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Fibre Channel Interface
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Product Manual
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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-2 and SCSI-3 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-2/SCSI-3 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, Inc. 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 channel transfer rate is 100 MB/second. 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.

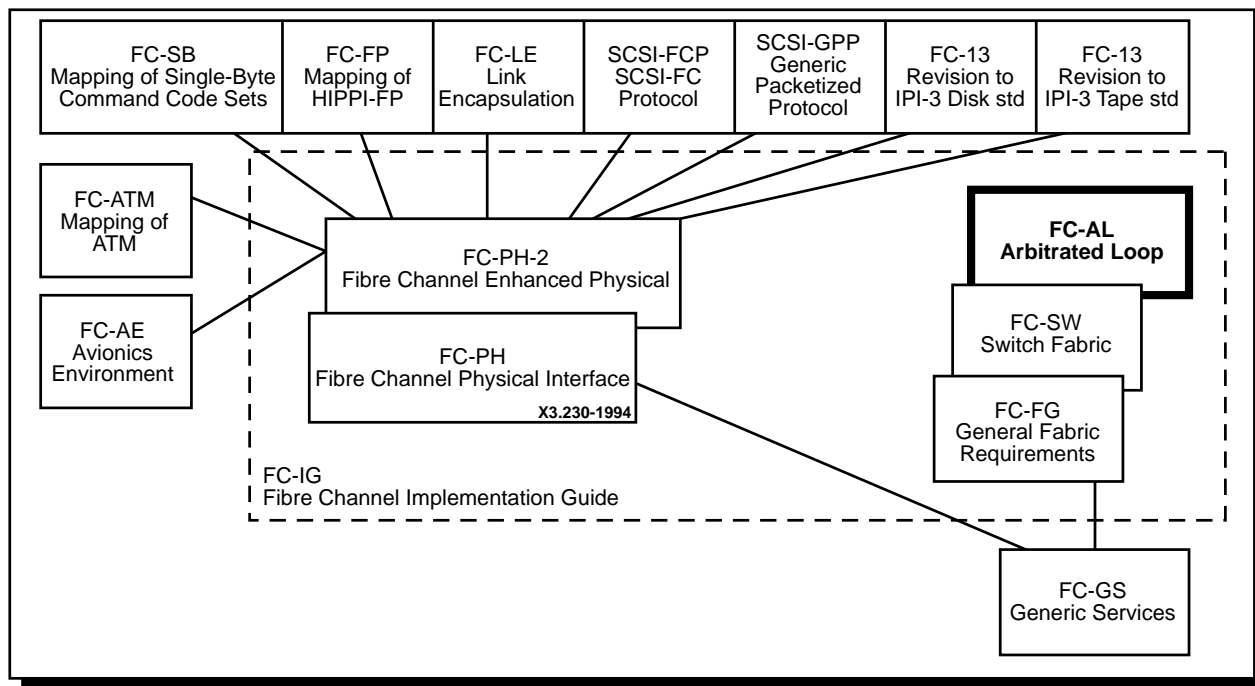


Figure 1. Fibre Channel standards

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
- Fibre Channel Physical and Signaling, Revision 4.3 (FC-PH)
- SCSI Fibre Channel Protocol, Revision 12 (SCSI-FCP)
- Fibre Channel Arbitrated Loop, Revision 4.5 (FC-AL)
- Fibre Channel Arbitrated Loop Direct Attach SCSI Profile

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 this Fibre Channel configuration. Seagate supports the arbitrated loop topology (FC-AL).

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)

FC-AL document is 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 as the primary topology for disc drive connections.

Note. Some brief discussions about items not directly associated with FC-AL 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.

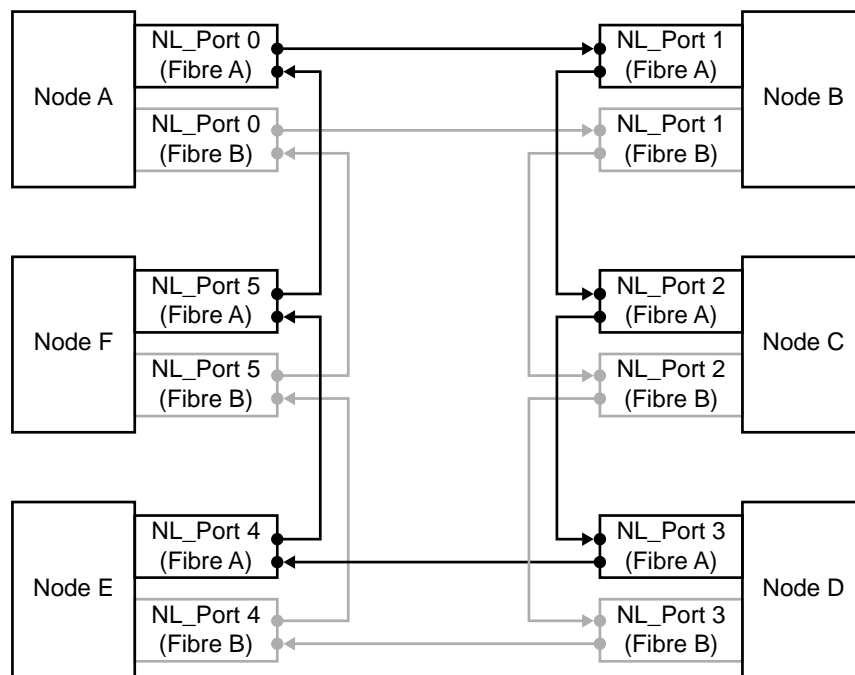


Figure 2. Arbitrated loop topology (dual port private loop)

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.

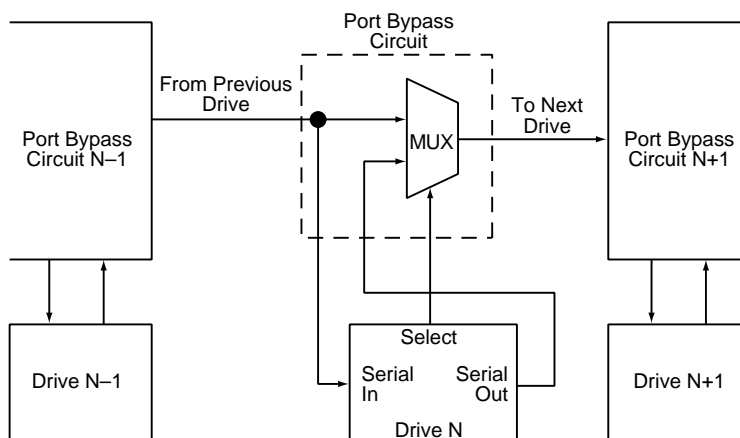


Figure 3. Port bypass circuit physical interconnect

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:

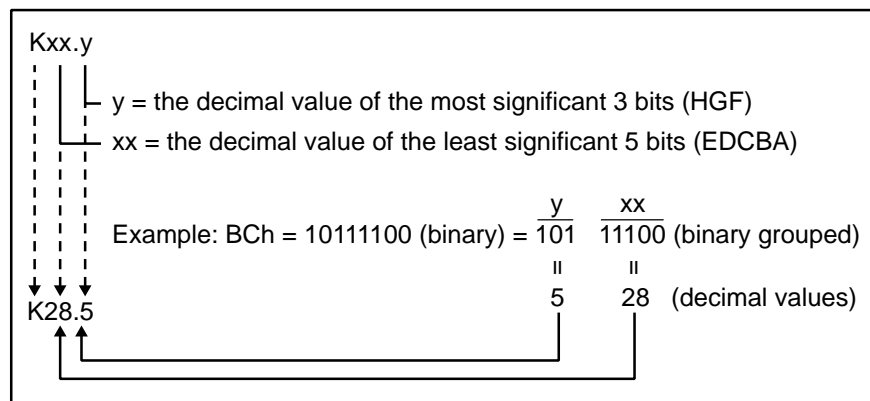


Figure 4. Decimal value translation

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.

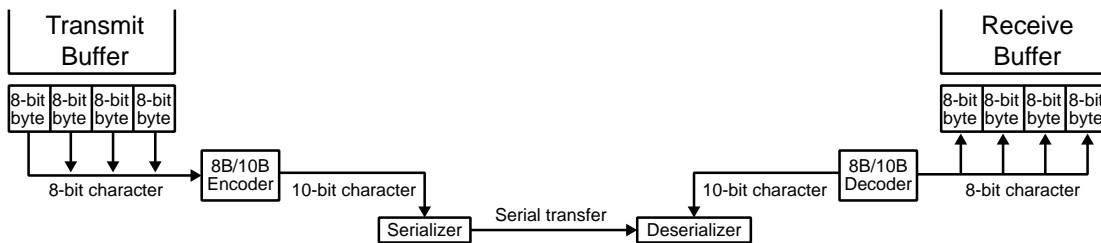


Figure 5. Serialization process

The bytes being transmitted are sent in increasing displacement.¹

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.

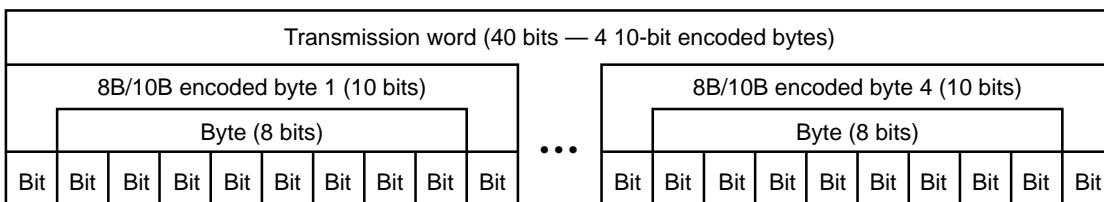


Figure 6. FC data hierarchy

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
SOF Initiate Class 3	SOFi3	Negative	K28.5 D21.5 D22.2 D22.2	BC B5 56 56
SOF Normal Class 3	SOFn3	Negative	K28.5 D21.5 D22.1 D22.1	BC B5 36 36
SOF Initialize Loop	SOFil	Negative	K28.5 D21.5 D22.2 D22.2	BC B5 56 56
SOF Fabric	SOFF	Negative	K28.5 D21.5 D24.2 D24.2	BC B5 58 58
EOF Terminate	EOFt	Negative Positive	K28.5 D21.4 D21.3 D21.3 K28.5 D21.5 D21.3 D21.3	BC 95 75 75 BC B5 75 75
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
EOF Normal	EOFn	Negative Positive	K28.5 D21.4 D21.6 D21.6 K28.5 D21.5 D21.6 D21.6	BC 95 D5 D5 BC B5 D5 D5
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
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 (OPNy)

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. Immediately after being opened, the target does not know where the OPNy came from and therefore cannot transmit back specifically to the initiator.

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

OPNfr is used by the open port (the initiator) 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 initiator is about to relinquish control of the loop for the current circuit.

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	Beginnin 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 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

Note. There are five 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 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.

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

Field definitions (listed alphabetically)

1 **Field name**

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.

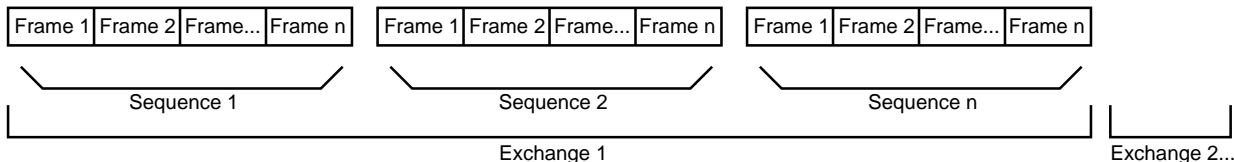


Figure 7. Relationship between frames, sequences, and exchanges

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	Payload Data Field	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.

Table 9. Frame Control (F_CTL) bit definitions (Continued)

Bit	Definition	Description
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 or 1100, the Information field contains a command. 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
0000	00	Basic Link Service
0010	01	Extended Link Service
1000	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 bit 1 indicates whether bytes are used. F_CTL bit 0 indicates how many fill bytes are used. 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.

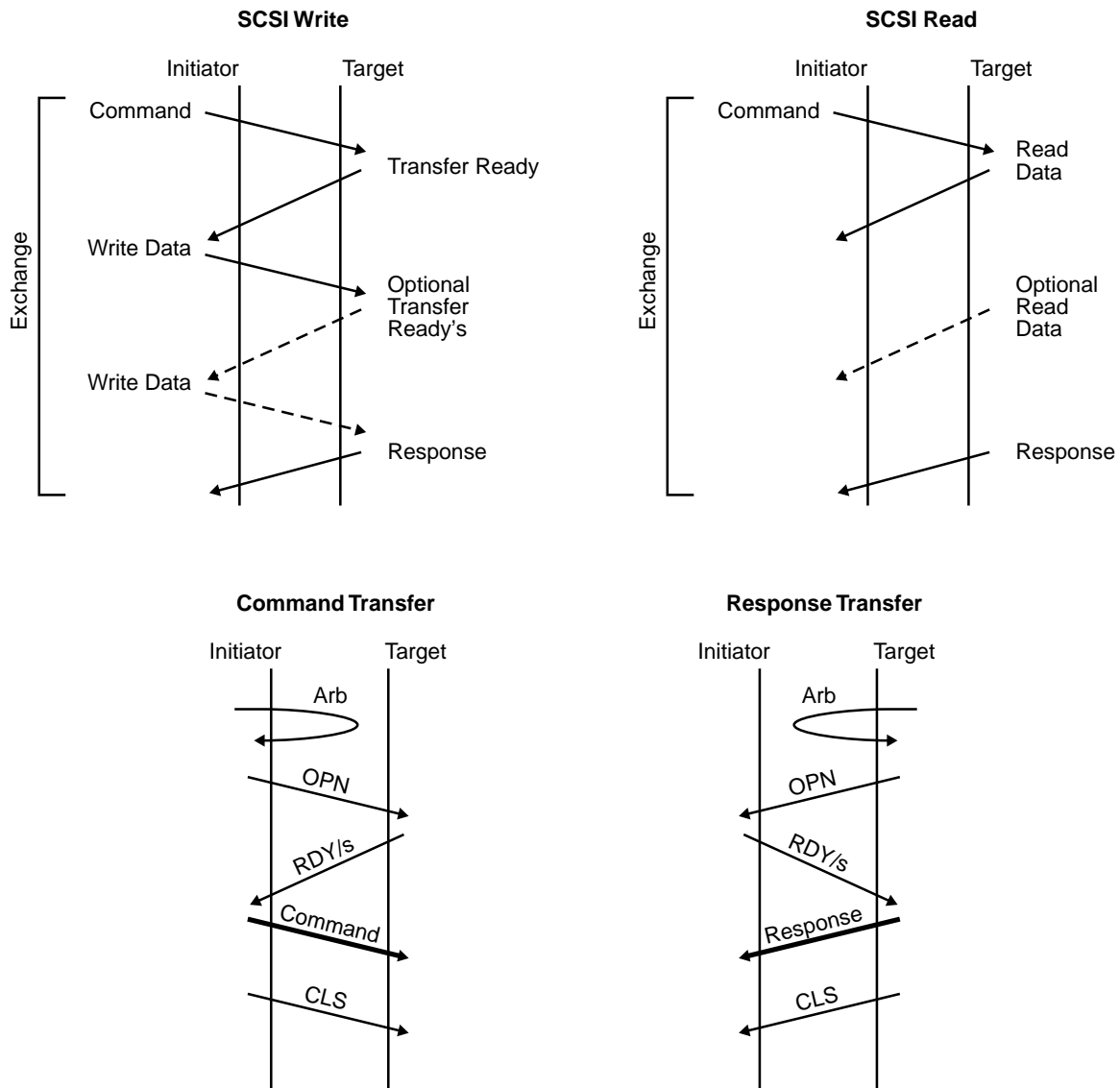


Figure 9. FC-SCSI exchanges, command and response transfers

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 (future)

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 ^R
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 ^R
24	*				*			*	18, 98, F8 ^R
25		*	*	*		*	*		39, 59, 79, B9, D9
26		*	*	*		*	*		3A, 5A, 7A, BA, DA
27	*				*			*	1B, 9B, FB ^R
28		*	*	*		*	*		3C, 5C, 7C, BC, DC
29	*				*			*	1D, 9D, FD ^R
30	*				*			*	1E, 9E, FE ^R
31	*				*			*	1F, 9F, FF ^R
Total 134	13	19	19	19	13	19	19	13	

* character with neutral disparity.

^R 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 (oo) 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.

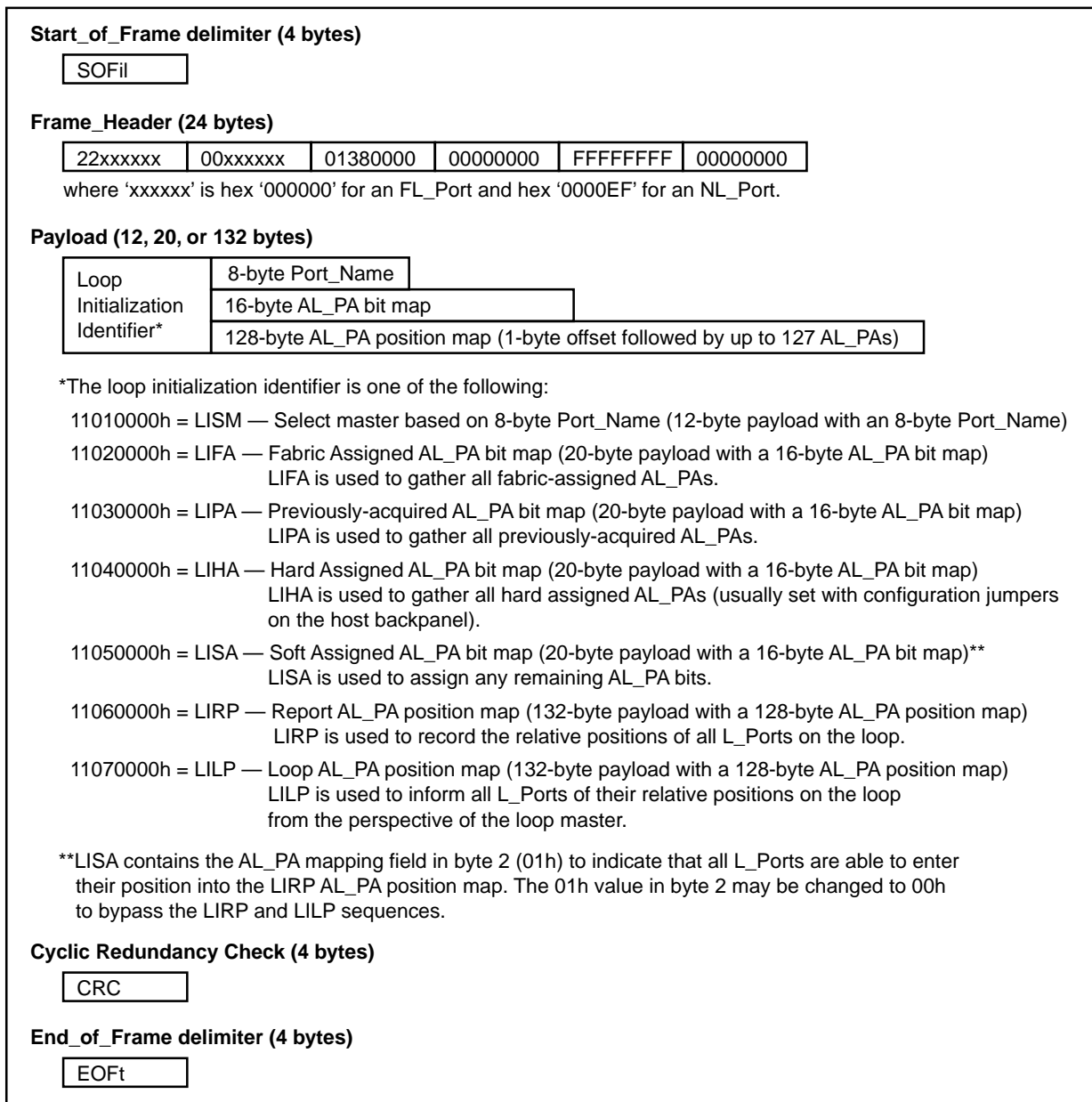


Figure 10. Loop initialization sequences

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 a port wants to acquire an AL_PA.
F8, AL_PS	Loop failure	The originating port has detected an input failure. The AL_PS is the AL_PA of the port.
F8, F7	Loop failure	The originating port has detected an input failure but the port does not have an AL_PA.
F7, AL_PS	Performance degradation	The originating port has detected poor loop performance. Example: The port is unable to win arbitration.
AL_PD, AL_PS	Selective reset	The source port (AL_PS) wants to reset the destination port (AL_PD). All ports complete loop initialization. The selected port performs a reset after loop initialization.

The next port in the loop receives the LIPs and transitions to the OPEN_INIT state and transmits LIPs to the next 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 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 ports then transmit 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

11010000	8-byte port name
----------	------------------

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

11020000	16-byte bit map of AL_PAs
----------	---------------------------

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
Bit map content	L	0	0	0	0	0	0	0	0	...	0

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
Bit map content	L	0	0	0	1	0	0	0	0	...	0

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
Bit map content	L	0	0	0	1	0	0	0	1	...	0

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
Bit map content	L	1	0	0	1	0	0	0	1	...	0

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'.

Byte map content	06	E8	D6	E2	6A	5F	08	FF	...	FF
-------------------------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----	-----------

Loop Initialization Loop Position (LILP)

132-byte payload

11070000	132-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.

Example

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.

Byte map content	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 continuously¹ 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.
 - higher than the Port_name in the payload, the NL_Port retransmits the received Loop Initialization Sequence.

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).

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 11050100h⁵, 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 or 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

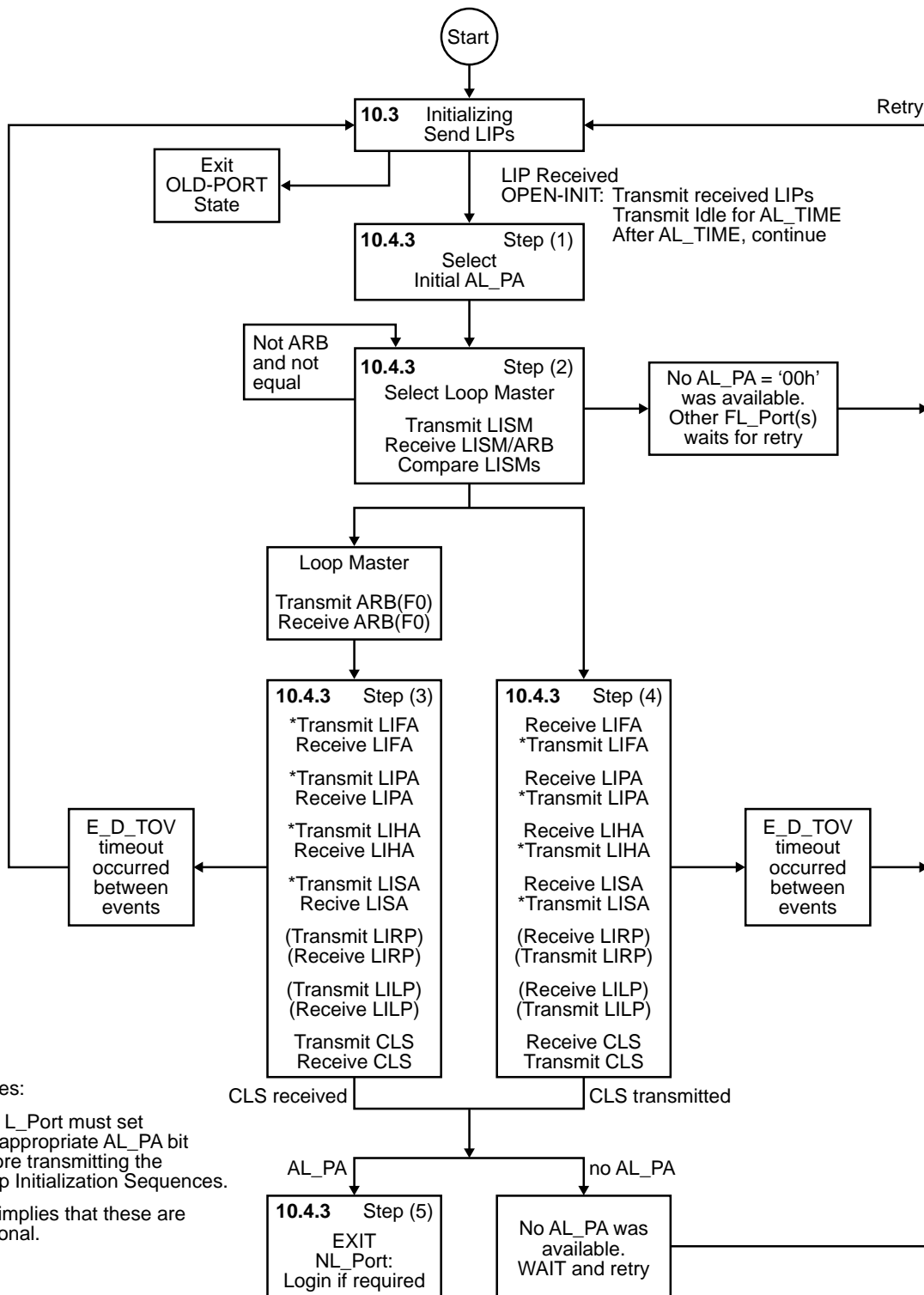


Figure 11. Loop initialization state machine

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.

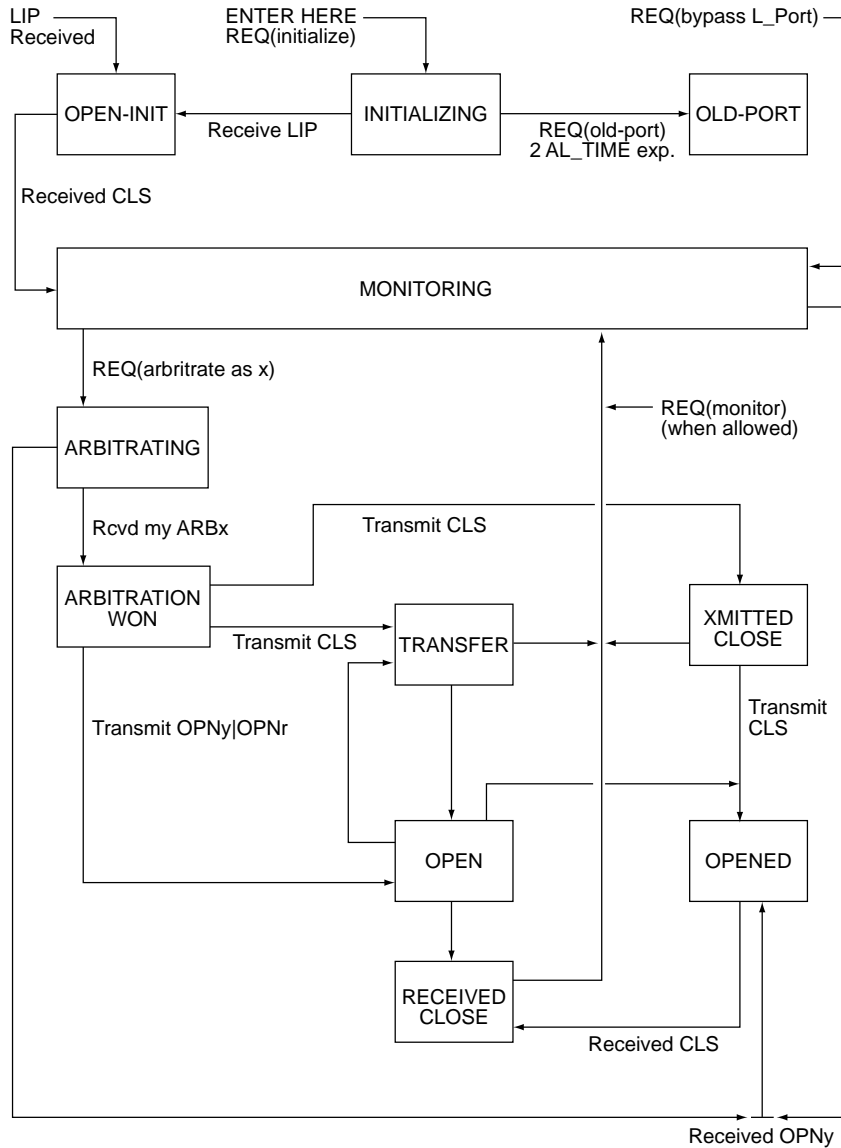


Figure 12. Loop state machine (simplified)

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 words¹ 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, OPNyy 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 Time Out 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 ARB's.

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_RDY's 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

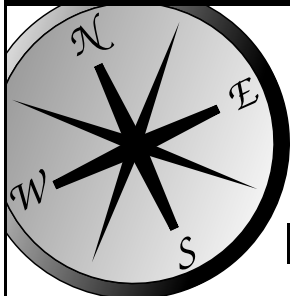
AL_PA (hex)	Bit map Word	Bit	AL_PA (hex)	Bit map Word	Bit	AL_PA (hex)	Bit map Word	Bit	AL_PA (hex)	Bit map Word	Bit
--	0	31	3C	1	31	73	2	31	B3	3	31
00	0	30	43	1	30	74	2	30	B4	3	30
01	0	29	45	1	29	75	2	29	B5	3	29
02	0	28	46	1	28	76	2	28	B6	3	28
04	0	27	47	1	27	79	2	27	B9	3	27
08	0	26	49	1	26	7A	2	26	BA	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																
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) _____							
3	Reserved _____ (LSB)							
4	(MSB) _____							
5	OX_ID Aborted _____ (LSB)							
6	(MSB) _____							
7	RX_ID Aborted _____ (LSB)							
8	(MSB) _____							
9	Lowest SEQ_CNT _____ (LSB)							
10	(MSB) _____							
11	Highest SEQ_CNT _____ (LSB)							

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 56.

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			
	Network Address ID				N_Port Identifier			
1								(LSB)
2	(MSB)							
3	Company Identifier Assigned by IEEE							
4								
5	(MSB)							
6	Unique Drive Identifier Assigned by Seagate							
7								

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

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) _____ Buffer to Buffer Credit _____ (LSB)							
3								
4	Contin Increasing Offset	Random Relative Offset	Valid Vendor Version	F_Port	Alternate Credit Model	0 Reserved	0 Reserved	0 Reserved
Common Features								
5	Reserved							
6	0 Reserved	0 Reserved	0 Reserved	0 Reserved	(MSB) _____			
7					Receive Data Field Size _____ (LSB)			
8	Reserved							
9	(MSB) _____ Total Concurrent Sequences _____ (LSB)							
10	(MSB) _____ Relative Offset by Info Category _____ (LSB)							
11								
12	(MSB) _____ E_D_TOV (Pt to Pt) _____ (LSB)							
13								
14								
15								

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).

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 standard supported by the drive is 4.3. A version level of 09h is defined for 4.3.

The drive requires 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.

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 Reserved	0 Reserved	0 Reserved	0 Reserved	(MSB) Receive Data Field Size			
7	(LSB)							
8	Reserved							
9	(MSB) Concurrent Sequences							(LSB)
10	0	(MSB) N_Port End to End Credit						(LSB)
11								
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.

Table 28. Recipient Control fields

Option	Drive requirement
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 checks only for class 3 service parameters.

30 Class 3 Service Parameters

Required 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.

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 Process Login (PRLI)

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

Table 33. 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	Orig Proc Assc Valid	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)**

33 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.

33 Data Overlay Allow

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

33 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.

33 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.

33 Initiator Function

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

33 LS Command Code (Link Services Command Code)

20h PRLI Payload.

33 Originator Process Associator

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

Must be set to zero (0).

33 Page Length

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

33 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).

33 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).

33 Responder Process Associator

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

Must be set to zero (0).

33 Service Parameters**33 Target Function**

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

33 Type Code

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

33 Type Code Extension

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

33 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 34. 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	Orig Proc Assc Valid	Resp Proc Assc Valid	Est Image Pair	0 Reserved	Response Code			
7	Reserved							
8	Originator Process Associator							
9								
10								
11								
12	Responder Process Associator							
13								
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)

34 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.

34 Data Overlay Allow

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

34 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.

34 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.

34 Initiator Function

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

34 LS Command Code (Link Services Command Code)

02h PRLI Accept Payload.

34 Originator Process Associator

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

Must be set to zero (0).

34 Page Length

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

34 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).

34 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).

34 Responder Process Associator

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

Must be set to zero (0).

34 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.

34 Service Parameters**34 Target Function**

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

34 Type Code

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

34 Type Code Extension

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

34 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.

9.2.4 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 35. 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	Reserved							
5	Reserved							
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)

35 LS Command Code (Link Services Command Code)

21h PRLO Payload.

35 Page Length

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

35 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).

35 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.

Table 36. 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)

36 LS Command Code (Link Services Command Code)

02h PRLO Accept Payload.

36 Page Length

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

36 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).

36 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.

36 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.

9.2.5 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 37. 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)**

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

0Fh RLS Payload.

37 **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 38. 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	(MSB)							Link Failure Count	
5									
6									
7									
8	(MSB)							Loss of Synchronization Count	
9									
10									
11									
12	(MSB)							Loss of Signal Count	
13									
14									
15									
16	(MSB)							Primitive Sequence Protocol Error	
17									
18									
19									
20	(MSB)							Invalid Transmission Word	
21									
22									
23									
24	(MSB)							Invalid CRC Count	
25									
26									
27									

Table number Field definitions (listed alphabetically)

38 Invalid CRC Count

Not supported.

38 Invalid Transmission Word

Not supported.

38 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).

38 Loss of Signal Count

Not supported.

38 Loss of Synchronization Count

Number of times the drive detects loss of synchronization.

Note. This count includes the Link Failure Count.

38 LS Command Code (Link Services Command Code)

02h RLS Accept Payload.

38 Primitive Sequence Protocol Error

Not supported.

9.2.6 Reinstate Recovery Qualifier (RRQ)

The Reinstate 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 39. 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							
(LSB)								
10	(MSB)							
11	RX_ID							
(LSB)								
12	(MSB)							
:	Association Header (optional)							
43								

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

39 Association Header

Not supported by the drive.

39 LS Command Code (Link Services Command Code)

12h RRQ Payload.

39 Originator S_ID (Originator Source Identifier)

Address identifier of the port that originated the exchange.

39 OX_ID (Originator Exchange Identifier)

The RRQ is the OX_ID of the Recovery Qualifier.

39 RX_ID (Responder Identifier)

The RRQ is the RX_ID of the Recovery Qualifier.

Table 40. 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)

40 LS Command Code (Link Services Command Code)

Not supported by the drive.

9.2.7 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.

9.2.8 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 41. 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								
8	(MSB)							
:	Port Name of Originator							
15								
16	(MSB)							
:	Node Name of Originator							
23								
24	Reserved							
25	(MSB)							
26	N_Port ID of Originator							
27								

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

41 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.

41 LS Command Code (Link Services Command Code)

52h ADISC Payload.

41 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.

41 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.

41 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 42. 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								
8	(MSB)							
:	Port Name of Responder							
15								
16	(MSB)							
:	Node Name of Responder							
23								
24	Reserved							
25	(MSB)							
26	N_Port ID of Responder							
27								

Table number

Field definitions (listed alphabetically)

42 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. 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.

42 LS Command Code (Link Services Command Code)

02h ADISC Accept Payload.

42 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.

42 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.

42 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.

9.2.9 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 43. 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)**

43 LS Command Code (Link Services Command Code)

01h LS_RJT Payload.

43 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.

43 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.

43 Vendor Unique

Not supported by the drive.

10.0 Enclosure services interface (ESI)

The ESI interface 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 interface 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 interface 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 µsec 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 µsec.

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

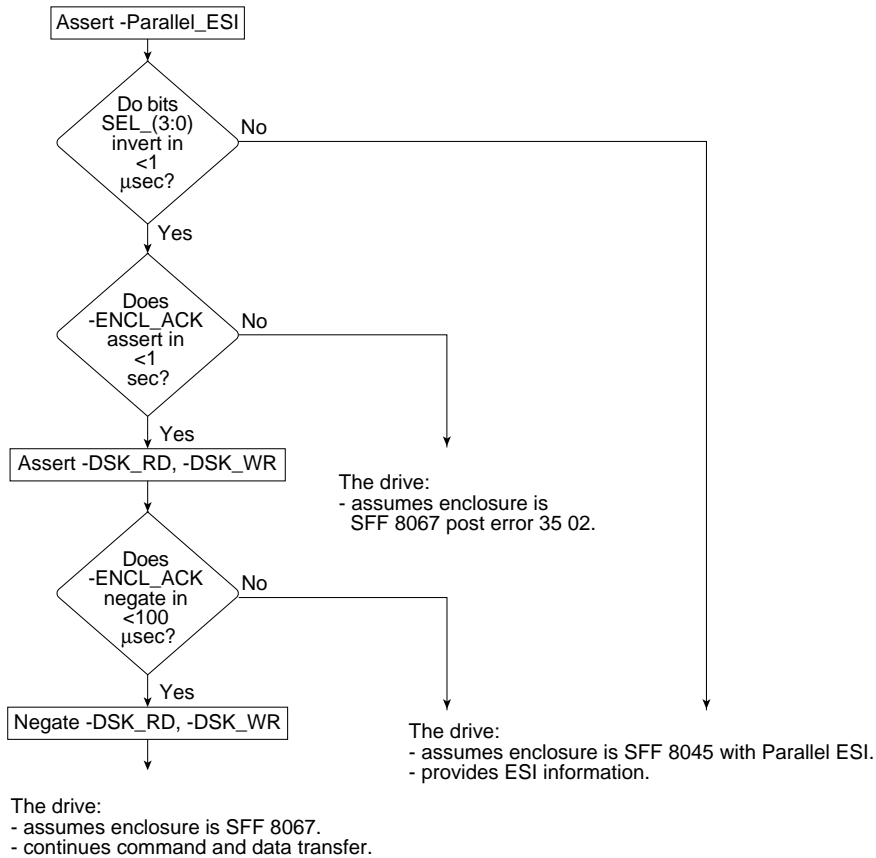


Figure 13. Discovery process flow diagram

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 Interface pinouts

Error! Reference source not found. This message is a mapping of the Select pins to the SFF 8045 ESI interface 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 44. SFF 8045 ESI interface pinouts

Pin	ESI interface
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 -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.

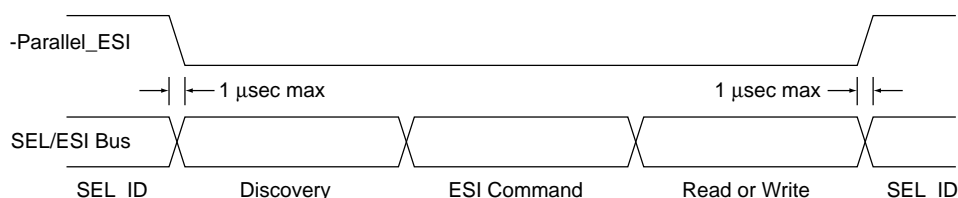


Figure 14. ESI transfer phases

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 45.

Table 45. ESI command format

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

Table number Field definitions (listed alphabetically)

45 Page Code

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

45 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.

45 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. Error! Reference source not found 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 46. SFF 8067 ESI interface pinouts

Pin	ESI interface
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 47 for the transfer order in bits and Table y for byte order.

Table 47. 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 48. 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

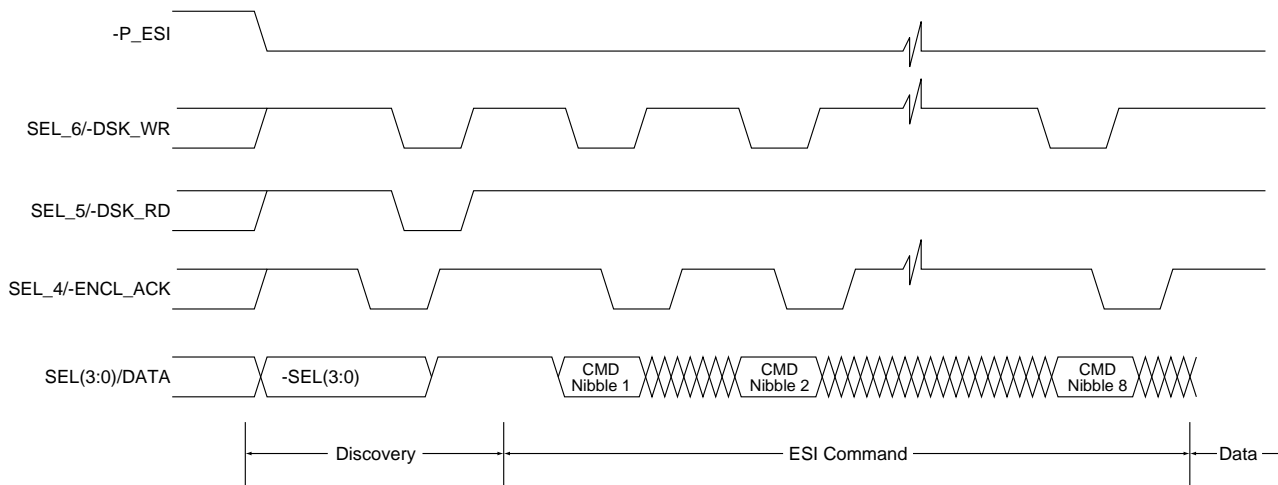


Figure 15. ESI command transfers

10.4.1 ESI read transfer

To receive data from the enclosure, the drive pulls `-DSK_RD` pin low to request information from the enclosure. The enclosure responds by driving the Data pins with ESI and pulling `-ENCL_ACK` low to signal that the data is valid. The drive strobes the data and allows high `-DSK_RD` to return high. The enclosure responds to the `-DSK_RD` going high by allowing `-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 `-P_ESI` low—the pull up resistor returns `-P_ESI` to a high level.

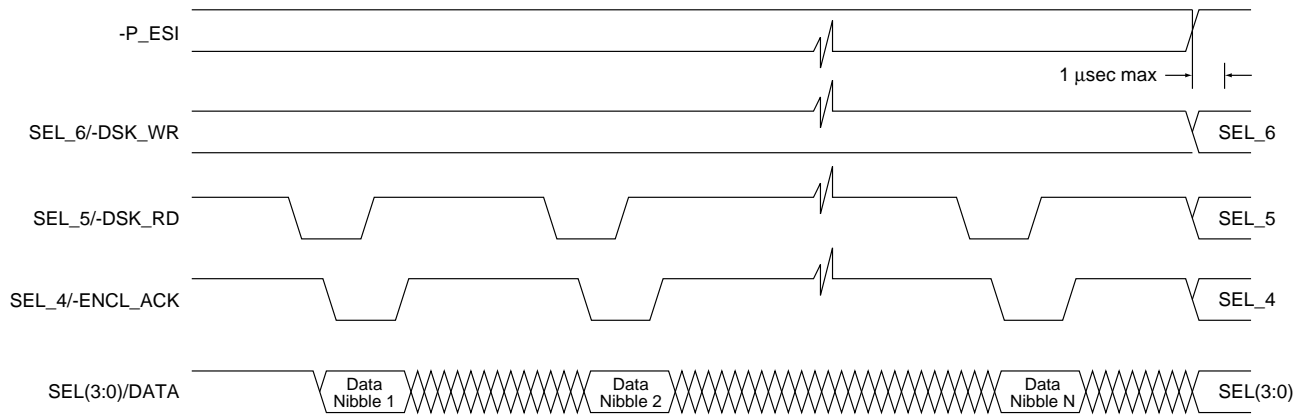


Figure 16. ESI reads

10.4.2 ESI write transfer

To send data to the enclosure, the drive places ESI data on the data pins and pulls `-DSK_WR` in low. The enclosure strobes the data and responds by pulling `-ENCL_ACK` low to signal the drive it has taken the data. The drive stops pulling `-DSK_WR` low, allows the pin to return to a high. The enclosure responds to the `-DSK_WR` going high by allowing `-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 `-P_ESI` low to return to a high.

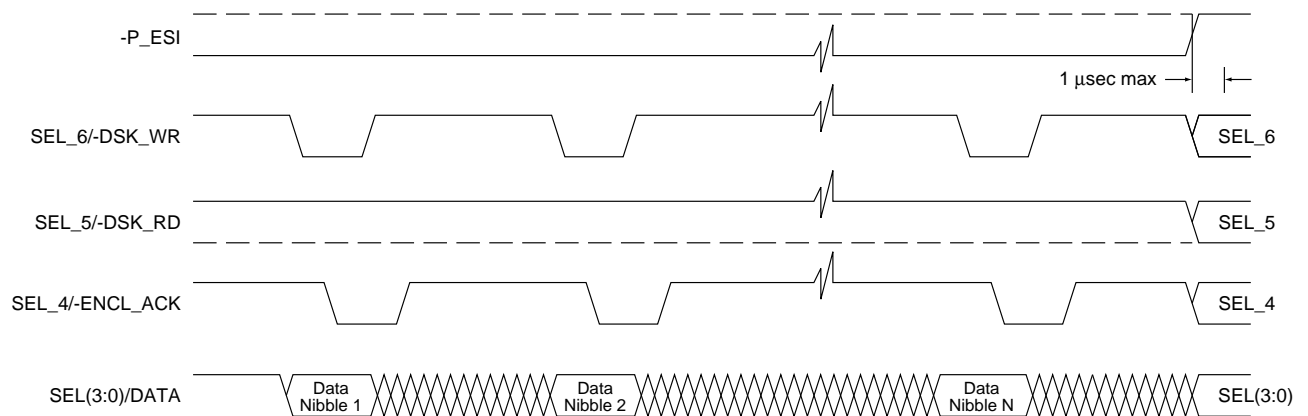
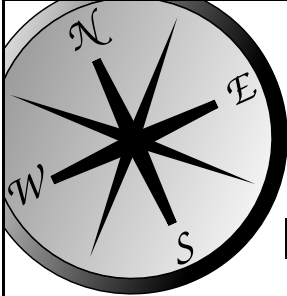


Figure 17. ESI writes

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

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.

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 49 and 50.

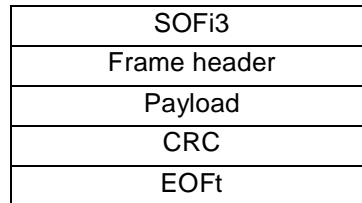


Table 49. FCP CMND frame header

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	0	1	1	0
	R_CTL							
1	(MSB) _____ D_ID _____ (LSB)							
2								
3								
4	0	0	0	0	0	0	0	0
	Reserved							
5	(MSB) _____ S_ID _____ (LSB)							
6								
7								
8	0	0	0	0	1	0	0	0
	Type							
9	(MSB) _____ F_CTL _____ (LSB)							
10								
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	(MSB) _____ 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	(MSB) _____ Parameter _____ (LSB)							
21								
22								
23								

**Table
number****Field definitions (listed alphabetically)****49 DF_CTL (Data Field Control)**

00h No optional Fibre Channel headers are used.

49 D_ID (Destination Identifier)

The address of the drive. This value must match the current address of the drive.

49 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.

49 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.

49 Parameter

Not used for the FCP CMND.

49 R_CTL (Routing Control)

Set to Unsolicited Command data sequence for the FCP CMND frame.

49 RX_ID (Responder Identifier)

Not used by the drive. FFFFh indicates the RX_ID is not being used.

49 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.

49 SEQ_ID (Sequence Identifier)

May be set to any value. The OX_ID field uniquely identifies each command between the initiator and the drive.

49 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.

49 Type

08h All SCSI FCP frames must be set to this value.

Table 50. 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 Reserved	0	Clear Task Set	Abort Task Set	0 Reserved
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)
-----------------	--

50 Abort Task Set

Clears only the queue of commands from the initiator originating the Abort Task Set.

50 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.

50 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.

50 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.

50 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.

50 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.

50 Read Data

Set to one (1) when the command specified by the CDB field will result in a data transfer to the initiator.

50 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.

50 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.

50 Term Task (Terminate Task)

Not supported by the drive.

50 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 52 and 53.

11.2.1.1 Operation Code

The Operation Code (Table 51) 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 52)

Group 1 - Ten-byte commands (see Table 53)

Group 2 - Ten-byte commands (see Table 53)

Group 3 - Reserved

Group 4 - Sixteen-byte commands

Group 5 - Twelve-byte commands

Group 6 - Vendor specific

Group 7 - Vendor specific

Table 51. Operation Code format for CDB

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

Table 52. Typical CDB for six-byte commands

Bit Byte	7	6	5	4	3	2	1	0
0	Operation Code							
1	0	0	0	(MSB)				
2	Reserved			Logical Block Address (if required)				
3	(LSB)							
4	Transfer Length (if required)							
5	Control Byte							

Table number

Field definitions (listed alphabetically)

52 Control Byte

See Section 11.2.1.6.

52 Logical Block Address

See Section 11.2.1.2.

52 Operation code

See Section 11.2.1.3.

52 Transfer Length

See Section 11.2.1.5.

Table 53. 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
2	Reserved			(MSB)				
3	Logical Block Address (if required)							
4	(LSB)							
5	Reserved							
6	Reserved							
7	Reserved			(MSB)				
8	Transfer Length (if required)							
9	(LSB)							
9	Control Byte							

Table number

Field definitions (listed alphabetically)

53 Control Byte

See Section 11.2.1.6.

53 Logical Block address

See Section 11.2.1.2.

53 Operation Code

See Section 12.0.

53 RelAdr (Relative Address)

See Section 11.2.1.4.

53 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 12.17.

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 useful in accessing structured data in a uniform manner. Relative addressing is only allowed when commands are linked. Details are given with those commands that use this feature.

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 54. 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)**

54 **Flag**

Drives supported by this manual do not use this bit.

54 **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.

54 **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 55. 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)

55 DF_CTL (Data Field Control)

00h No optional Fibre Channel headers are used.

55 D_ID (Destination Identifier)

The address of the initiator that originated the command for which the data is being requested.

55 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.

55 OX_ID (Originator Exchange Identifier)

The drive returns the OX_ID it received from the initiator with the FCP CMND.

55 Parameter

Not used for the FCP XFER RDY.

55 R_CTL (Routing Control)

Set to Data Descriptor.

55 RX_ID (Responder Identifier)

Not used by the drive. The value of FFFFh indicates the RX_ID is not being used.

55 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.

55 SEQ_ID (Sequence Identifier)

The drive sends FFh.

55 S_ID (Source Identifier)

Address of the drive.

55 Type

08h For all SCSI FCP frames.

Table 56. 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)

56 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.

56 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	Note: 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 57. 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	(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	1	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															
(LSB)																
16	(MSB)															
17	OX_ID															
(LSB)																
18	1	1	1	1	1	1	1	1								
19	1	1	1	1	1	1	1	1								
RX_ID																
20	(MSB)															
21	RO															
22									(LSB)							
23																

Table
number**Field definitions (listed alphabetically)****57 DF_CTL (Data Field Control)**

00h Indicates no optional Fibre Channel headers are used.

57 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.

57 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 58. 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.

57 OX_ID (Originator Exchange Identifier)

The value assigned by the initiator in the FCP CMND.

57 R_CTL (Routing Control)

Set to Solicited Data for the FCP DATA frame.

57 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.

57 RX_ID (Responder Identifier)

Not used by the drive. The value of FFFFh indicates the RX_ID is not being used.

57 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.

57 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.

57 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.

57 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 59. 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									(LSB)							
3																
4	0	0	0	0	0	0	0	0								
	Reserved															
5	S_ID															
6									(LSB)							
7																
8	0	0	0	0	1	0	0	0								
	Type															
9	F_CTL															
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															
17									(LSB)							
18	1	1	1	1	1	1	1	1								
19	1	1	1	1	1	1	1	1								
	RX_ID															
20	Parameter															
21									(LSB)							
22																
23																

**Table
number****Field definitions (listed alphabetically)****59 DF_CTL (Data Field Control)**

00h Indicates no optional Fibre Channel headers are used.

59 D_ID (Destination Identifier)

The address of the initiator that originated the command.

59 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.

59 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.

59 Parameter

Not used for the FCP RSP.

59 R_CTL (Routing Control)

Set to Command Status for the FCP RSP frame.

59 RX_ID (Responder Identifier)

Not used by the drive. The value of FFFFh indicates the RX_ID is not being used.

59 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.

59 SEQ_ID (Sequence Identifier)

Set to FFh by the drive.

59 S_ID (Source Identifier)

The address of the drive.

59 Type

08h The value for all SCSI FCP frames.

Table 60. 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)

60 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.

60 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.

60 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.

60 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.

60 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.

60 Response Information

Format is shown in Table 61. 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 61. Response Information format

Bit Byte (*)	7	6	5	4	3	2	1	0
0 (24) : 2 (26)	(MSB) _____ Reserved _____ (LSB)							
3 (27)	Response Information Code							
4 (28) : 7 (31)	(MSB) _____ Reserved (optional) _____ (LSB)							

60 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.

60 SCSI Extended Sense Information

Additional information related to a Check Condition returned in the SCSI Status byte. See Table 62 on page 105.

60 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.

60 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 62. 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 62. 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 (50-51)	Product Unique Sense Data							

*Fibre Channel frame byte number shown in parenthesis.

Table number

Field definitions (listed alphabetically)

62 Additional Sense Code and Additional Sense Code Qualifier

Provide additional clarification of errors when Sense Key is valid. Error code definitions are in Table 68. 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).

62 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.

62 Command Specific Data

These four bytes contain data for the command.

62 EOM (End of Medium)

Always zero (0) for disc drives.

62 Error Code

70h Current error.

71h Deferred error.

These two error conditions are described in Section 11.5.1.2.

62 Filemark

Always zero (0) for disc drives.

62 ILI (Incorrect Length Indicator)

The requested (previous command) block of data did not match the logical block length of the data on the medium.

62 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.

62 Product Unique Sense Data

Not presently used.

62 Segment Number

Always zeros.

62 Sense Key

General error category. These are listed in Table 67. The code given in byte 12 provides additional clarification of errors. See the Additional Sense Code field definition for related information.

62 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 67.

Note. After a Format Immediate command, bytes 16 and 17 become a formatting progress indicator with values in the range 0 to FFFF. Value 0 during format indicates that formatting just started. Value FFFF indicates formatting is complete.

62 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 63. 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.	64
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.	65
02h (Not Ready)	1	These fields are only defined for the Format Unit command with the Immed bit set to one (1).	66

Table 64. Field Pointer bytes

Bit Byte	7	6	5	4	3	2	1	0
15	SKSV	C/D	Reserved		BPV	Bit Pointer		
16	(MSB) _____							
17	_____ Field Pointer							(LSB)

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

64 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.

64 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.

64 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.

64 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 63.

Table 65. 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)****65 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 114.

65 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 63.

Table 66. 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)****66 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.

66 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 63.

Table 67 lists the sense keys in the extended sense data format that are used by the disc drive.

Table 68 lists the extended sense, additional sense, and additional sense qualifier codes.

Table 67. 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 SCSI interface parity error, 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 68. 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 signal
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	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
1C	00	Defect list not found
1D	00	Miscompare during verify operation

Table 68. Error codes for bytes 12 and 13 of sense data (values are in hexadecimal) (Continued)

Byte 12 (ASC)	Byte 13 (ASCQ)	Description
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	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
2A	00	Parameters changed
2A	01	Mode parameters changed
2A	02	Log parameters changed
2C	00	Command sequence error
2F	00	Tagged commands cleared by another initiator
31	00	Medium format corrupted
31	01	Format failed
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
35	04	Enclosure services transfer refused
37	00	Parameter rounded
3F	01	Microcode changed
3F	02	Changed operating definition
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	SCSI bus parity error
48	00	Initiator detected error

Table 68. Error codes for bytes 12 and 13 of sense data (values are in hexadecimal) (Continued)

Byte 12 (ASC)	Byte 13 (ASCQ)	Description
49	00	Invalid message
4E	00	Overlapped commands attempted
5B	00	Log exception
5B	01	Threshold condition met
5B	02	Log parameter value at maximum
5C	00	Servo RPL status change
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
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.

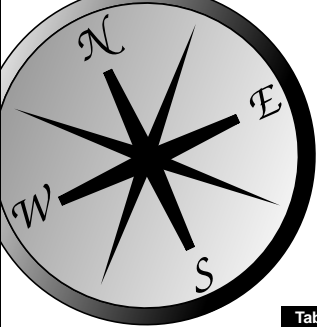
A target that receives a parameter value that is not an exact supported value adjusts the value to one that it supports and returns Check Condition status with a sense key of Recovered Error. The additional sense code is set to Rounded Parameter. The initiator is responsible for issuing an appropriate 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	Field name

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

Table 69. 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 118)
Compare	39h	x				12.2 (see page 118)
Copy	18h	x				12.3 (see page 118)
Copy and Verify	3Ah	x				12.4 (see page 118)
Format Unit	04h		x	x		12.5 (see page 119)
Inquiry	12h	x		x		12.6 (see page 127)
Lock-unlock Cache	36h					
Log Select	4Ch	x			x	12.7 (see page 140)
Log Sense	4Dh	x			x	12.8 (see page 149)
Mode Select (6)	15h		x	x		12.9 (see page 152)
Mode Select (10)	55h		x		x	12.10 (see page 156)
Mode Sense (6)	1Ah		x	x		12.11 (see page 157)
Mode Sense (10)	5Ah		x		x	12.12 (see page 189)
Move Medium	A7h					
Persistent Reserve In	5Eh					
Persistent Reserve Out	5Fh					
Prefetch	34h					
Prevent/Allow Medium Removal	1Eh		x	x		12.13 (see page 191)
Read (6)	08h		x	x		12.14 (see page 192)
Read (10) (Read Extended)	28h		x		x	12.15 (see page 194)
Read Data Buffer	3Ch		x		x	12.16 (see page 196)
Read Capacity	25h		x		x	12.17 (see page 198)
Read Defect Data	37h		x		x	12.18 (see page 200)
Read Element Status	B4h					
Read Long	3Eh		x		x	12.19 (see page 203)
Reassign Blocks	07h		x	x		12.20 (see page 205)
Rebuild	81h				x	12.21 (see page 207)
Receive Diagnostic Results	1Ch	x		x		12.22 (see page 210)
Regenerate	82h					
Release (6)	17h		x	x		12.24 (see page 220)
Release (10)	57h		x		x	12.25 (see page 220)
Report LUNs	A0h					
Request Sense	03h	x		x		12.26 (see page 222)
Reserve (6)	16h		x	x		12.27 (see page 223)
Reserve (10)	56h		x		x	12.28 (see page 224)
Rezero Unit	01h		x	x		12.29 (see page 227)
Search Data Equal	31h					
Search Data High	30h					
Search Data Low	32h					
Seek (6)	0Bh		x	x		12.30 (see page 228)
Seek (10) (Seek Extended)	2Bh		x		x	12.31 (see page 229)
Send Diagnostic	1Dh	x		x		12.32 (see page 230)
Set Limits	33h					
Start/Stop Unit	1Bh		x	x		12.33 (see page 234)
Synchronize Cache	35h		x		x	12.34 (see page 235)
Test Unit Ready	00h	x		x		12.35 (see page 236)
Verify	2Fh		x		x	12.36 (see page 237)
Write (6)	0Ah		x	x		12.37 (see page 239)
Write (10) (Write Extended)	2Ah		x		x	12.38 (see page 241)
Write and Verify	2Eh		x		x	12.39 (see page 243)
Write Data Buffer	3Bh	x			x	12.40 (see page 244)
Write Long	3Fh		x		x	12.41 (see page 248)
Write Same	41h					
XDread	52h					12.42 (see page 249)
XDwrite	50h					12.43 (see page 250)
XDwrite Extended	80h					12.44 (see page 252)
XPwrite	51h					

Table 70. 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		12.35 (see page 236)
01h	Rezero Unit		x	x		12.29 (see page 227)
03h	Request Sense	x		x		12.26 (see page 222)
04h	Format Unit		x	x		12.5 (see page 119)
07h	Reassign Blocks		x	x		12.20 (see page 205)
08h	Read (6)		x	x		12.14 (see page 192)
0Ah	Write (6)		x	x		12.37 (see page 239)
0Bh	Seek (6)		x	x		12.30 (see page 228)
12h	Inquiry	x		x		12.6 (see page 127)
15h	Mode Select (6)		x	x		12.9 (see page 152)
16h	Reserve (6)		x	x		12.27 (see page 223)
17h	Release (6)		x	x		12.24 (see page 220)
18h	Copy	x				12.3 (see page 118)
1Ah	Mode Sense (6)		x	x		12.11 (see page 157)
1Bh	Start/Stop Unit		x	x		12.33 (see page 234)
1Ch	Receive Diagnostic Results	x		x		12.22 (see page 210)
1Dh	Send Diagnostic	x		x		12.32 (see page 230)
1Eh	Prevent/Allow Medium Removal		x	x		12.13 (see page 191)
25h	Read Capacity		x		x	12.17 (see page 198)
28h	Read (10) (Read Extended)		x		x	12.15 (see page 194)
2Ah	Write (10) (Write Extended)		x		x	12.38 (see page 241)
2Bh	Seek (10) (Seek Extended)		x		x	12.31 (see page 229)
2Eh	Write and Verify		x		x	12.39 (see page 243)
2Fh	Verify		x		x	12.36 (see page 237)
30h	Search Data High					
31h	Search Data Equal					
32h	Search Data Low					
33h	Set Limits					
34h	Prefetch					
35h	Synchronize Cache		x		x	12.34 (see page 235)
36h	Lock-unlock Cache					
37h	Read Defect Data		x		x	12.18 (see page 200)
39h	Compare	x				12.2 (see page 118)
3Ah	Copy and Verify	x				12.4 (see page 118)
3Bh	Write Data Buffer	x			x	12.40 (see page 244)
3Ch	Read Data Buffer		x		x	12.16 (see page 196)
3Eh	Read Long		x		x	12.19 (see page 203)
3Fh	Write Long		x		x	12.41 (see page 248)
40h	Change Definition	x				12.1 (see page 118)
41h	Write Same					
4Ch	Log Select	x			x	12.7 (see page 140)
4Dh	Log Sense	x			x	12.8 (see page 149)
50h	XDwrite					12.43 (see page 250)
51h	XPwrite					
52h	XDread					12.42 (see page 249)
55h	Mode Select (10)		x		x	12.10 (see page 156)
56h	Reserve (10)		x		x	12.28 (see page 224)
57h	Release (10)		x		x	12.25 (see page 220)
5Ah	Mode Sense (10)		x		x	12.12 (see page 189)
5Eh	Persistent Reserve In					
5Fh	Persistent Reserve Out					
80h	XDwrite Extended					12.44 (see page 252)
81h	Rebuild				x	12.21 (see page 207)
82h	Regenerate					
A0h	Report LUNs					
A7h	Move Medium					
B4h	Read Element Status					

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 72.

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 Section 11.4 of individual drive's Product Manual, Volume 1, to see if the drive supports format progress indication, or deferred error handling in case of an error occurrence during formatting.

Table 71. 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	0	0	0	0	0	NACA	Flag	Link

Table
number

Field definitions (listed alphabetically)

71 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 73).

71 Defect List Format

Specifies additional information related to the defect list. (See Table 72 for further information.)

71 Flag

The Flag bit is not supported by drives described in this manual.

71 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 73), followed by an initialization pattern descriptor (Table 74 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).

71 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 12.14). Interleave values other than zero or one are vendor specific.

71 Link

See Control Bytes subheading in Section 11.2.1.6.

71 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

The following definitions of flaw categories are supplied to help you understand the alternatives listed in Table 72.

- 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 72. Format Unit parameter definition (format variations)

CDB-Byte (see Table 71)					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 77). 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 77). 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 78). 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 78). 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 73.
 [2] See individual drive's Product Manual, Volume 1, for support/non-support.

The defect list shown in Table 73 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 73 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 73
Initialization Pattern Descriptor	See Table 74
Defect Descriptors	See Tables 76, 77, and 78

12.5.1.1 Defect List header

Table 73. 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	Defect List Length							
3								

Table number Field definitions (listed alphabetically)

73 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 73) and specifies a format pattern of greater than 1 byte (see Table 74), and/or if the IP Modifier bits are set to 01 or 10 (see Table 74). 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.

73 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 77 or Table 78.

Note. The initiator may not use any previously defined C, G, or D lists if the sector size (block length) has been changed.

73 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.

73 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.

73 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.

73 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.

73 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 75). 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 75.

- 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.

73 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.

73 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 74. 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)**

74 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 75. 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 75. 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.

74 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.

74 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 73. Three formats are possible:

- Block format (Seagate does not support the block format, except as a customer special option)
- Index format (see Table 77)
- Physical Sector format (see Table 78).

Table 76. Defect descriptors

Byte	Description
0–n	Defect descriptor bytes (Refer to Table 77 for Index format and Table 78 for Physical Sector format)

Table 77. 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 71 and 72.

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. (Defect Bytes from Index)

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 78. 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 71 and 72.

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 80 on page 129.

Table 79. 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	0	0	0	0	0	NACA	Flag	Link

Table number **Field definitions (listed alphabetically)****79 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.

79 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.

79 Flag

The Flag bit is not supported by drives described in this manual.

79 Link

See Control Bytes subheading in Section 11.2.1.6.

79 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

79 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 80.

Table 80. 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	1 NACA	0	Response Data Format			
4	Additional Length							
5	0	0	0	0	0	0	0	0
6	Reserved	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 80 Field definitions (listed alphabetically)

80 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.

80 AENC (Asynchronous Event Notification Capability)

0 The disc drive does not support the asynchronous event notification capability.

80 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.

80 CMD QUE (Command Queuing)

- 0 The disc drive does not support tagged command queuing.
- 1 The disc drive supports tagged command queuing.

80 Copyright Notice

The 48 bytes of ASCII data "Copyright (c) XXXX Seagate All rights reserved," where "XXXX" indicates the current year (for example: 1997).

80 Drive Serial Number

The 8 bytes of ASCII data containing 8-digit drive serial number.

80 Dual P (Dual Port)

- 0 The disc drive is not a dual port device.
- 1 The disc drive is a dual port device.

80 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 12.22 and 12.32). The drive returns Enclosure Services Information (ESI) data as a result of a Receive Diagnostic Results command.

80 LINKED (Linked Command)

- 0 The disc drive does not support linked commands.
- 1 The disc drive supports linked commands.

80 NACA (Normal Auto Contingent Allegiance)

- 1 The disc drive supports the setting of the NACA bit in the Control Byte of the CDB.

80 Peripheral Qualifier and Peripheral Device Type

00h A direct-access device (magnetic disc) is connected to this logical unit.

80 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.

80 Product Identification

The ASCII data containing the drive model number. The data is left-aligned within this field.

80 Product Revision Level

The four bytes of ASCII data containing the last four digits of the firmware release number.

80 ReIAr (Relative Addressing)

- 0 The disc drive does not support the relative addressing mode.
- 1 The disc drive supports the relative addressing mode. When this bit = 1, the Linked Command (LINKED) bit must also be set to one because relative addressing can only be used with linked commands.

80 Reserved

Byte 56 through byte 95 are filled with 00h.

80 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.

80 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.

80 TRMIOP (Terminate I/O Process)

0 The disc drive does not support the Terminate I/O Process message.

80 TrnDis (Transfer Disable)

Not supported.

80 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 81. 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)

81 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.

81 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.

81 Peripheral Qualifier and Peripheral Device Type

00h A direct-access device (magnetic disc) is connected to this logical unit.

81 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 82.

Table 82. Vital product data page codes

Page Code	Description
00h	Supported vital product data pages
80h	Unit Serial Number page
81h	Implemented Operating Definition 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 83. 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)**

83 Page Code

Page 80h provides the product serial number for the disc drive. See bytes 4–8 (Product Serial Number field).

83 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.

83 Peripheral Qualifier and Peripheral Device Type

00h A direct-access device (magnetic disc) is connected to this logical unit.

83 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 84. 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)

84 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.

84 Default Operating Definition

Returns the value of the default operating definition.

84 Page Code

81h Defines the current operating definition, the default operating definition, and which operating definitions are implemented by the disc drive.

84 Page Length

04h The length of the implemented operating definition data (in bytes).

84 Peripheral Qualifier and Peripheral Device Type

00h A direct-access device (magnetic disc) is connected to this logical unit.

84 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.

84 Supported Operating Definition

The operating definition supported by this device.

12.6.4 Firmware Numbers page (C0h)

Table 85. 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)
-----------------	---

85 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.

85 Page Code

C0h Provides the firmware release numbers for the disc drive.

85 Page Length

20h The length of the Firmware Numbers page (in bytes).

85 Peripheral Qualifier and Peripheral Device Type

00h A direct-access device (magnetic disc) is connected to this logical unit.

85 Servo RAM Release Date in ASCII

This field contains the servo RAM release data in ASCII format.

85 Servo RAM Release Number

This field contains the servo RAM release number.

85 Servo ROM Release Date in ASCII

This field contains the servo ROM release data in ASCII format.

85 Servo ROM Release Number

This field contains the servo ROM release number.

12.6.5 Date Code page (C1h)

Table 86. 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)

86 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.

86 Page Code

C1h Provides the date code from the disc drive defect list.

86 Page Length

0Ch The length (in bytes) of the Date Code page.

86 Peripheral Qualifier and Peripheral Device Type

00h A direct-access device (magnetic disc) is connected to this logical unit.

86 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.

12.6.6 Jumper Settings page (C2h)

Table 87. 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)**

87 Page Code

C2h Provides the status of the option selections at the disc drive connector.

87 Page Length

02h The length (in bytes) of the Jumper Settings page.

87 Peripheral Qualifier and Peripheral Device Type

00h A direct-access device (magnetic disc) is connected to this logical unit.

87 Sel. ID (Select-ID)

AL_PA Select-ID mapping is shown on the next page (see Table 88).

87 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 88. 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		

12.6.7 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 89. Device Behavior page (C3h)

Bit Byte	7	6	5	4	3	2	1	0
00	Peripheral Qualifier			Peripheral Device Type				
01	Page Code (C3h)							
02	Reserved							
03	Page Length							
04	Version Number							
05	Behavior Code							
06	Behavior Code Version Number							
07 : 23	ASCII Model Number (16 bytes)							
24	Maximum Interleave							
25	Default Number of Cache Segments							
26+	Feature flags and additional byte fields will go here but are undefined at this time.							

Table number Field definitions (listed alphabetically)

89 ASCII Model Number

Identical to the Product Identification Number given in the standard Inquiry command data (see Table 80).

89 Behavior Code and Behavior Code Version Number

Jointly assigned by the Firmware Engineering Managers of all SCSI design locations.

89 Default Number of Cache Segments

Identical to the same parameter given in the Mode Caching page (see Table 115).

89 Feature flags and additional byte fields...

These bytes are not yet defined.

89 Maximum Interleave

The maximum value which the drive can support in the least significant byte of Interleave in the Format Unit command (see Table 71). 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 112).

89 Page Code

C3h Provides the behavior code information for the drive.

89 Page Length

32h The length of the Device Behavior page (in bytes).

89 Peripheral Qualifier and Peripheral Device Type

00h A direct-access device (magnetic disc) is connected to this logical unit.

89 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 90. 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 92. 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 90. 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	0	0	0	0	0	NACA	Flag	Link

Table number Field definitions (listed alphabetically)

90 Flag

The Flag bit is not supported by drives described in this manual.

90 Link

See Control Bytes subheading in Section 11.2.1.6.

90 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

90 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).

90 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.

90 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 92 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 92). The Page code (byte 0) specifies which log the page pertains to. The page code assignments are listed in Table 95. Initiator cannot send page zero (0).

90 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 92 and 93).
- 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 93) 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 91 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 91. 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 Sense command also uses the format of Table 92 so explanations pertaining to the table apply generally to both Log Select and Log Sense commands, with differences noted. However, only one log page is selected and returned with each Log Sense command. See Section 12.8. This table is not repeated in Section 12.8.

Table 92. 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)**

92 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 93.

92 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.

92 Page Code

Valid page codes are listed in Table 95.

92 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 93. 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		Rsvd	LP
3	Parameter Length (n-3 bytes)							
4	Parameter Value							
:								
n								

Table number **Field definitions (listed alphabetically)****93 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.

93 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.

93 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.

93 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 is 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.

93 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 96.

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.

93 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.

93 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.

93 TMC (Threshold Met Criteria)

This field defines the basis for comparison of the cumulative and threshold values. See Table 94 for meanings of values in this field. The TMC field is only valid when the ETC bit is one.

Table 94. 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 116) must also be one.

93 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 95. Detailed descriptions follow the table.

Table 95. Log Page codes

Page Code	Description	Section
02h	Error Counter page (Write)	12.7.1
03h	Error Counter page (Read)	12.7.1
05h	Error Counter page (Verify)	12.7.1
06h	Non-Medium Error page	12.7.2
37h	Cache Statistics page	12.7.3

12.7.1 Write, Read, and Verify Error Counter pages (code 02, 03, 05h)

Table 96 defines the parameter code field for the write, read, and verify error counter pages.

Table 96. Write, Read, 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)

96 Parameter Code

00h through 06h specify six counters each for write, read, and verify errors (18 counters). A description of the type (category of error) counters specified by codes 00h through 06h are described following.

- 00h 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.
- 01h 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.
- 02h 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.
- 03h 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.
- 04h 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.
- 05h 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 disc 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. Data bytes transferred to the initiator during a Mode Select, Mode Sense, Inquiry, Write Data Buffer, etc. do not count; only user data bytes are counted by this counter.
- 06h Total Uncorrected Errors. This parameter code specifies the counter that contains the total number of blocks for which an unrecoverable data error has occurred.

12.7.2 Non-Medium Error page (code 06h)

Log page code 06h specifies non-medium errors.

Table 97. Non-Medium Error page (code 06h)

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)****97** **Parameter Code**

00h The number of recoverable error events other than write, read, or verify errors (00h is the only code supported for this page).

12.7.3 Cache Statistics page (code 37h)

Log Page code 37h specifies Cache Statistics page.

Table 98. 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)

98 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 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 99. The format of the data pages sent back by the drive is shown in Table 92.

Table 99. 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	0	0	0	0	0	NACA	Flag	Link

Table number Field definitions (listed alphabetically)

99 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.

99 Flag

The Flag bit is not supported by drives described in this manual.

99 Link

See Control Bytes subheading in Section 11.2.1.6.

99 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

99 Operation Code

4Dh The operation code for the Log Sense command.

99 Page Code

The page of data requested by the command (see Table 95). 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 100 (Page Code 00h) returns the list of log pages that the drive supports. This page is not defined for the Log Select command.

99 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.

99 Parameter Pointer

A parameter code (see Table 96) 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.

99 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.

99 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 93) to a nonvolatile location, and then performs the rest of the Log Sense command.

Table 100. Supported log pages

Bit Byte	7	6	5	4	3	2	1	0
0	Reserved		Page Code (00h)					
1	Reserved							
2	(MSB)							
3	Page Length (n-3)						(LSB)	
4 : n	Supported Page List							

Table number Field definitions (listed alphabetically)

100 Page Code

00h Supported log pages page code.

100 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.

100 Supported Page List

A list of all log page codes implemented by the target in ascending order beginning with Page Code 00h.

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 separate set of mode parameters for up to 16 initiators that could be on the FC-AL. If an initiator sends a Mode Select command that changes any parameters that apply to other initiators, 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 101. 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	SP
2	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	
4	Parameter List Length								
5	0	0	0	0	0	NACA	Flag	Link	

Table number Field definitions (listed alphabetically)

101 Flag

The Flag bit is not supported by drives described in this manual.

101 Link

See Control Bytes subheading in Section 11.2.1.6.

101 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

101 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.

101 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.

101 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 102) 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 102.

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 109) 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 109).
- If the initiator sends a page descriptor with an unsupported page code value and the Strict mode is enabled. (see Table 109).
- If the initiator sends a value in the Number of Blocks field (see Table 102) 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 102. 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 103 and 108)
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Table 102 Field definitions (listed alphabetically)**102 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.

102 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).

102 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.

102 Medium Type

00h Define the default type direct access device.

102 Mode Select Page Headers And Their Parameters

See Mode Sense command (see Section 12.11) for detailed descriptions.

102 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 103. 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 108). 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 104. 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	0	0	0	0	0	NACA	Flag	Link

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.

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 105. 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	0	DBD	0	0
2	PCF		Page Code					
3	0	0	0	0	0	0	0	0
4	Allocation Length							
5	0	0	0	0	0	0	Flag	Link

Table number **Field definitions (listed alphabetically)****105 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.

105 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. Byte 3 of the Mode Sense header contains 00h to indicate a block descriptor length of zero.

105 Flag

The Flag bit is not supported by drives described in this manual.

105 Link

See Control Bytes subheading in Section 11.2.1.6.

105 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 below (also see the individual drive's Product Manual, Volume 1).

00h Unit Attention Page parameters (returned last of the pages).

01h Error Recovery parameters.

02h Disconnect/Reconnect Control parameters.

03h Format parameters.

04h Rigid Disc Drive Geometry parameters.

07h Verify Error Recovery Page parameters.

08h Caching page.

0Ah Control Mode page.

0Ch Notch and Partition page.

10h XOR Control Mode page.

1Ah Power condition page.

1Ch Informational Exceptions Control page.

3Fh Return all supported pages.

105 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 106. Mode Sense (6) data

Bit Byte	7	6	5	4	3	2	1	0
0	Sense Data Length							
1	0	0	0	0	0	0	0	0
Medium Type								
2	WP	Reserved		DPO-FUA	Reserved			
3	0	0	0	0	0	0	0	0
Block Descriptor Length (8 decimal)								

Block descriptor data

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)							

Parameter information

0–n	Mode Sense Page Headers and Their Parameters
-----	--

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

106 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.

106 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.

106 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.

106 Medium Type

00h The disc drive supports only 00h (default medium).

106 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.

106 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.

106 WP (Write Protect)

0 The medium is write enabled.

1 The medium is write protected.

Mode Sense page descriptor header**Table 107. 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)****107 Mode Parameters**

The contents of the mode pages being transferred. The number of bytes is indicated in the Page Length field.

107 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 108). 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 108. Mode sense page code section references

Page code	Page description	Reference table
00h	Unit Attention page	109 (page 162)
01h	Error Recovery	110 (page 164)
02h	Disconnect/Reconnect Control	111 (page 167)
03h	Format Parameters	112 (page 169)
04h	Rigid Disc Drive Geometry	113 (page 172)
07h	Verify Error Recovery page	114 (page 174)
08h	Caching page	115 (page 176)
0Ah	Control Mode page	116 (page 179)
0Ch	Notch and Partition page	117 (page 181)
10h	XOR Control Mode page	118 (page 183)
1Ah	Power Condition page	119 (page 185)

Table 108. Mode sense page code section references

Page code	Page description	Reference table
1Ch	Informational Exceptions Control page	120 (page 186)

107 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.

107 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 109. 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	0	0 Reserved	IL	Unit Attn	0	Rnd	Strict	SCSI-2
3 Default	Reserved							

Table number Field definitions (listed alphabetically)

109 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.

109 Page Code

00h Unit Attention page code.

109 Page Length

02h The length of the Unit Attention page (in bytes).

109 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.

109 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.

109 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.

109 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.

109 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 110. 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 110. Error Recovery page (01h)

Bit Byte	7	6	5	4	3	2	1	0
Page descriptor header								
0	1 PS	0	0	0	0	0	0	1 Page Code (01h)
1	Page Length (0Ah bytes)							
Error recovery parameters								
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				(LSB)	
11								

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

110 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.

110 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.

110 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.

110 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.

110 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.

110 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.

110 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 errors. 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.

110 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.

110 Page Code

01h Error Recovery page code.

110 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.

110 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.

110 PS (Parameter Savable)

This bit is not used with the Mode Select command.

1 Page 01h parameter data is savable.

110 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.

110 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.

110 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.

110 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.

110 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 111. 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 111. Disconnect/Reconnect Control page (02h)

Bit Byte	7	6	5	4	3	2	1	0
Page descriptor header								
0	1 PS	0	0	0	0	0	1	0 Page Code (02h)
1	Page Length (0Eh)							
Disconnect/reconnect control parameters								
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	<div style="display: flex; justify-content: space-between;"> MSB Maximum Burst Size LSB </div>							
12 Default	EMDP	0	0	0	DImm	DTDC		
13–15	Reserved							

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

111 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.

111 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.

111 Bus Inactivity Limit

Not supported (bytes 4 and 5).

111 Connect Time Limit

Not supported (bytes 8 and 9).

111 DImm (Disconnect Immediate)

Not supported.

111 Disconnect Time Limit

Not supported (bytes 6 and 7).

111 DTDC (Data Transfer Disconnect Control)

Not supported.

111 EMDP (Enable Modify Data Pointers)

Not supported.

111 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 ≥ 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.

111 Page Code

02h Disconnect/Reconnect Control page code.

111 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.

111 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 112. 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 112, 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 112. Format Parameters page (03h)

Bit	7	6	5	4	3	2	1	0	
Byte									
Page descriptor header									
0	1	0	0	0	0	0	1	1	
	PS		Page Code (03h)						
1	Page Length (16h)								
Format parameters									
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)

112 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.

112 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.

112 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.

112 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.

112 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.

112 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.

112 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.

112 Page Code

03h Format Parameters page code.

112 Page Length

16h The length of the Format Parameters page (in bytes).

112 PS (Parameter Savable)

This bit is not used with the Mode Select command.

1 The page 03h parameter data is savable.

112 RMB (Removable)

0 Indicates that the logical unit supports removable media.

1 Indicates that the logical unit does not support support removable media.

The status of this bit is reflected in the Inquiry command, removable media bit (RMB).

112 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.

112 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.

112 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.

112 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 113. 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 113. Rigid Disc Drive Geometry Parameters page (04h)

Bit Byte	7	6	5	4	3	2	1	0
Page descriptor header								
0	1 PS	0	0	0	0	1	0	0
Page Code (04h)								
1	Page Length (16h)							
Rigid disc drive geometry parameters								
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								
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)

113 Drive Step Rate

Not applicable.

113 Landing Zone Cylinder

Not applicable.

113 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.

113 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.

113 Number of Heads

The maximum number of data (read/write) heads on the disc drive.

113 Page Code

04h Rigid Disc Drive Geometry Parameters page code.

113 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.

113 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 101) is 1.

113 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.

113 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).

113 Starting Cylinder–Reduced Write Current

Not applicable.

113 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 114. Verify Error Recovery page (07h)

Bit Byte	7	6	5	4	3	2	1	0
Page descriptor header								
0	1 PS	0 Reserved	Page Code (07h)					
1	Page Length (0Ah)							
Verify error recovery parameters								
2 Default	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 number Field definitions (listed alphabetically)

114 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.

114 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.

114 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.

114 Page Code

07h Verify Error Recovery page code.

114 Page Length

0Ah This field specifies the length of the parameter that follows (in bytes).

114 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.

114 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.

114 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.

114 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.

114 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 115. Caching Parameters page (08h)

Bit Byte	7	6	5	4	3	2	1	0
Page descriptor header								
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)

115 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.

115 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.

115 CAP (Caching Analysis Permitted)

- 1 Caching analysis enabled.
- 0 Caching analysis disabled.

Caching analysis results are placed in the SCSI Logging Information Table, Table 98. See individual drive's Product Manual, Volume 2, SCSI Bus Conditions and Miscellaneous Features Supported table.

115 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).

115 Disable Prefetch Transfer Length

Prefetch is disabled for any SCSI Read command whose requested transfer length exceeds this value.

115 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.

115 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).

115 FSW (Force Sequential Write)

- 1 Multiple block writes are to be transferred over the SCSI bus 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.

115 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.

115 LBCSS (Logical Block Cache Segment Size)

Not used at this time.

115 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.

115 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.

115 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.

115 Minimum Prefetch

The minimum number of sectors to prefetch, regardless of the delay it may cause to other commands.

115 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.

115 Number of Cache Segments

The number of segments into which the host requests the drive divide the cache.

115 Page Code

08h Caching Parameters page for Mode Sense/Mode Select page code.

115 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.

115 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.

115 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.

115 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.

115 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.

115 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.

115 DPO (Disable Page Out)

- 1 The cache replacement algorithm should not replace existing cache data with the current data (if possible). If a cache segment must be overwritten, it should be made the LRU.

115 FUA (Force Unit Access)

Read:

- 1 The requested data must be read from the media. If cache data which overlaps the request has not yet been written to the media, it should be written before the read is allowed to occur.

Write:

- 1 All data must be written to the media before the SCSI operation returns the FCP RSP.

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 116. 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	0	QErr	DQue
4 Default	Reserved	RAC	0	0	SWP	0	0	0
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	Reserved (All Zeros)							
11	Reserved (All Zeros)							

Table number**Field definitions (listed alphabetically)****116 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.

116 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.

116 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.

116 Page Code

0Ah Control Mode page code.

116 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.

116 PS (Parameter Savable)

This bit is not used with the Mode Select command.

1 Page 0Ah parameter data is savable in nonvolatile memory.

116 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.

116 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.

116 RAC (Report A Check)

Not used at this time.

116 RLEC (Report Log Exception Condition)

1 The drive reports log exception conditions.

0 The drive does not report log exception conditions.

116 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 117. 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)

117 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.

117 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.

117 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.

117 Maximum Number of Notches

The maximum number of notches supported by the drive.

117 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.

117 Page Code

0Ch Notch page code.

117 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.

117 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.

117 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.

117 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 118. 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 Default	0	0	0	0	0	0	XORDis	Reserved	
	Reserved								
3 Default	0	0	0	0	0	0	0	0	
	Reserved								
4–7 Default	(MSB)		Maximum XOR Write Size						(LSB)
8–11 Default	(MSB)		Reserved						(LSB)
12–15 Default	(MSB)		Maximum Regenerate Size						(LSB)
16–19 Default	(MSB)		Maximum Rebuild Read Size						(LSB)
20 21	(MSB)		Reserved						(LSB)
22 23	(MSB)		Rebuild Delay						(LSB)

Table 118 Field definitions (listed alphabetically)**118 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.

118 Page Code

10h XOR Control Mode page code.

118 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.

118 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.

118 Maximum XOR Write Size

The maximum transfer length (in blocks) that the target accepts for a single XDWrite Extended, SXWrite, or XPWrite command.

118 Maximum Regenerate Size

The maximum regenerate length (in blocks) that the target accepts for the Regenerate command.

118 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.

118 Rebuild Delay

The minimum time (in milliseconds) between successive Read commands during a rebuild operation.

12.11.11 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 119. 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								
7								
8	(MSB)							
9	Standby Condition Timer							
10								
11								
11								

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

119 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.

119 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.

119 Page Code

1Ah Power Condition page code.

119 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.

119 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.

119 Standby

Not supported at this time.

119 Standby Condition Timer

Not supported at this time.

12.11.12 Informational Exceptions Control page (1Ch)

The Informational Exceptions Control page (see Table 120) 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 120. 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)

120 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.

120 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.

120 LogErr (Log Errors)

- 0 The logging of informational exception conditions within a target is vendor specific.
- 1 The target logs informational exception conditions.

120 MRIE (Method of Reporting Informational Exceptions)

Indicates the methods that are used by the target to report informational exception conditions (see Table 121). The priority of reporting multiple information exceptions is vendor specific.

Table 121. 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.

120 Page Code

1Ch Informational Exceptions Control page code.

120 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.

120 PS (Parameter Savable)

This bit is not used with the Mode Select command.

120 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.

120 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.

120 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 122. 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	0	0	0	0	0	NACA	Flag	Link

See the Mode Sense (6) command (Section 12.11) for a description of the fields in this command.

Table 123. Mode Sense (10) data

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB) _____							
1	Sense Data Length _____ (LSB)							
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	(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 106)
-----	---------------------------------------

0-n	Mode Sense Page Headers and Their Parameters
-----	--

Table number Field definitions (listed alphabetically)

123 Block Descriptor Data

See Table 106.

123 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.

123 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.

123 Medium Type

00h (default medium). This is the only valid value.

123 Mode Sense Page Headers and Their Parameters

See Table 106.

123 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.

123 WP (Write Protect)

- 0 The medium is write enabled.
- 1 The medium is write protected.

12.13 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.

12.14 Read command 08h

The Read command requests the disc drive to transfer data to the initiator.

Table 124. 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 Reserved			(MSB)	Logical Block Address (LSB)			
2								
3								
4	Transfer Length							
5	0	0	0	0	0	NACA	Flag	Link

Table number Field definitions (listed alphabetically)

124 Flag

The Flag bit is not supported by drives described in this manual.

124 Link

See Control Bytes subheading in Section 11.2.1.6.

124 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

124 Logical Block Address

The logical block at which the read operation will begin.

124 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 12.27) 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	Sense key
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

12.15 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 125.

This command operates the same as the Read command (see Section 12.14) 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 12.27) exists, and no data is read.

Table 125. 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
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	0	0	0	0	0	NACA	Flag	Link

Table
number

Field definitions (listed alphabetically)

125 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.

125 Flag

The Flag bit is not supported by drives described in this manual.

125 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.

125 Link

See Control Bytes subheading in Section 11.2.1.6.

125 Logical Block Address

The logical block at which the read operation begins, if RelAdr bit is zero (see RelAdr bit description).

125 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

125 RelAdr (Relative Address)

Drives supported by this manual do not implement this option.

125 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.

Condition	Sense Key
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

12.16 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 126.

Table 126. 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	0	0	0	0	0	NACA	Flag	Link

Table number Field definitions (listed alphabetically)

126 Allocation Length

The number of bytes available for returning read buffer command data.

126 Buffer ID

0

126 Buffer Offset

0

126 Flag

The Flag bit is not supported by drives described in this manual.

126 Link

See Control Bytes subheading in Section 11.2.1.6.

126 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 12.16.1)
0	1	0	Read data (Section)
0	1	1	Read descriptor (Section)

126 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

12.16.1 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 127. 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)**

127 Buffer Capacity

The number of bytes available in the read buffer.

127 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.

127 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 128. 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)**

128 Buffer Capacity

The total number of data bytes that are available in the disc drive's data buffer (see 12.40.1 and 12.40.2). 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.

128 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.

12.17 Read Capacity command 25h

The Read Capacity command provides a means for the initiator to request the capacity of the disc drive information.

Table 129. 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	0	0	0	0	0	NACA	Flag	Link

Table number **Field definitions (listed alphabetically)****129** **Flag**

The Flag bit is not supported by drives described in this manual.

129 **Link**

See Control Bytes subheading in Section 11.2.1.6.

129 **Logical Block Address**

The 32-bit address of the logical block affected by this command.

129 **NACA (Normal Auto Contingent Allegiance)**

See Control Bytes subheading in Section 11.2.1.6.

129 **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.

129 RelAdr (Relative Address)

Drives supported by this manual do not implement this option.

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 130.

Table 130. 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)

12.18 Read Defect Data 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 131.

Table 131. 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						Defect List Format		
						1	0	1
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	0	0	0	0	0	NACA	Flag	Link

Table number Field definitions (listed alphabetically)

131 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.

131 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.

131 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.

131 Flag

The Flag bit is not supported by drives described in this manual.

131 Link

See Control Bytes subheading in Section 11.2.1.6.

131 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

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 132.

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 131).

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 132. Defect List Header description

Bit Byte	7	6	5	4	3	2	1	0
0	Reserved							
	0	0	0	0	0	0	0	0
1	0	0	0	P	G	1	0	0 or
	Reserved			CDB		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)

132 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.

132 Defect List Format

100	A list in the Bytes from Index format.
101	A list in the Physical Sector format.

132 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 77 and 78 for the format of Defect Descriptor bytes.

12.19 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 133. 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	0	0	0	0	0	NACA	Flag	Link

**Table
number****Field definitions (listed alphabetically)****133 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.)

133 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.

133 Flag

The Flag bit is not supported by drives described in this manual.

133 Link

See Control Bytes subheading in Section 11.2.1.6.

133 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.

133 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

133 RelAdr (Relative Address)

1 The Logical Block Address field is a two's complement displacement. This negative or positive displacement is to be added to the logical block address last accessed on the logical unit to form the logical block address for this com-

mand. This feature is only available when linking commands. The feature requires that a previous command in the linked group has accessed a block of data on the logical unit.

- 0 The Logical Block Address field specifies the first RelAdr logical block of the range of logical blocks to be operated on by this command.

12.20 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 134. 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)**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 FFFFFFFFh.

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 135. Reassign Blocks defect list

Bit Byte	7	6	5	4	3	2	1	0
Defect list header								
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)							
Defect descriptors								
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)**

135 Defect Descriptor

Specifies a four-byte defect logical block address that contains the defect. The defect descriptors are in ascending order.

135 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.

12.21 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 136. 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 136 Field definitions (listed alphabetically)**136 Control**

See Section 11.2.1.6.

136 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.

136 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.

136 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 137.

1 The rebuild parameter list includes intermediate data.

136 Logical Block Address

The first logical block address on the target device that will contain xor result data.

136 Parameter List Length

The length, in bytes, of the parameter list that is transferred from the initiator to the target. See Table 137.

136 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.

136 Rebuild Length

The number of blocks to be written to the medium and the number of blocks that are read from each source.

Table 137. 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)(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 definitions (listed alphabetically)**

137 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.

137 Number of Source Descriptors

The number of source descriptors in the parameter data.

137 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.

137 Source Descriptor/Pad Length

The sum of the lengths (in bytes) of all of the source descriptors and the pad.

137 Source Descriptor

This field identifies the source device target identifiers and starting logical block addresses on the devices for the rebuild operation. See Table 138 for the source descriptor format.

Table 138. Source descriptor format

Bit Byte	7	6	5	4	3	2	1	0	
0	Source Device Address								(MSB)
1									
2									
3									
4									
5									
6									
7									
8	Reserved								(MSB)
9									
10									
11									
12	Source Starting Logical Block Address								(MSB)
13									
14									
15									
								(LSB)	
								(LSB)	
								(LSB)	
								(LSB)	

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

138 Source Device Address

The SAM-compliant target identifier of the data source device.

138 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.

12.22 Receive Diagnostic Results command 1Ch

The Receive Diagnostic Results command requests analysis data be sent to the initiator after completion of a Send Diagnostic command. 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 141 or 144, respectively. If the Send Diagnostic Self Test bit is set, the data returned is described in Table 147.

Table 139. 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
2	Page Code							
3	Allocation Length (in bytes) (MSB)							
4	Allocation Length (in bytes) (LSB)							
5	0	0	0	0	0	NACA	Flag	Link

Table number Field definitions (listed alphabetically)

139 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.

139 Flag

The Flag bit is not supported by drives described in this manual.

139 Link

See Control Bytes subheading in Section 11.2.1.6.

139 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

139 Page Code

The Page Code number of the Diagnostic page to be received. See Table 140 for page code descriptions.

Table 140. Page Code descriptions

Page Code	Description	Reference Table
00h	List of Supported Diagnostic Pages	141
01h	Enclosure Configuration Page	143
02h	Enclosure Control/Status Page	143
03h	Enclosure Help Text Page	143
04h	Enclosure String Out/In Page	143
05h	Enclosure Threshold Out/In Page	143
06h	Enclosure Array Control/Status Page	143
07h	Enclosure Element Descriptor Page	143
08h	Enclosure Short Status Page	143
40h	Address Translation Page	144
none	Self Test Diagnostic Results	147

139 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 147.
- 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.

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 141 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 and the Page Code set to 00h, the drive sends back the Supported Diagnostic Page 00h (See Table 141). It is not necessary to have first issued a Send Diagnostic command to receive Page 00h data.

Table 141. 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)****141 Page Code**

00h Provides the supported diagnostic pages information for the drive.

141 Page Length

n - 3 The length (in bytes) of the Supported Diagnostic page.

141 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 142.

Table 142. Supported Diagnostic pages

Page Code	Description	Reference
00h	Supported Diagnostic pages	Table 141
01h - 08h	SCSI Enclosure Services Information (ESI) pages	Table 143
40h	Translate Address page	Table 144

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 X3T10xxxx regarding the SCSI-3 Enclosure Services Command Set (SES) for descriptions of the data presented in the SES pages.

Table 143. SCSI Enclosure Services Information (ESI) page format

Bit Byte	7	6	5	4	3	2	1	0
0	Page Code (01h - 08h)							
1	Page specific							
2	(MSB)							
3	Page Length (n - 3)							
n	(LSB)							
n	Page specific							

Table
number

Field Definitions (listed alphabetically)

143 Page Code

01h - 08h Enclosure Services Information (ESI) pages.

143 Page Length

n - 3

143 Page specific

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 144. 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 145 and 146)							

Table number Field definitions (listed alphabetically)

144 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.

144 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.

144 Page Code

40h Translate Address page–Receive Diagnostic page code.

144 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.

144 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.

144 Supplied Format

The value from the Send Diagnostic command supplied format field (see Table 160).

144 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 145 and 146.

144 Translated Format

The value from the Send Diagnostic command translate format field (see Table 160). The values are 000 (Logical block format) or 101 (Physical sector address format).

Table 145. Address field logical block address format

Bit Byte	7	6	5	4	3	2	1	0	
0	Logical Block Address								(MSB)
1									
2									
3									(LSB)
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)

145 Logical Block Address

The 32-bit address of the logical block.

Table 146. Address field physical sector address format

Bit Byte	7	6	5	4	3	2	1	0	
0	Cylinder Number								(MSB)
1									
2									(LSB)
3	Head Number								
4	Sector Number								
5									
6									
7									

Table number Field definitions (listed alphabetically)

146 Cylinder Number

This field contains the drive cylinder number.

146 Head Number

This field contains the drive head number.

146 Sector Number

This field contains the drive sector number.

Table 147. 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)

147 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.

147 Additional Vendor-unique Fault Information

Vendor-unique data.

147 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.

147 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.

12.23 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 148. 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)****148 Control**

See Section 11.2.1.6.

148 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.

148 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.

148 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 137.

1 The regenerate parameter list includes intermediate data.

148 Logical Block Address

The first logical block address on the target device that will contain xor result data.

148 Parameter List Length

The length, in bytes, of the parameter list that is transferred from the initiator to the target. See Table 149.

148 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.

148 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 149. 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)**

149 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.

149 Number of Source Descriptors

The number of source descriptors in the parameter data.

149 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.

149 Source Descriptor/Pad Length

The sum of the lengths (in bytes) of all of the source descriptors and the pad.

149 Source Descriptor

This field identifies the source device target identifiers and starting logical block addresses on the devices for the rebuild operation. See Table 150 for the source descriptor format.

Table 150. 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)**

150 Source Device Address

The SAM-compliant target identifier of the data source device.

150 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.

12.24 Release (6) command 17h

Not implemented. If the drive receives this command, the drive sends a Check Condition status and a sense key of Illegal Request. Use the Reserve (10) command (57h).

12.25 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 151. 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	(MSB) _____							
8	_____ Parameter List Length _____ (LSB)							
9	0	0	0	0	0	NACA	Flag	Link

Table number **Field definitions (listed alphabetically)****151** **Extent (Extent Release)**

Not supported and must be zero (0).

151 **Flag**

The Flag bit is not supported by drives described in this manual.

151 **Link**

See Control Bytes subheading in Section 11.2.1.6.

151 **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 12.28.

151 **NACA (Normal Auto Contingent Allegiance)**

See Control Bytes subheading in Section 11.2.1.6.

151 **Operation Code**

57h The operation code for the Release (10) command.

151 **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 159).

0Eh The value sent when Page 40h is sent (see Table 160).

151 Reservation Identification

Not supported.

151 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.

151 Third-Party Device ID

Not supported.

12.26 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 152. 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 152. 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	0	0	0	0	0	NACA	Flag	Link

Table number Field definitions (listed alphabetically)

152 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.

152 Flag

The Flag bit is not supported by drives described in this manual.

152 Link

See Control Bytes subheading in Section 11.2.1.6.

152 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

12.27 Reserve (6) command 16h

Not implemented. If the drive receives this command, the drive sends a Check Condition status and a sense key of Illegal Request. Use the Reserve (10) command (56h).

12.28 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 153. 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
2	Reservation Identification							
3	Third-Party Device ID							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB) _____							
8	_____ (LSB)							
9	0	0	0	0	0	NACA	Flag	Link

Table number **Field definitions (listed alphabetically)****153 Extent (Extent Release)**

Must be zero (0). Extent is not supported by the drive.

153 Flag

The Flag bit is not supported by drives described in this manual.

153 Link

See Control Bytes subheading in Section 11.2.1.6.

153 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.

153 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

153 Operation Code

56h The operation code for the Reserve (10) command.

153 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.

153 Reservation Identification

Not supported.

153 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.

153 Third-Party Device ID

Not supported.

12.28.1 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.

12.28.2 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 12.25). 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.

12.28.3 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.

12.28.4 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 154. Parameter list format for third-party addressing

Bit Byte	7	6	5	4	3	2	1	0
0	(MSB) Reserved (LSB)							PA_VAL
1	FCP_Port Identifier							(LSB)
2								
3								
4	Process Associator							(LSB)
5								
6								
7								

Table number Field definitions (listed alphabetically)

154 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.

154 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.

154 Process Associator

Not supported and not checked.

12.29 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 155. 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	0	0	0	0	0	NACA	Flag	Link

Table number **Field definitions (listed alphabetically)****155 Flag**

The Flag bit is not supported by drives described in this manual.

155 Link

See Control Bytes subheading in Section 11.2.1.6.

155 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

12.30 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 156. Seek command (0Bh)

Bit	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	1
1	Reserved			(MSB)	Logical Block Address			
2								
3								(LSB)
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	NACA	Flag	Link

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

156 **Flag**

The Flag bit is not supported by drives described in this manual.

156 **Link**

See Control Bytes subheading in Section 11.2.1.6.

156 **Logical Block Address**

The maximum logical block address that may be specified for a Seek command is defined in Read Capacity Data, Section 12.17.

156 **NACA (Normal Auto Contingent Allegiance)**

See Control Bytes subheading in Section 11.2.1.6.

12.31 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 157.

Table 157. 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	0	0	0	0	0	NACA	Flag	Link

Table number **Field definitions (listed alphabetically)****157** **Flag**

The Flag bit is not supported by drives described in this manual.

157 **Logical Block Address**

This command operates the same as the Seek command (Section 12.30) except that a four-byte Logical Block Address is specified.

157 **Link**

See Control Bytes subheading in Section 11.2.1.6.

157 **NACA (Normal Auto Contingent Allegiance)**

See Control Bytes subheading in Section 11.2.1.6.

12.32 Send Diagnostic command 1Dh

This command requests that the disc drive perform diagnostic tests on itself, or perform other optional operations. Table 158 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 159) and then request a supported additional operation. The disc drive supports the pages listed in Table 142 (see page 212).

For systems which support disconnection, the disc drive will disconnect while executing this command.

Table 158. Send Diagnostic command (1Dh)

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	1	1	1	0	1
1	0	0	0	0	Rsvd	Self Test	DEVOFL	Unit OFL
2	0	0	0	Reserved	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	(see explanation below)			
	Parameter List Length (LSB)							
5	0	0	0	0	0	NACA	Flag	Link

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

158 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.

158 Flag

The Flag bit is not supported by drives described in this manual.

158 Link

See Control Bytes subheading in Section 11.2.1.6.

158 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

158 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 159).

0Eh The value sent when Page 40h is sent (see Table 160).

158 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 159 and 160 which show formats of the two pages supported by disc drive.

158 Self Test

This bit determines whether the drive will perform its default self test.

- 0 Instructs the disc drive to perform the operation called out in the parameter list in the data out following the Send Diagnostic command data block. For disc drives, the pages that may be in the parameter list are described in the Parameter List Length field definition above.
- 1 Directs the disc drive to complete its default self test. If the self test is requested, the Parameter List Length must be set to zero and no data will be transferred. If the self test passes successfully, the command terminates with a good condition status; otherwise, the command terminates with a check condition status and, if extended sense is implemented, the Sense Key is set to Hardware Error.
- The disc drive performs only its default self test. This includes:
- Seeking to a reserved non user-accessible cylinder
 - writing, reading, and verifying data for each data surface

158 Unit OFL (Logical Unit Off Line)

- 0 Disables write operations on user medium or operations that affect user visible medium positioning. The bit is not interpreted by the disc drive.

12.32.1 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 141). 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 159. 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)**

159 **Page Code**

00h Supported Diagnostic Pages code.

159 **Page Length**

0000h Must be zero.

12.32.2 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 139).

Table 160. 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)

160 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 145 and Table 146.

160 Page Code

40h Translate Address page-Send Diagnostic command page code.

160 Page Length

000Ah The length (in bytes) of the Translate Address—Send Diagnostic page.

160 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.

160 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.

12.33 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 161. 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	0	0	0	0	0	NACA	Flag	Link	

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

161 **Flag**

The Flag bit is not supported by drives described in this manual.

161 **Immed (Immediate)**

- 0 Status is returned after the operation is completed.
- 1 Status is returned as soon as the operation is initiated.

161 **Link**

See Control Bytes subheading in Section 11.2.1.6.

161 **NACA (Normal Auto Contingent Allegiance)**

See Control Bytes subheading in Section 11.2.1.6.

161 **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.

12.34 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 162. 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	0	0	0	0	0	NACA	Flag	Link

Table number**Field definitions (listed alphabetically)****162 Flag**

The Flag bit is not supported by drives described in this manual.

162 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.

162 Link

See Control Bytes subheading in Section 11.2.1.6.

162 Logical Block Address

The logical block at which the Synchronize Cache operation begins.

162 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

162 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.

162 RelAdr (Relative Address)

Drives supported by this manual do not implement this option.

12.35 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 163. 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	0	0	0	0	0	NACA	Flag	Link

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

163 **Flag**

The Flag bit is not supported by drives described in this manual.

163 **Link**

See Control Bytes subheading in Section 11.2.1.6.

163 **NACA (Normal Auto Contingent Allegiance)**

See Control Bytes subheading in Section 11.2.1.6.

12.36 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 164. The drive disconnects while this command is being executed if the initiator supports disconnect/reconnect.

Table 164. Verify command (2Fh)

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	0	1	1	1	1
1	0 0		0	0	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	0	0	0	0	0	NACA	Flag	Link

Table number **Field definitions (listed alphabetically)****164 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.

164 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.

164 Flag

The Flag bit is not supported by drives described in this manual.

164 Link

See Control Bytes subheading in Section 11.2.1.6.

164 Logical Block Address

The logical block at which the verify operation begins, if RelAdr is zero (0).

164 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

164 RelAdr (Relative Address)

Drives supported by this manual do not implement this option.

164 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.

12.37 Write command 0Ah

The Write command requests that the disc drive write the data transferred by the initiator to the medium (discs).

Table 165. Write command (0Ah)

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0
1	Reserved			Logical Block Address (MSB) _____ (LSB)				
2								
3								
4	Transfer Length							
5	0	0	0	0	0	NACA	Flag	Link

Table number **Field definitions (listed alphabetically)****165 Flag**

The Flag bit is not supported by drives described in this manual.

165 Link

See Control Bytes subheading in Section 11.2.1.6.

165 Logical Block Address

The logical block at which the write operation begins.

165 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

165 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 12.14).

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 12.27) 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	Sense key
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.

12.38 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 166. Refer also to the Write Caching section in the individual drive's Product Manual, Volume 2, for information on write cache control.

Table 166. 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	0	0	0	0	0	NACA	Flag	Link

Table number **Field definitions (listed alphabetically)****166 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).

166 Flag

The Flag bit is not supported by drives described in this manual.

166 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.

166 Link

See Control Bytes subheading in Section 11.2.1.6.

166 Logical Block Address

The logical block at which the write operation begins, if RelAdr bit is zero (see RelAdr bit definition).

166 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

166 RelAdr (Relative Address)

Drives supported by this manual do not implement this option.

166 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 12.37) 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 12.27) 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.

Condition	Sense Key
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

12.39 Write and Verify command 2Eh**Table 167. 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	0	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	0	0	0	0	0	NACA	Flag	Link

Table number **Field definitions (listed alphabetically)****167 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.

167 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.

167 Flag

The Flag bit is not supported by drives described in this manual.

167 Link

See Control Bytes subheading in Section 11.2.1.6.

167 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).

167 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

167 RelAdr (Relative Address)

Drives supported by this manual do not implement this option.

167 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.

12.40 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 168. 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	0	0	0	0	0	NACA	Flag	Link

Table number Field definitions (listed alphabetically)

168 Buffer ID

Implemented only by drives that support modes 110b and 111b.

168 Buffer Offset

Implemented only by drives that support modes 110b and 111b.

168 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.

168 Flag

The Flag bit is not supported by drives described in this manual.

168 Link

See Control Bytes subheading in Section 11.2.1.6. All bits are zero for all modes.

168 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 169. Mode definitions

Bit 2	Bit 1	Bit 0	Mode Definition
0	0	0	Write combined header and data (Section 12.40.1)
0	1	0	Write data (Section 12.40.2)
1	0	0	Download microcode
1	0	1	Download microcode and save (Section 12.40.3)
1	1	0	Download microcode with offsets
1	1	1	Download microcode with offsets and save (Section 12.40.4)

168 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

12.40.1 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 170. 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							

12.40.2 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.

12.40.3 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 (see Section 4.6) for all initiators with an extended sense of Power On, Reset, or Bus Device Reset Occurred (Sense Data Error Code 29 00h). 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 168 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.

12.40.4 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 (see Section 4.6) 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.

12.41 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 171. 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
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	0	0	0	0	0	NACA	Flag	Link

Table number Field definitions (listed alphabetically)

171 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.)

171 Flag

The Flag bit is not supported by drives described in this manual.

171 Link

See Control Bytes subheading in Section 11.2.1.6.

171 Logical Block Address

The 32-bit address of the logical block affected by this command.

171 NACA (Normal Auto Contingent Allegiance)

See Control Bytes subheading in Section 11.2.1.6.

171 RelAdr (Relative Address)

- 1 The Logical Block Address field is a two's complement displacement. This negative or positive displacement is to be added to the logical block address last accessed on the logical unit to form the logical block address for this command. This feature is only available when linking commands. The feature requires that a previous command in the linked group has accessed a block of data on the logical unit.
- 0 The Logical Block Address field specifies the logical block at which the write operation occurs.

12.42 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 Sdread 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 172. XDread command (52h)

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	1	0	1	0	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)****172** **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.

172 **Control**

See Section 11.2.1.6.

172 **Logical Block Address**

The 32-bit address of the logical block affected by this command.

12.43 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 173. Xdwrite command (50h)

Bit Byte	7	6	5	4	3	2	1	0
0	0	0	1	1	0	0	1	0
1	Reserved			DPO	FUA	Disable write	Reserved	
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	Reserved							
7	Transfer Length (MSB)							
8	Transfer Length (LSB)							
9	Control							

Table number Field definitions (listed alphabetically)

173 Control

See Section 11.2.1.6.

173 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.

173 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.

173 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).

173 Logical block address

The starting logical block address of the data to be affected by the xor operation.

173 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.

12.44 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 exten reservation.

Table 174. XDwrite Extended command (80h)

Bit Byte	7	6	5	4	3	2	1	0
0	0	1	0	1	0	0	0	0
1	Table Address	Reserved	Reserved	DPO	FUA	Disable Write	Port Control	
2	Logical Block Address (MSB)							
3	Logical Block Address							
4	Logical Block Address							
5	Logical Block Address (LSB)							
6	Secondary Logical Block Address (MSB)							
7	Secondary Logical Block Address							
8	Secondary Logical Block Address							
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)

174 Control

See Section 11.2.1.6.

174 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.

174 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.

174 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).

174 Logical block address

The starting logical block address of the data to be affected by the xor operation.

174 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.

174 Transfer length

The number of logical blocks that will be transferred to the XDwrite Extended target and to the XPwrite target.

13.0 Seagate technical support services

If you need assistance 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 assistance with your Seagate® drive or other Seagate products, use one of the Seagate technical support services listed below.

SeaFONE® 1-800-SEAGATE

Seagate's 800 number (1-800-732-4283) allows toll-free access to automated self-help services, providing answers to commonly asked questions, troubleshooting tips, and specifications for disc drives and tape drives. This service is available 24 hours daily and requires a touch-tone phone. International callers can reach this automated self-help service by dialing 408-456-4496.

Online services

Using a modem, you can obtain troubleshooting tips, free utility programs, drive specifications and jumper settings for Seagate's entire product line. You can also download software for installing and analyzing your drive.

SeaNET™

You can obtain technical information about Seagate products over the Internet from Seagate's World Wide Web home page (<http://www.seagate.com>) or Seagate's ftp server (<ftp://ftp.seagate.com>). You can also send E-mail with your questions to **DiscSupport @ Seagate.com** or **TapeSupport @ Seagate.com**.

Seagate CompuServe forum

Online technical support for Seagate products is available on CompuServe. To access our technical support forum, type **go seagate**. This forum provides information similar to that found on SeaBOARD. In addition, you can type questions or browse through previous questions and answers on the forum messages.

SeaBOARD®

SeaBOARD 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).

Location	Phone number
Australia	61-2-9756-2359
England	44-1628-478011
France	33 1-48 25 35 95
Germany	49-89-140-9331
Singapore	TBA
Taiwan	886-2-719-6075
Thailand	662-531-8111
USA	Disc: 408-434-1080; Tape: 408-456-4415

FAX services

SeaFAX®

You can use a touch-tone telephone to access Seagate's automated FAX system to receive technical support information by return FAX. This service is available 24 hours daily.

Location	Phone number
Australia	61-2-9756-5170
England	44-1628-894084
USA	1-800-SEAGATE or 408-456-4496

Seagate technical support FAX

You can FAX questions or comments to technical support specialists 24 hours daily. Responses are sent during business hours.

Location	Phone number
Australia	61-2-9725-4052
England	44-1628-890660
France	33 1-46 04 42 50

Location	Phone number
Germany	49-89-1430-5100
Hong Kong	852-2368 7173
Japan	81-3-5462-2979
Korea	82-2-556-7294/4251
Singapore	65-488-7528
Taiwan	886-2-715-2923
USA	408-944-9120

Direct-support services

Seagate technical support

For one-on-one help, you can talk to a technical support specialist during local business hours. Before calling, note your system configuration and drive model number (STxxxx).

Location	Phone number
Australia	61-2-9725-3366 (9:00 A.M. to 5:00 P.M., M–F)
England	44-1628-894083 (10:00 A.M. to 1:00 P.M., 2:00 P.M. to 5:00 P.M., M–F)
France	33 1-41 86 10 86 (9:30 A.M. to 12:30 P.M., 2:00 P.M. to 5:00 P.M., M–F)
Germany	Disc: 49-89-140-9332; Tape: 49-89-140-9333 (9:30 A.M. to 12:30 P.M., 2:00 P.M. to 4:00 P.M., M–F)
Hong Kong	852-2368 9918
Korea	82-2-556-8241
Singapore	65-488-7584 (9:00 A.M. to 12:00 P.M., 2:00 P.M. to 5:00 P.M., M–F)
Taiwan	886-2-514-2237
USA	Please dial 1-800-SEAGATE or 408-456-4496 for the specific product telephone number. (6:00 A.M. to 11:15 A.M., 12:30 P.M. to 5:00 P.M., Pacific time, M–F)

SeaTDD™ 408-944-9121

Using a telecommunications device for the deaf (TDD), you can send questions or comments 24 hours daily and exchange messages with a technical support specialist between 6:00 A.M. to 11:15 A.M. and 12:30 P.M. to 5:00 P.M. (Pacific time) Monday through Friday.

Customer service centers

Seagate direct OEM, Distribution, and System Integrator customers should contact their Seagate service representative for warranty information. Other customers should contact their place of purchase. Seagate offers comprehensive customer support for all Seagate drives. These services are available worldwide.

Location	Phone number	FAX number
Asia Pacific and Australia	65-485-3595	65-485-4980
Europe, Middle East, and Africa	31-2031-67300	31-2065-34320
Japan	81-3-5462-2904	81-3-5462-2979
USA	1-800-468-3472	405-949-6740
Other Americas (Brazil, Canada, Mexico)	405-949-6706	405-949-6738
<i>Manufacturer's representatives</i>		
Brazil		
MA Informatica	55-11-810-7794	55-21-253-6467
Canada		
Memofix	905-660-4936	905-660-8738
Adtech	905-812-8099	905-812-7807
	1-800-624-9857	
Mexico		
Abicom Seamax SA DE CV	525-546-6965	525-546-4888

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 represents 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. [X3.230199X].

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. [X3.270199X].

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. [X3.270199X].

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.

Average power

The optical power measured using an average reading power meter when the Fibre Channel is transmitting a specified code sequence as defined in the test procedure.

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

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

A 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 (i.e., contents of a frame Û one buffer).

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. A group of eight bits. 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.

CD

Compact disk.

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 bi-directional 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 bi-directional 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 delimit

Classes of service

Different types of services provided by the Fabric and used by the communicating N_Ports.

Coaxial cable

An electrical transmission medium consisting of concentric conductors separated by a dielectric material with the spacings and material arranged to give a specified electrical impedance.

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. [X3.270199X]

Command byte count

Upper limit on the extent of the data to be transferred by the SCSI command. [X3.270199X]

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. [X3.270199X]

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. Continuously Increasing Relative Offset (RO[i]) for a given Information Category (i) is specified by the following:

$RO[i](n+1) = RO[i](n) + \text{Length of Payload}[i](n)$ where n is ≥ 0 and represents the consecutive frame count of frames for a given Information Category within a single Sequence. $RO[i](0) = \text{Initial Relative Offset (IRO}[i])$ for the Information Category i (see Relative Offset and Random Relative Offset).

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. [X3.270199X]

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. [X3.270199X]

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. [X3.270199X]

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 [X3.230199X].

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. [X3.230199X]

FCP

Fibre Channel Protocol.

FCP I/O operation

An unlinked SCSI command, a series of linked SCSI commands, or a task management function. [X3.270199X]

FCP_Port

An N_Port or NL_Port that supports the SCSI Fibre Channel Protocol.

FCPH

The architecture specified by the Fibre Channel standard. [X3.230199X]

FCS

Frame Check Sequence (see N.i).

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 (see FC-AL document).

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. [X3.270199X]

Initiator identifier

Token by which a target identifies the initiator device. [X3.270199X]

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 (see FC-AL document).

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. [X3.270199X]

Logical unit identifier

Identifier used by an initiator to reference the logical unit. [X3.270199X]

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

Loop_IDs are 7-bit values numbered contiguously from 0 to 126 decimal and represent 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 such as CCITT or IEEE 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. [FCAL]

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.

Numerical aperture

The sine of the radiation or acceptance half angle of an optical fibre, multiplied by the refractive index of the material in contact with the exit or entrance face. See FOTP-177.

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 fall time

The time interval required for the falling edge of an optical pulse to transition between specified percentages of the signal amplitude. For lasers the transitions are measured between the 80% and 20% points. For LED media the specification points are 90% and 10%.

Optical fall time

The time interval required for the falling edge of an optical pulse to transition between specified percentages of the signal amplitude. For lasers the transitions are measured between the 80% and 20% points. For LED media the specification points are 90% and 10%.

Optical fiber system test practice (OFSTP)

Standards developed and published by the Electronic Industries Association (EIA) under the EIA/TIA-526 series of standards.

Optical fibre

Any filament or fibre, made of dielectric material, that guides light.

Optical path penalty

A link penalty to account for those effects other than attenuation.

Optical reference plane

The plane that defines the optical boundary between the plug and the receptacle.

Optical return loss (ORL)

The ratio (expressed in units of dB) of optical power incident upon a component port or an assembly to the optical power reflected by that component when that component or assembly is introduced into a link or system.

Optical rise time

The time interval required for the rising edge of an optical pulse to transition between specified percentages of the signal amplitude. For lasers the transitions are measured between the 20% and 80% points. For LED media the specification points are 10% and 90%.

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 NLVPorts 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. [X3.270199X]

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. Each bit in the reserved field is denoted by "r". NOTE Future enhancements to FC-PH may define usages for these 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.

return loss

See optical return loss.

RFI

Radio Frequency Interference.

RIIN

reflection induced intensity noise.

RIN[12]

Laser noise in dB/Hz measured relative to the average optical power with 12dB return loss.

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[11]

The ratio of the reflected signal from a port to the incident signal at the port.

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. [X3.270199X]

SCSI-2

The architecture specified by ANS X3.131-1994.

SCSI-3

The architecture specified by ANS X3.270-199X.

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. [X3.230199X]

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. [X3.270199X]

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

A 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. [X3.270199X]

Target

An SCSI device that receives SCSI commands and directs such commands to one or more logical units for execution. [X3.270199X]

Target identifier

Address of up to 64 bits by which a target is identified. [X3.270199X]

Task

An object within the logical unit representing the work associated with a command or group of linked commands. [X3.270199X]

Task attribute

The queuing specification for a task (SIMPLE, ORDERED, HEAD OF QUEUE, ACA). [X3.270199X]

Task identifier

The information uniquely identifying a task. [X3.270199X]

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. [X3.270199X]

TNC

Acronym for a threaded Neil-Councilman coaxial cable connector. Specifications for TNC style connectors are defined in MIL-C-39012 and MIL-C-23329.

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 [X3.230199X].

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

World wide name.

X_ID

Exchange_Identifier.

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