command after the self-test has been completed. Not all Seagate drives support this mode.

While performing a device self-test in foreground mode, the device server responds to all commands except Inquiry, Report LUNs, and Request Sense with a Check Condition status, a sense key of Not Ready and an additional sense code of Logical Unit Not Ready, Self-test In Progress.

If a device server is performing a device self-test in the foreground mode and a test segment error occurs during the test, the device server updates the Device Self-test results log page (see Section 12.8.4) and reports Check Condition status with a sense key of Hardware Error and an additional sense code of Logical Unit Failed Self-test. The application client may obtain additional information about the failure by reading the Device Self-test Results log page. If the device server is unable to update the Self-test Results log page, it returns a Check Condition status with a sense key of Hardware Error and an additional sense code of Logical Unit Unable To Update Self-test Log.

An application client should reserve the logical unit before initiating a device self-test in the foreground mode. An application client may terminate a device self-test that is being performed in the foreground mode using an Abort Task, Abort Task Set, or Clear Task Set task management function. If a task manager receives an Abort Task, Abort Task Set, or Clear Task Set task management function while performing a device self-test in the foreground mode, it aborts the device self-test and updates the Device Self-test Results log page (see Section 12.8.4).

### 13.2.3.2 Background mode

When a device server receives a Send Diagnostics command specifying a device self-test to be performed in the background mode, the device server returns status for that command as soon as the command descriptor block has been validated.

After returning status for the Send Diagnostics command specifying a self-test to be performed in the background mode, the device server shall initialize the Device Self-test Results log page (see Section 12.8.4) as follows. The self-test code from the Send Diagnostics command shall be placed in the Self-test Code field in the log page. The Self-test Results field shall be set to Fh. After the Self-test results log page is initialized, the device server shall begin the first self-test segment.

While the device server is performing a self-test in the background mode, it shall terminate with a Check Condition status any Send Diagnostics command it receives that meets one of the following criteria:

- a. The Self-test bit is one; or
- b. The Self-test Code field contains a value other than 000b or 100b.

When terminating the Send Diagnostics command, the sense key is set to Not Ready and the additional sense code is set to Logical Unit Not Ready, Self-test In Progress.

While performing a device self-test in the background mode, the device server suspends the device self-test to service any other commands received with the exceptions listed below.

#### Exception commands for background self-tests

- Send Diagnostics (with Self-test Code field set to 100b)
- Write Buffer (with the mode set to any download microcode option)
- Format Unit
- Start/Stop Unit (stop only)

Suspension of the device self-test to service the command occurs as soon as possible, but should never take longer than two seconds.

If one of the exception commands listed above is received, the device server shall abort the self-test, update the self-test log, and service the command as soon as possible but not longer than two seconds after the command descriptor block has been validated.

**Note.** An application client may terminate a self-test that is being performed in the background mode by issuing a Send Diagnostics command with the Self-test Code field set to 100b (Abort background self-test function).

**13.2.3.3 Elements common to foreground and background self-test modes**

The Progress Indication field returned in response to a Request Sense command (see Section 12.30) may be used by the application client at any time during execution of a device self-test to poll the logical unit's progress. While executing a self-test (unless an error has occurred), the device server responds to a Request Sense command by returning a sense key of Not Ready and an additional sense code of Logical Unit Not Ready, Self-test In Progress with the sense key specific bytes set for progress indication.

The application client may obtain information about the twenty most recently completed device self-tests by reading the Device Self-test Results log page (see Section 12.8.4). This is the only method an application client can use to obtain information about self-tests performed in the background mode.

Table 227 summarizes when a logical unit returns status after receipt of a self-test command, how an application client may abort a device self-test, how a logical unit handles new commands that are received while a device self-test is in progress, and how a logical unit reports a device self-test failure.

**Table 227: Device Self-test mode summary**

<b>Mode</b>	<b>When status is returned</b>	<b>How to abort the Device Self-test</b>	<b>Processing of subsequent commands while Device Self-test is executing</b>	<b>Device Self-test failure reporting</b>
Foreground	After the self-test is complete	Abort Task task management function	If the command is Inquiry, Report LUNs, or Request Sense, process normally. Otherwise, terminate with Check Condition status, Not Ready sense key, and Logical Unit Not Ready, Self-test In Progress additional sense code.	Terminate with Check Condition status, Hardware Error sense key, and Logical Unit Failed Self-test or Logical Unit Unable To Update Self-test Log additional sense code.
Background	After the CDB is validated	Send Diagnostics command with Self-test Code field set to 100b	Process the command, except as described in 13.2.3.2.	Application client checks Device Self-test results log page (see 12.8.4) after the Progress Indication field returned from Request Sense indicates the self-test is complete.



## 14.0 Seagate Technology support services

### Online Services

#### *Internet*

For online information about Seagate products, visit [www.seagate.com](http://www.seagate.com) or e-mail your disc or tape questions to:

#### *Presales Support:*

Disc: [http://www.seagate.com/support/email/email\\_presales.html](http://www.seagate.com/support/email/email_presales.html) or [DiscPresales@Seagate.com](mailto:DiscPresales@Seagate.com)

Tape: [http://www.seagate.com/support/email/email\\_tape\\_presales.html](http://www.seagate.com/support/email/email_tape_presales.html) or  
[Tape\\_Sales\\_Support@Seagate.com](mailto:Tape_Sales_Support@Seagate.com)

#### *Technical Support:*

Disc: [http://www.seagate.com/support/email/email\\_disc\\_support.html](http://www.seagate.com/support/email/email_disc_support.html) or [DiscSupport@Seagate.com](mailto:DiscSupport@Seagate.com)

Tape: [http://www.seagate.com/support/email/email\\_tape\\_support.html](http://www.seagate.com/support/email/email_tape_support.html) or [TapeSupport@Seagate.com](mailto:TapeSupport@Seagate.com)

**SeaBOARD<sup>®</sup>** is a computer bulletin board system that contains information about Seagate disc and tape drive products and is available 24 hours daily. Set your communications software to eight data bits, no parity and one stop bit (8-N-1).

### Automated Services

**SeaFONE<sup>®</sup> (1-800-SEAGATE)** is Seagate's toll-free number (1-800-732-4283) to access our automated self-help services. Using a touch-tone phone, you can find answers to service phone numbers, commonly asked questions, troubleshooting tips and specifications for disc drives and tape drives 24 hours daily. International callers can reach this service by dialing +1-405-936-1234.

**SeaFAX<sup>®</sup>** is Seagate's automated FAX delivery system. Using a touch-tone phone, you can obtain technical support information by return FAX 24 hours daily. This service is available worldwide.

### Presales Support

#### *Presales Support*

Our Presales Support staff can help you determine which Seagate products are best suited for your specific application or computer system. *Disc:* 1-877-271-3285; *Tape:* 1-800-626-6637.

#### *Online Tape Purchases*

US customers can purchase Seagate data cartridges, tape supplies, accessories, and select Seagate tape drive products 24 hours daily at <http://buytape.seagate.com>.

### Technical Support

If you need help installing your drive, consult your dealer. Dealers are familiar with their unique system configurations and can help you with system conflicts and other technical issues. If you need additional help, you can talk to a Seagate technical support specialist. Before calling, note your system configuration and drive model number (ST#####).

**SeaTDD<sup>™</sup> (+1-405-936-1687)** is a telecommunications device for the deaf (TDD). You can send questions or comments 24 hours daily and exchange messages with a technical support specialist from 8:00 A.M. to 12:15 P.M. and 1:30 P.M. to 6:00 P.M. (central time) Monday through Friday.

### Customer Service (CSO)

#### *Warranty Service*

Seagate offers worldwide customer support for Seagate drives. Seagate direct OEM, Distribution and System Integrator customers should contact their Seagate service center representative for warranty information. Other customers should contact their place of purchase.

## Authorized Service Centers

If you live outside the US, you can contact an Authorized Service Center for service.

## USA/Canada/Latin America Support Services

### Presales Support

*Disc:* 1-877-271-3285 or +1-405-936-1210 FAX: +1-405-936-1683  
*Tape:* 1-800-626-6637 or +1-714-641-2500 FAX: +1-714-641-2410

### Technical Support (SeaFONE)

1-800-SEAGATE or +1-405-936-1234 (for specific product phone number)  
 FAX: *Disc:* +1-405-936-1685; *Tape:* +1-405-936-1683

**SeaFAX** 1-800-SEAGATE  
**SeaTDD** +1-405-936-1687  
**SeaBOARD** *Disc:* +1-405-936-1600; *Tape:* +1-405-936-1630

### Warranty Service

USA 1-800-468-3472 FAX: +1-405-949-6740  
 Mexico and Latin America +1-405-949-7758 FAX: +1-405-949-6738

Canada  
*Memofix*<sup>1</sup> +1-905-660-4936 or 1-800-636-6349 FAX: +1-905-660-4951  
<http://www.memofix.com>  
*Adtech*\* +1-905-812-8099 or 1-800-624-9857 FAX: +1-905-812-7807  
<http://www.adtech1.com>

Brazil  
*MA Informatica* +55-21-516-6649 FAX: +55-21-223-3156  
 e-mail: [sgt\\_cso@gbl.com.br](mailto:sgt_cso@gbl.com.br)

## European Support Services

For European customer support, dial the toll-free number for your specific country for presales support, technical support, SeaFAX and warranty service.

If your country is not listed here, dial our European call center at +31-20-316-7222 from 8:30 A.M. to 5:00 P.M. (European central time) Monday through Friday. The European call center is located in Amsterdam, The Netherlands.

### Call Center

Austria	0 800-20 12 90
Belgium	0 800-74 876
Denmark	80 88 12 66
France	0 800-90 90 52
Germany	0 800-182 6831
Ireland	1 800-55 21 22
Italy	800-790695
Netherlands	0 800-732 4283
Norway	800-113 91
Poland	00 800-311 12 38
Spain	900-98 31 24
Sweden	0 207 90 073
Switzerland	0 800-83 84 11

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1. Authorized Service Centers

Turkey 00 800-31 92 91 40  
 United Kingdom 0 800-783 5177

### **SeaBOARD**

Germany +49-89-1409331

### **Fax Services—All European Countries**

Presales/Technical Support/Warranty Service 31-20-653-3513

### **Africa/Middle East Support Services**

For presales, technical support, warranty service and FAX services in Africa and the Middle East, dial our European call center at +31-20-316-7222 from 8:30 a.m. to 5:00 p.m. (European central time) Monday through Friday, or send a FAX to +31-20-653-3513. The European call center is located in Amsterdam, The Netherlands.

### **Asia/Pacific Support Services**

#### **Technical Support**

Australia	+61-2-9725-3366	FAX: +61-2-9725-4052
Hong Kong	+852-2368 9918	FAX: +852-2368 7173
Japan	—	FAX: +81-3-5462-2979
Singapore	+65-488-7584	FAX: +65-488-7528
Taiwan	+886-2-2514-2237	FAX: +886-2-2715-2923

#### **SeaFAX**

Australia +61-2-9756-5170

#### **Warranty Service**

Japan	+81-3-5462-2904	FAX: +81-3-5462-2979
Asia/Pacific and Australia	+65-485-3595	FAX: +65-488-7503





## Appendix A. Glossary

This section contains a glossary of terms used in this publication.

### **ABTS**

Abort Sequence.

### **ABTX**

Abort Exchange.

### **ACC**

Accept.

### **ACK**

Acknowledgment.

### **Active**

The state of Sequence Initiator until all the Data frames for the Sequence have been transmitted. The state of Sequence Recipient until all the Data frames for the Sequence have been received. The period of time during which frames of a Sequence (or an Exchange) are actively being transmitted or received.

### **Active Virtual Circuit Credit limit**

The maximum number of VC\_Credits available for a Virtual Circuit in the Active state. It represent the maximum number of VC\_Credits held by an N\_Port on a given Virtual Circuit when the Circuit is in the active state.

### **Address identifier**

An address value used to identify source (S\_ID) or destination (D\_ID) of a frame.

### **ADVC**

Advise Credit.

### **Alias**

Alias is a group address recognized by an N\_Port if the N\_Port has registered as a member of the group, with the Alias Server.

### **Alias address identifier (alias)**

One or more address identifiers which may be recognized by an N\_Port in addition to its N\_Port Identifier. An alias address identifier is Fabric unique and may be common to multiple N\_Ports.

### **Alias-Token**

A 12-byte field to indicate the type of Alias (such as Multicast, Hunt Group) and certain properties associated with the Alias (such as FC-PH TYPE, Node Name for the Common Controlling Entity).

### **Application client**

An object that is the source of SCSI commands.

### **Application client buffer offset**

Offset in bytes from the start or base address of the application client's data buffer to the location for the transfer of the first byte of a data delivery service request.

### **Arbitrated loop topology**

A topology where L\_Ports use arbitration to establish a point-to-point circuit. A configuration that allows multiple ports to be connected serially.

**Attenuation**

The transmission medium power loss expressed in units of dB.

**Available BB\_Credit**

Also called "Available buffer-to-buffer credit." A transmitter uses this variable to determine permission to transmit frames, and if so, the allowable number of frames to transmit. The transmitter may transmit a frame when the Available BB\_Credit value is greater than 0. The rules for modifying Available BB\_Credit are:

- (a) in an OPN Initiator, Available BB\_Credit may be initialized to a value less than or equal to the Login\_BB\_Credit of the OPN Recipient upon transmission of any OPN;
- (b) in an OPN Recipient (acting as a Sequence Initiator), Available BB\_Credit may be initialized to a value less than or equal to Login\_BB\_Credit of the OPN Initiator (acting as a Sequence Recipient) upon receipt of a full duplex OPN;
- (c) Available BB\_Credit is decremented upon transmission of a frame;
- (d) Available BB\_Credit is incremented upon receipt of R\_RDY, except that following an OPN to or from a Sequence Recipient with Login\_BB\_Credit>0, one R\_RDY is discarded for each frame sent until the number of R\_RDYs discarded equals the Login\_BB\_Credit value.

**Available\_receive\_buffers**

In class 3, the number of buffers in a receiving port which are available for receiving frames at link rate. Equal to the largest number of R\_RDYs an NL\_port can issue immediately upon transmission or receipt of an OPN. BB Flow control rules keep this number greater than or equal to the Available BB\_Credit variable in a transmitting port. The number of available receive buffers must be greater than or equal to Login\_BB\_Credit upon receipt of any OPN.

**Bandwidth**

Maximum effective transfer rate for a given set of physical variants such as communication model, Payload size, Fibre speed, and overhead specified by FC-PH.

**Base address**

The address of the lowest address byte to be transferred to or from an application client buffer.

**Baud**

The encoded bit rate per second.

**BB Credit\_CNT**

Buffer-to-buffer Credit\_Count.

**BB\_buffer**

The buffer associated with buffer-to-buffer flow control.

**BB\_Credit**

Buffer-to-buffer Credit.

**Beginning Running Disparity**

The Running Disparity present at a transmitter when Encoding of the Special Code associated with an Ordered Set is initiated, or at a receiver when Decoding of the Special Character associated with an Ordered Set is initiated.

**BER**

See Bit error rate.

**Bit error rate (BER)**

The statistical probability of a transmitted bit being erroneously received in a communication system. The BER is measured by counting the number of erroneous bits at the output of a receiver and dividing by the total number of bits.

**Bit synchronization**

The state in which a receiver is delivering retimed serial data at the required BER.

**Block**

An upper level construct of application data related to a single Information Category and transferred within a single Sequence.

**BNC**

Acronym for a Bayonet-Neil-Councilman Coaxial Cable Connector. Specifications for BNC style connectors are defined in EIA/TIA 403-A and MIL-C-39012.

**BSY**

Busy.

**Buffer**

A logical construct which holds the contents of a single frame.

**Byte**

An eight-bit entity with its least significant bit denoted as bit 0 and most significant bit as bit 7. The most significant bit is shown on the left side in FC-PH, unless specifically indicated otherwise. Bytes are packed four per 32-bit word, or eight per 64-bit word.

**Cable plant**

All passive communications elements (e.g., optical fibre, twisted pair, or coaxial cable, connectors, splices, etc.) between a transmitter and a receiver.

**CATV**

Central Antenna Television.

**CCITT**

Comite Consultatif International, Telegraphique et Telephonique (see ITV-TS).

**CDB**

Command descriptor block.

**Center wavelength (LED)**

The average of the two wavelengths measured at the half amplitude points of the power spectrum.

**Centre wavelength (laser)**

The nominal value of the central wavelength of the operating, modulated laser. This is the wavelength where the effective optical power resides.

**Character**

Any Transmission Character associated by FC-1 transmission code with a FC-2 data byte or special code. Transmission characters are generated and interpreted only by FC-1.

**Circuit**

A bidirectional path within the Fabric.

**Class 1 service**

A service which establishes a dedicated connection between communicating N\_Ports.

**Class 2 service**

A service which multiplexes frames at frame boundaries to or from one or more N\_Ports with acknowledgement provided.

**Class 3 service**

A service which multiplexes frames at frame boundaries to or from one or more N\_Ports without acknowledgement.

**Class 4 bidirectional circuits**

A pair of unidirectional virtual circuits between two communicating N\_Ports.

**Class 4 Circuit Initiator**

The N\_Port which initiates the setup of a Class 4 circuit.

**Class 4 Circuit Recipient**

The N\_Port which accepts a Class 4 circuit with the Originator N\_Port.

**Class 4 end-to-end credit limit**

The maximum amount of end-to-end credit available for a virtual circuit. It represents the maximum number of Class 4 end-to-end credit held by an N\_Port on a given virtual circuit.

**Class 4 service**

A service that establishes virtual circuits to provide fractional bandwidth service between communicating N\_Ports. The service multiplexes frames at frame boundaries to or from one or more N\_Ports with acknowledgement provided.

**Class 1/SOFcl**

Class 1 frame with a SOFcl delimiter.

**Classes of service**

Different types of services provided by the Fabric and used by the communicating N\_Ports.

**Code balance**

The numerical sum of the 1 bits in any 10 bits in the transmitted bit stream divided by 10 (e.g., 1110100011 has a code balance of  $6/10 = 60\%$ ).

**Code bit**

The smallest time period used by FC-0 for transmission on the media.

**Code violation**

An error condition that occurs when a received transmission character cannot be decoded to a valid data byte or special code using the validity checking rules specified by the transmission code.

**Comma**

The seven bit sequence 0011111 or 1100000 in an encoded stream.

**Comma character**

A special character containing a comma.

**Command**

A request describing a unit of work to be performed by a device server.

**Command byte count**

Upper limit on the extent of the data to be transferred by the SCSI command.

**Command descriptor block (CDB)**

A structure up to 16 bytes in length used to communicate a command from an application client to a device server.

**Concatenation**

A logical operation that “joins together” strings of data. This operation is represented with the symbol “||”. Two or more fields are concatenated to provide a reference of uniqueness (e.g., S\_ID||X\_ID).

**Connection**

See Dedicated Connection.

**Connection initiator**

The source N\_Port which initiates a Class 1 connection with a destination N\_Port through a connection request and also receives a valid response from the destination N\_Port to complete the connection establishment.

**Connection recipient**

The destination N\_Port which receives a Class 1 connect-request from the connection Initiator and accepts establishment of the connection by transmitting a valid response.

**Connection-oriented frames**

Frames sent in either a Class 1 dedicated connection or a Class 4 circuit.

**Connectionless buffers**

Receive buffers participating in connectionless service and capable of receiving connectionless frames.

**Connectionless frames**

Frames participating in connectionless service (i.e., Class 1 frames with SOFc1, Class 2, and Class 3 frames referred to individually or collectively).

**Connectionless service**

Communication between two N\_Ports performed without a dedicated connection.

**Continuously increasing relative offset**

The relationship specified between relative offset values contained in frame (n) and frame (n+1) of an information category within a single Sequence.

**COR**

Camp-On Request.

**Credit**

The maximum number of receive buffers allocated to a transmitting N\_Port or F\_Port. It represents the maximum number of outstanding frames which can be transmitted by that N\_Port or F\_Port without causing a buffer overrun condition at the receiver.

**Credit\_CNT**

Credit Count.

**CTI**

Circuit Initiator.

**CTR**

Circuit Recipient.

**Current running disparity**

The running disparity present at a transmitter when Encoding of a valid data byte or special code is initiated, or at a receiver when decoding of a transmission character is initiated.

**D\_ID**

Destination\_Identifier.

**Data character**

Any transmission character associated by the transmission code with a valid data byte.

**Data frame**

A frame containing information meant for FC-4/ULP or the link application.

**Data out delivery service**

A confirmed service used by the device server to request the transfer of data from the application client.

**dB**

Decibel.

**dBm**

Decibel (relative to 1 mw power).

**Decoding**

Validity checking of received transmission characters and generation of valid data bytes and special codes from those characters.

**Dedicated connection**

A communicating circuit guaranteed and retained by the Fabric for two given N\_Ports.

**Dedicated duplex**

A synonym for Class 1 dedicated connection.

**Dedicated simplex**

A unidirectional Class 1 connection with ACKs transmitted in Class 2.

**Delimiter**

An ordered set used to indicate a frame boundary.

**Destination N\_Port**

The N\_Port to which a frame is targeted.

**Destination\_Identifier (D\_ID)**

The address identifier used to indicate the targeted destination of the transmitted frame.

**Device server**

An object within the logical unit which executes SCSI tasks and enforces the rules for task management.

**DF\_CTL**

Data Field Control.

**Discard policy**

An error handling policy where an N\_Port is able to discard data frames received following detection of a missing frame in a sequence.

**Disconnection**

The process of removing a dedicated connection between two N\_Ports.

**Disparity**

The difference between the number of ones and zeros in a transmission character.

**Dispersion**

A term used to denote pulse broadening and distortion. The two general categories of dispersion are modal dispersion, due to the difference in the propagation velocity of the propagation modes in a multimode fibre, and chromatic dispersion, due to the difference in propagation of the various spectral components of the optical source.

**DJ**

Deterministic jitter.

**DUT**

Device under test.

**E\_D\_TOV**

Error\_Detect\_Timeout value.

**ECL**

Emitter Coupled Logic.

**EE\_buffer**

The buffer associated with end-to-end flow control.

**EE\_Credit**

End-to-End Credit.

**EE\_Credit\_CNT**

End-to-End Credit Count.

**EIA**

Electronic Industries Association.

**Electrical fall time**

The time interval for the falling edge of an electrical pulse to transition from its 90% amplitude level to its 10% amplitude level.

**Electrical rise time**

The time interval for the rising edge of an electrical pulse to transition from its 10% amplitude level to its 90% amplitude level.

**EMC**

Electromagnetic compatibility.

**Encoding**

Generation of transmission characters from valid data bytes and special codes.

**EOF**

End of frame.

**ESB**

Exchange Status Block.

**ESTC**

Estimate Credit.

**ESTS**

Establish Streaming.

**Exchange**

The basic mechanism which transfers information consisting of one or more related non-concurrent sequences which may flow in the same or opposite directions. An exchange may span multiple Class 1 dedicated connections. The exchange is identified by an Originator Exchange\_Identifier (OX\_ID) and a Responder Exchange\_Identifier (RX\_ID).

**Exchange Status Block**

A logical construct which contains the state of an exchange. An originator N\_Port has an Originator Exchange Status Block and the responder N\_Port has a Responder Exchange Status Block for each concurrently active Exchange.

**Exchange\_Identifier (X\_ID)**

A generic reference to OX\_ID and RX\_ID (see Exchange).

**Exclusive connection**

A Class 1 dedicated connection without Intermix (see dedicated connection).

**Execute command service**

A peer-to-peer, confirmed service requested by the application client to perform a SCSI command.

**Extinction ratio**

The ratio (in dB) of the average optical energy in a logic one level to the average optical energy in a logic zero level measured under modulated conditions at the specified baud rate.

**Eye opening**

The time interval across the eye, measured at the 50% normalized eye amplitude which is error free to the specified BER.

**F\_BSY**

Fabric\_Port\_Busy.

**F\_BSY(DF)**

F\_BSY response to a data frame.

**F\_BSY(LC)**

F\_BSY response to any link control except P-BSY.



**F\_CTL**

Frame\_Control.

**F\_Port**

The Link\_Control\_Facility within the fabric which attaches to an N\_Port through a link. An F\_Port is addressable by the N\_Port attached to it, with a common well known address identifier (hex "FFFFFFE") (see local F\_Port, and remote F\_Port).

**F\_Port**

Fabric\_Port.

**F\_Port Name**

A Name\_Identifier associated with an F\_Port.

**F\_RJT**

Fabric\_Port\_Reject.

**Fabric**

The entity which interconnects various N\_Ports attached to it and is capable of routing frames by using only the D\_ID information in a FC-2 frame header.

**Fabric\_Name**

A Name\_Identifier associated with a fabric.

**FACT**

Fabric Activate Alias.

**FC**

Fibre Channel

**FC-4 Region**

A set of N\_Ports connected either point-to-point or to a common fabric, such that any N\_Port in the set can successfully complete the N\_Port Login procedure with all other N\_Ports in the set and successfully maintain an exchange for a particular FC-4.

**FC-PH**

ANSI X3.230-1994, Fibre Channel Physical and Signaling Interface.

**FC-4**

Fibre Channel Layer 4 mapping layer.

**FCP**

Fibre Channel Protocol.

**FCP I/O operation**

An unlinked SCSI command, a series of linked SCSI commands, or a task management function.

**FCP\_Port**

An N\_Port or NL\_Port that supports the SCSI Fibre Channel Protocol.

**FCPH**

The architecture specified by the Fibre Channel standard.

**FCS**

Frame Check Sequence.

**FCSI**

Fibre Channel Systems Initiative.

**FDACT**

Fabric Deactivate Alias.

**Fiber optic test procedure (FOTP)**

Standards developed and published by the Electronic Industries Association (EIA) under the EIA-RS-455 series of standards.

**Fibre**

A general term used to cover all transmission media specified in FC-PH.

**Fibre Channel Name**

A Name\_Identifier which is Fibre Channel unique.

**Fibre optic cable**

A jacketed optical fibre or fibres.

**FL\_Port**

An F\_Port that contains Arbitrated Loop functions associated with Arbitrated Loop topology.

**FOTP**

Fiber optic test procedure.

**FQXID**

Fully qualified exchange identifier.

**Fractional bandwidth**

A portion of the total bandwidth available on a path.

**Frame**

An indivisible unit of information used by FC-2.

**Frame Content**

The information contained in a frame between its Start-of-Frame and End-of-Frame delimiters, excluding the delimiters.

**FRU**

Field Replaceable Unit.

**FT-1**

Frame type 1.

**FT-0**

Frame type 0.

**Fully qualified exchange identifier**

A token used to uniquely identify a FCP I/O Operation.

**FWHM**

Full Width Half Max.

**GAID**

Get Alias\_ID.

**Hard address**

The AL\_PA which an NL\_Port attempts to acquire in the LIHA Loop Initialization Sequence.

**Hex**

Hexadecimal notation.

**HG**

Hunt Group.

**Hunt Group**

A set of N\_Ports with a common alias address identifier managed by a single node or common controlling entity. However, FC-PH does not presently specify how a Hunt Group can be configured.

**Hz**

Hertz = 1 cycle per second.

**ID**

Identifier.

**Idle**

See "Idle Word."

**Idle Word (Idle)**

An ordered set of four transmission characters which are normally transmitted between frames. The Idle Word is also referred to as an Idle.

**IEEE**

Institute of Electrical and Electronics Engineers.

**Ignored**

A field that is not interpreted by the receiver.

**Infinite buffer**

A terminology to indicate that at FC-2 level, the amount of buffer available at the Sequence Recipient is unlimited. The ULP chooses the amount of buffer per Sequence based on its MTU (maximum transfer unit).

**Information Category**

A frame header field indicating the category to which the frame payload belongs (e.g., Solicited Data, Unsolicited Data, Solicited Control, and Unsolicited Control).

**Information transfer**

Transfer of frames whose payload has meaning to the cooperating FC-4s.

**Information Unit**

An organized collection of data specified by FC-4 to be transferred as a single sequence by FC-2.

**Information Unit**

An organized collection of data specified by FC-4 to be transferred as a single sequence by FC-2.

**Initial Relative Offset**

A relative offset value specified at the sending end by an upper level for a given block or subblock and used by the sending FC-2 in the first frame of that block or subblock (see subblock, block, and Relative Offset). Initial Relative Offset value may be zero or non-zero.

**Initialization**

For FC-1 level the period beginning with power on and continuing until the transmitter and receiver of that level become operational.

**Initiator**

An SCSI device containing application clients that originate device service requests and task management functions to be processed by a target SCSI device.

**Initiator identifier**

Token by which a target identifies the initiator device.

**Interface connector**

An optical or electrical connector which connects the media to the Fibre Channel transmitter or receiver. The connector consists of a receptacle and a plug.

**Intermix**

A service which interleaves Class 2 and Class 3 frames on an established Class 1 connection.

**Intersymbol interference**

The effect on a sequence of symbols in which the symbols are distorted by transmission through a limited bandwidth medium to the extent that adjacent symbols begin to interfere with each other.

**IP**

Internet Protocol.

**IPA**

Initial process associator.

**ITV-TS**

The International Union–Telecommunication Standardization (formerly CCITT).

**IU**

Information Unit.

**Jitter**

Deviations from the ideal timing of an event which occur at high frequencies. Low frequency deviations are tracked by the clock recovery and do not directly affect the timing allocations within a bit cell. Jitter is not tracked by the clock recovery and directly affects the timing allocations in a bit cell. For FC-PH the lower cutoff frequency for jitter is defined as the bit rate divided by 2,500. Jitter is customarily subdivided into deterministic and random components.

**Jitter, deterministic (DJ)**

Timing distortions caused by normal circuit effects in the transmission system. Deterministic jitter is often subdivided into duty cycle distortion (DCD) caused by propagation differences between the two transitions of a signal and data dependent jitter (DDJ) caused by the interaction of the limited bandwidth of the transmission system components and the symbol sequence.

**Jitter, random (RJ)**

Jitter due to thermal noise which may be modeled as a Gaussian process. The peak-to-peak value of RJ is of a probabilistic nature and thus any specified value yields an associated BER.

**JNA**

Join Alias Group.

**L\_Port**

An N\_Port or F\_Port that contains Arbitrated Loop functions associated with Arbitrated Loop topology.

**LA RJT**

Link Application Reject.

**LAN**

Local Area Network.

**laser chirp**

A phenomenon in lasers where the wavelength of the emitted light changes during modulation.

**LCF**

Link Control Facility.

**LCR**

Link Credit Reset.

**LED**

light emitting diode.

**level**

1. A document artifice used to group related architectural functions. No specific correspondence is intended between levels and actual implementations.
2. a specific value of voltage (e.g., voltage level).

**link**

1. Two unidirectional fibres transmitting in opposite directions and their associated transmitters and receivers.
2. The full-duplex FC-0 level association between FC-1 entities in directly attached Ports (see Port).

**Link\_Control\_Facility**

A link hardware facility which attaches to an end of a link and manages transmission and reception of data. It is contained within each N\_Port and F\_Port.

**LLC**

Logical Link Control.

**Local F\_Port**

The F\_Port to which an N\_Port is directly attached by a link (see remote F\_Port).

**LOGI**

Log in.

**Logical unit**

A target resident entity that implements a device model and executes SCSI commands sent by an application client.

**Logical unit identifier**

Identifier used by an initiator to reference the logical unit.

**Login\_BB\_Credit**

On FC-AL, equal to the number of receive buffers that a receiving NL\_ port must have available when a loop circuit is established. Login\_BB\_Credit is discovered in the PDISC or PLOGI protocol.

**LOGO**

Log out.

**LOL**

Loss of light.

**Loop Tenancy**

The period of time beginning when a port wins arbitration and ending when it receives a CLS in response to its own CLS, or forwards a CLS transmitted to it.

**Loop\_ID**

7-bit values numbered contiguously from 0 to 126 decimal and representing the 127 legal hard addresses on a loop (not all of the 256 possible AL\_PAs are used in FC-AL for reasons related to running disparity). Loop\_IDs correspond to the 7-bit SEL word in SFF-8045 used for specifying hard addresses. Decimal 127 (7F hex) is not a valid Loop\_ID, but is used to signify that no hard address is being assigned to an NL\_Port.

**Loopback**

A mode of FC-1 operation in which the information passed to the FC-1 transmitter for transmission is shunted directly to the FC-1 receiver, overriding any signal detected by the receiver on its attached fibre.

**LR**

Link Reset primitive sequence.

**LRR**

Link Reset Response primitive sequence.

**LS\_ACC**

Link Service Accept.

**LW**

Long wavelength.

**m**

Meter.

**MAC**

Media Access Control.

**Mandatory**

A function which is required to be supported by a compliant implementation of FC-PH.

**MAS**

Master of link.

**Mb**

Mega bit.

**MB**

Mega byte.

**MBd**

Mega baud.

**Meaningful**

A control field or bit shall be applicable and shall be interpreted by the receiver, wherever it is specified as meaningful. Wherever it is specified as “not meaningful,” it shall be ignored (see valid).

**MM**

Multimode.

**Mode-partition noise**

Noise in a laser based optical communication system caused by the changing distribution of laser energy partitioning itself among the laser modes (or lines) on successive pulses in the data stream. The effect is a different center wavelength for the successive pulses resulting in arrival time jitter attributable to chromatic dispersion in the fibre.

**ms**

Millisecond.

**μs**

Microsecond.

**N\_Port**

A hardware entity which includes a Link\_Control\_Facility. It may act as an originator, a responder, or both.

**N\_Port**

Node\_Port.

**N\_Port Identifier**

A fabric-unique address identifier by which an N\_Port is uniquely known. The identifier may be assigned by the fabric during the initialization procedure. The identifier may also be assigned by other procedures not defined in FC-PH. The identifier is used in the S\_ID and D\_ID fields of a frame.

**N\_Port Name**

A Name\_Identifier associated with an N\_Port.

**NA**

Not applicable.

**NAA**

Network Address Authority.

**NACT**

N\_Port Activate Alias.

**Name\_Identifier**

A 64-bit identifier, with a 60-bit value preceded with a 4-bit Network Address Authority Identifier, used to identify entities in Fibre Channel such as N\_Port, Node, F\_Port, or Fabric.

**NDACT**

N\_Port Deactivate Alias.

**Network\_Address\_Authority (NAA)**

An organization which administers network addresses.

**Network\_Address\_Authority (NAA) identifier**

A four-bit identifier defined in FC-PH to indicate a Network\_Address\_Authority (NAA).

**NL\_Port**

An N\_Port that contains arbitrated loop functions associated with the Fibre Channel Arbitrated Loop topology.

**Node**

A collection of one or more N\_Ports or NL\_Ports controlled by a level above FC-2.

**Node\_Name**

A Name\_Identifier associated with a node.

**Non-repeating ordered set**

An ordered set which, when issued by FC-2 to FC-1 for transmission, is to be transmitted once.

**NOP**

No operation.

**NOS**

Not Operational primitive sequence.

**Not Operational**

A receiver or transmitter that is not capable of receiving or transmitting an encoded bit stream respectively, based on the rules defined by FC-PH for error control. For example, FC-1 is Not Operational during Initialization.

**ns**

Nanosecond.

**NTP**

Network Time Protocol.

**OESB**

Originator Exchange Status Block.

**OFC**

Open fibre control.

**Offset**

Relative Offset.

**OFSTP**

Optical fiber system test practice.

**OLS**

Online primitive sequence.



**Open**

The period of time starting when a sequence (an exchange) is initiated until that sequence (the exchange) is normally or abnormally terminated.

**Open fibre control (OFC)**

A safety interlock system that controls the optical power level on an open optical fibre cable.

**Operation**

A construct which may be used by a level above FC-2 and is associated with one or more exchanges.

**Operation\_Associator**

A value used in the Association\_Header to identify a specific operation within a Node and correlate communicating processes related to that operation. Operation\_Associator is the mechanism by which an operation within a given Node is referred to by another communicating Node. Operation\_Associator is a generic reference to Originator Operation\_Associator and Responder Operation\_Associator (see Process\_Associator).

**Operational**

The state of a receiver or transmitter that is capable of receiving or transmitting an encoded bit stream, respectively, based on the rules defined by FC-PH for error control. Those receivers capable of accepting signals from transmitters requiring laser safety procedures are not considered operational after power on until a signal of a duration longer than that associated with laser safety procedures is present at the fibre attached to the receiver.

**OPN Initiator**

The port on an Arbitrated Loop that sent the OPN primitive.

**Optical fibre**

Any filament or fibre, made of dielectric material, that guides light.

**Optional**

Characteristics that are not required by FC-PH. However, if any optional characteristic is implemented, it shall be implemented as defined in FC-PH.

**Ordered set**

A transmission word composed of a special character in its first (leftmost) position and data characters in its remaining positions. An ordered set is represented by the combination of special codes and data bytes which, when encoded, result in the generation of the transmission characters specified for the ordered set.

**Originator**

The logical function associated with an N\_Port responsible for originating an exchange.

**Originator Exchange Identifier (OX\_ID)**

An identifier assigned by an originator to identify an exchange and meaningful only to the originator (see Responder Exchange Identifier).

**ORL**

Optical return loss.

**OVC\_ID**

Originator VC\_ID.

**OX\_ID**

Originator\_Exchange\_Identifier.

**P\_BSY**

N\_Port Busy.

**Payload**

Contents of the data field of a frame, excluding optional headers and fill bytes, if present.

**PDISC**

Discover N\_Port Service parameters.

**Plug**

The cable half of the interface connector which terminates an optical or electrical signal transmission cable.

**Port**

A generic reference to an N\_Port or F\_Port.

**Port\_Name**

A Name\_Identifier associated with a port.

**Power on state**

In this state, any circuits or optical devices respond to controls resulting from higher levels.

**ppm**

Parts per million.

**Preferred Address**

On FC-AL, the AL\_PA which an NL\_Port attempts to acquire first during loop initialization. Following power-on reset, the preferred address of a private NL\_Port is its hard address (if any). Following receipt of a LIP other than LIP(AL\_PD,AL\_PS), the preferred address of a private NL\_Port is its previously acquired address. Fabric-assigned or soft addresses are not considered to be preferred.

**Previously Acquired Address**

This address only has meaning during loop initialization. During initialization, it is the AL\_PA which was in use prior to receipt of LIP. After the time a loop initialization completes and the next one begins, an NL\_Port has no previously acquired address.

**Primitive Sequence**

An ordered set transmitted repeatedly and continuously until a specified response is received.

**Primitive Signal**

An ordered set designated to have a special meaning such as an Idle or Receiver\_Ready (R\_RDY).

**Private loop device**

A device with only private NL\_Ports.

**Private NL\_Port**

An NL\_Port which is observing the rules of private loop behavior.

**PRLI**

Process Login.

**PRLO**

Process Logout.

**Process policy**

An error handling policy where an N\_Port is able to continue processing Data frames received following detection of one or more missing frames in a sequence.

**Process\_Associator**

A value used in the Association\_Header to identify a process or a group of processes within a Node. Process\_Associator is the mechanism by which a process is addressed by another communicating process. Process\_Associator is a generic reference to Originator Process\_Associator and Responder Process\_Associator (see Operation\_Associator).

**Profile**

An interoperability specification that provides implementation guidelines for systems manufacturers, system integrators, component manufacturers, and users seeking to design and select interoperable Fibre Channel peripherals, hosts, and components. A Profile specifies particular settings for various Fibre Channel physical, link-level, and upper-level protocol options to enhance interoperability.

**Public loop device**

A device with at least one public NL\_Port.

**Public NL\_Port**

An NL\_Port which can observe the rules of either public or private loop behavior. A public NL\_Port may have open Exchanges with both private and public NL\_Ports concurrently.

**QoSF**

Quality of Service Facilitator.

**QoSR**

Quality of Service Request.

**R\_CTL**

Routing Control.

**R\_A\_TOV**

Resource\_Allocation\_Timeout value.

**R\_RDY**

Receiver\_Ready.

**R\_T\_TOV**

Receiver\_Transmitter\_Timeout Value.

**Random Relative Offset**

The relationship specified between Relative Offset values contained in frame (n) and frame (n+1) of an Information Category within a single Sequence. For a given Information Category i within a single Sequence, Random Relative Offset (RO[i]) value for a frame (n+1) is unrelated to that of the previous frame (n). (see Initial Relative Offset and Continuously Increasing Relative Offset).

**RCS**

Read Connection Status.

**Receiver**

1. The portion of a Link\_Control\_Facility dedicated to receiving an encoded bit stream from a fibre, converting this bit stream into Transmission Characters, and Decoding these characters using the rules specified by FC-PH.

2. An electronic circuit (Rx) that converts a signal from the media (optical or electrical) to an electrical retimed (or nonretimed) serial logic signal.

**Receiver overload**

The condition of exceeding the maximum acceptable value of the received average optical power at point R of figure 8 to achieve a BER < 10(-12).

**Receiver sensitivity**

The minimum acceptable value of average received signal at point R of figure 8 to achieve a BER < 10(-12). It takes into account power penalties caused by use of a transmitter with a worst-case output. In the case of an optical path, it does not include power penalties associated with dispersion, jitter, effects related to the modal structure of the source or reflections from the optical path. These effects are specified separately in the allocation of maximum optical path penalty.

**Receptacle**

The fixed or stationary female half of the interface connector which is part of the transmitter or receiver.

**Reflections**

Power returned to point S of figure x by discontinuities in the physical link.

**Relative Offset (Offset)**

The displacement, expressed in bytes, of the first byte of a Payload related to an upper level defined-origin for a given Information Category (see Continuously Increasing and Random Relative Offset).

**Relative Offset space**

A virtual address space defined by the sending upper level for a single information category. The address space starts from zero, representing the upper level defined-origin, and extends to its highest value.

**Remote F\_Port**

The F\_Port to which the other communicating N\_Port is directly attached (see local F\_Port).

**Repeating ordered set**

An ordered set which, when issued by FC-2 to FC-1 for transmission, is to be repetitively transmitted until a subsequent transmission request is issued by FC-2.

**REQCS**

Request Clock Synchronization.

**Request byte count**

Number of bytes to be moved by a data delivery service request.

**RES**

Read Exchange Status Block.

**RESB**

Responder Exchange Status Block.

**reserved**

A field which is filled with binary zeros by the source N\_Port and is ignored by the destination N\_Port. **Note:** Future enhancements to FC-PH may define usages for reserved fields. The reserved fields should not be checked or interpreted. Any violation of this guideline may result in loss of upward compatibility with future implementations which comply with future enhancements to FC-PH.

**Responder**

The logical function in an N\_Port responsible for supporting the Exchange initiated by the Originator in another N\_Port.

**Responder Exchange\_Identifier (RX\_ID)**

An identifier assigned by a Responder to identify an Exchange and meaningful only to the Responder.

**RFI**

Radio Frequency Interference.

**RIIN**

reflection induced intensity noise.

**RJ**

Random jitter.

**RJT**

Reject.

**RIN**

Relative intensity noise.

**RMC**

Remove connection.

**RMS**

Root mean square.

**RNC**

Report node capability.

**RO**

Relative offset.

**RSS**

Read sequence status block.

**RTV**

Read timeout value.

**Run length**

Number of consecutive identical bits in the transmitted signal, e.g., the pattern 0011111010 has a run length of five (5).

**Running disparity**

A binary parameter indicating the cumulative disparity (positive or negative) of all previously issued transmission characters.

**RVC\_ID**

Responder VC\_ID.

**RVCS**

Read virtual circuit status.

**Rx**

Receiver.

**RX\_ID**

Responder\_Exchange\_Identifier.

**s or sec**

Second(s).

**S/N**

signal-to-noise ratio.

**S\_ID**

Source\_Identifier.

**S\_Length**

Security\_Length.

**S\_Type**

Security\_Type.

**SBCCS**

Single byte command code sets.

**SCN**

State change notification.

**SCR**

Stacked connect request.

**SCSI**

Small Computer System Interface.

**SCSI device**

A device that originates or services SCSI commands.

**SEQ-CNT**

Sequence count.

**SEQ\_ID**

Sequence ID.

**Sequence**

A set of one or more data frames with a common Sequence\_ID (SEQ\_ID), transmitted unidirectionally from one N\_Port to another N\_Port with a corresponding response, if applicable, transmitted in response to each data frame.

**Sequence initiator**

The N\_Port which initiates a sequence and transmits data frames to the destination N\_Port.

**Sequence recipient**

The N\_Port which receives data frames from the sequence initiator and, if applicable, transmits responses (Link\_Control frames) to the sequence initiator.

**Sequence status block**

A logical construct which tracks the state of a sequence. Both the sequence initiator and the sequence recipient have a sequence status block for each concurrently active sequence.

**Sequence\_ID (SEQ\_ID)**

An identifier used to identify a sequence.

**SISB**

Sequence initiator status block.

**SM**

Single mode.

**SOF**

Start of frame.

**Solicited control**

One of the information categories indicated in the frame header.

**Solicited data**

One of the information categories indicated in the frame header.

**Source N\_Port**

The N\_Port from which a frame is transmitted.

**Source\_Identifier (S\_ID)**

The address identifier used to indicate the source port of the transmitted frame.

**Special character**

Any transmission character considered valid by the transmission code but not equated to a valid data byte. Special characters are provided by the transmission code for use in denoting special functions.

**Special code**

A code which, when encoded using the rules specified by the transmission code, results in a special character. Special codes are typically associated with control signals related to protocol management (e.g., K28.5).

**Spectral width**

1. FWHM (Full Width Half Maximum) The absolute difference between the wavelengths at which the spectral radiant intensity is 50 percent of the maximum power. This form is typically used for LED optical sources.
2. RMS The weighted root mean square width of the optical spectrum. See FOTP-127. This form is typically used for laser optical sources.

**SRSB**

Sequence recipient status block.

**SSB**

Sequence status block.

**Status**

A single byte returned by the device server to the application client in its response to indicate the completion and completion state of a command.

**STP**

Shielded twisted pair.

**Streamed sequence**

A new Class 1 or Class 2 sequence initiated before receiving the final acknowledgement for the previous sequence in the same exchange. Any new Class 3 sequence initiated before the expiration of R\_A\_TOV for all data frames in the previous sequence.

**Subblock**

An upper level construct which contains partial application data for a single information category (see block). A collection of subblocks for a given information category may be specified for transfer within a single sequence.

**SW**

Short wavelength.

**Synchronization**

Receiver identification of a transmission word boundary.

**Tag**

The initiator-specified component of the task identifier.

**Target**

A SCSI device that receives SCSI commands and directs such commands to one or more logical units for execution.

**Target identifier**

Address of up to 64 bits by which a target is identified.

**Task**

An object within the logical unit representing the work associated with a command or group of linked commands.

**Task attribute**

The queuing specification for a task (Simple, Ordered, Head of Queue, ACA).

**Task identifier**

The information uniquely identifying a task.

**Task management function**

A peer-to-peer confirmed service provided by a task manager that can be invoked by an application client to affect the execution of one or more tasks.

**TP**

Twisted pair.

**TPLS**

Test process login status.

**Transceiver**

A transmitter and receiver combined in one package.



**Transmission character**

Any encoded character (valid or invalid) transmitted across a physical interface specified by FC-0. Valid transmission characters are specified by the transmission code and include data and special characters.

**Transmission code**

A means of encoding data to enhance its transmission characteristics. The transmission code specified by FC-PH is byte-oriented, with:

1. Valid data bytes; and
2. Special codes encoded into 10-bit transmission characters.

**Transmission word**

A string of four contiguous transmission characters occurring on boundaries that are zero modulo 4 from a previously received or transmitted special character.

**Transmitter**

1. The portion of a Link\_Control\_Facility dedicated to converting valid data bytes and special codes into transmission characters using the rules specified by the transmission code, converting these transmission characters into a bit stream, and transmitting this bit stream onto the transmission medium (optical or electrical).
2. An electronic circuit (Tx) that converts an electrical logic signal to a signal suitable for the communications media (optical or electrical).

**Tx**

Transmitter.

**TYPE**

Data structure type.

**UI**

Unit interval == 1 bit period.

**ULP**

Upper layer protocol.

**ULP**

Upper Level Protocol.

**ULP process**

A function executing within an FC node which conforms to Upper Layer Protocol (ULP) defined protocols when interacting with ULP processes residing in other FC nodes.

**Uncategorized information category**

One of the information categories indicated in the frame header.

**Unrecognized ordered set**

A transmission word containing a K28.5 in its first (leftmost) position but not defined to have meaning by FC-PH.

**Unsolicited control**

One of the information categories indicated in the frame header.

**Unsolicited data**

One of the information categories indicated in the frame header.

**Upper level**

A level above FC-2.

**Upper Level Protocol (ULP)**

The protocol user of FC-4.

**Valid**

A validity control bit indicates if a field is valid, in which case, the value in the field shall be treated as valid. If a validity control bit indicates that a field is invalid, the value in the field shall be treated as invalid (see meaningful).

**Valid data byte**

A string of eight contiguous bits within FC-1 which represents a value with 0 to 255, inclusive.

**Valid frame**

A frame received with a valid Start\_of\_Frame (SOF), a valid End\_of\_Frame (EOF), valid data characters, and proper cyclic redundancy check (CRC) of the frame header and data field.

**VC**

Virtual circuit.

**VC\_Credit**

Virtual circuit credit.

**VC\_ID**

Virtual circuit identifier.

**VC\_RDY**

Virtual circuit ready.

**Vendor unique**

Functions, code values, and bits not defined by FC-PH and set aside for private usage between parties using FC-PH. **Caution:** different implementations of FC-PH may assign different meanings to these functions, code values, and bits.

**Virtual circuit (VC)**

A unidirectional path between two communicating N\_Ports that permits Class 4 service to be used. Two virtual circuits are required to form a Class 4 circuit.

**Virtual Circuit Credit (VC\_Credit)**

The number of receiver buffers allocated to a virtual circuit by an F\_Port. It represents the maximum number of frames that an N\_Port may transmit without causing a buffer overrun condition at the F\_Port receiver.

**Virtual circuit credit limit**

The maximum number of VC\_Credits available for a virtual circuit. It represents the maximum number of VC\_Credits held by an N\_Port on a given virtual circuit.

**Virtual Circuit Identifier (VC\_ID)**

An identifier associated with either the originator (OVC\_ID) or responder (RVC\_ID) for a virtual circuit.

**Virtual path**

A fixed route through a fabric in support of a virtual circuit.

**WAN**

Wide area network.

**Well-known addresses**

A set of address identifiers defined in FC-PH to access global server functions such as a name server.

**Word**

A string of four contiguous bytes occurring on boundaries that are zero modulo 4 from a specified reference.

**Worldwide\_Name**

A Name\_Identifier which is worldwide unique, and represented by a 64-bit unsigned binary value.

**WWN**

Worldwide name.

**X\_ID**

Exchange\_Identifier.



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**Seagate Technology, LLC**  
**920 Disc Drive, Scotts Valley, California 95066-4544, USA**  
*Publication Number: 77767496, Rev. B, Printed in USA*