C141-C009-01EN

# MAU3036RC, MAU3073RC, MAU3147RC SERIES
# MAV2036RC, MAV2073RC SERIES

# DISK DRIVES

# SERIAL ATTACHED SCSI INTERFACE SPECIFICATIONS

FUJITSU

## FOR SAFE OPERATION

### Handling of This Manual

This manual contains important information for using this product.  Read thoroughly before using the product.  Use this product only after thoroughly reading and understanding especially the section "Important Alert Items" in this manual.  Keep this manual handy, and keep it carefully.

FUJITSU makes every effort to prevent users and bystanders from being injured or from suffering damage to their property.  Use the product according to this manual.

This product is designed and manufactured for use in standard applications such as office work, personal devices and household appliances.  This product is not intended for special uses (atomic controls, aeronautic or space systems, mass transport vehicle operating controls, medical devices for life support, or weapons firing controls) where particularly high reliability requirements exist, where the pertinent levels of safety are not guaranteed, or where a failure or operational error could threaten a life or cause a physical injury (hereafter referred to as "mission-critical" use).  Customers considering the use of these products for mission-critical applications must have safety-assurance measures in place beforehand.  Moreover, they are requested to consult our sales representative before embarking on such specialized use.

First Edition March 2005

The contents of this manual may be revised without prior notice.

# Revision History

(1/1)

| Edition | Date | Revised section (*1)<br>(Added/Deleted/Altered) | Details |
|---|---|---|---|
| 01 | 2005.02.20 | — | — |

*1 Section(s) with asterisk (*) refer to the previous edition when those were deleted.

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# Preface

This manual explains concerning the 3.5 inch hard disk drives with internal Serial Attached SCSI (SAS) controller.

The purpose of this manual is to provide the specifications and functions of SAS for use of these magnetic disk drives incorporated into user systems, and to present the information necessary for creating host system software.  This manual is written for users who have a basic knowledge of hard disk drives and their use in computer systems.

The composition of manuals related to these disk drives and the range of subjects covered in this manual are shown in “Manual Organization,” provided on a subsequent page.  Please use these other manuals along with this manual as necessary.

The organization of this manual, related reference manual and conventions for alert messages follow.

## Overview of Manual

This manual consists of the following six chapters, glossary, abbreviation, and index:

### Chapter 1  SAS Interface

This chapter describes the topology, physical and electrical requirements, interface protocol, and other operations of the interface.

### Chapter 2  Command Processing

This chapter describes the basic logical specifications related to command processing.

### Chapter 3  Data Buffer Management

This chapter describes the data buffer configuration, data transfer processing functions and cache operations.

### Chapter 4  Command Specifications

This chapter describes detailed command specifications and how to use them.

### Chapter 5 Sense Data and Error Recovery Methods

This chapter describes the configuration and contents of sense data which report to the host system when an error occurs, etc., key information necessary for error recovery, recommended procedures for error recovery to be executed through host system software and retry processing.

### Chapter 6 Disk Media Management

This chapter describes the procedure for initializing the disk media, methods of treating media defects and data recovery methods.

### Glossary

The glossary explains technical terms which are necessary to the reader's understanding when reading this manual.

### Acronyms and Abbreviations

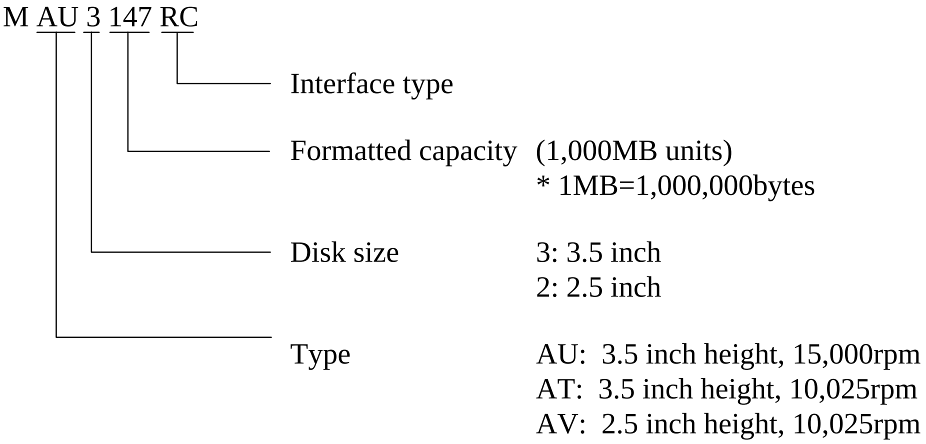
This list shows the full spelling of abbreviations used in this manual.

### Index

## CONVENTIONS USED IN THIS MANUAL

The model names of the disk drives covered by this manual differ depending on their device types and capacity (*1). In addition, these disk drives are called Intelligent Disk Drive (IDD), "drive" or "device" in this manual.

Note: Model Name



M AU 3 147 RC

Interface type

Formatted capacity (1,000MB units)
* 1MB=1,000,000bytes

Disk size 3: 3.5 inch
2: 2.5 inch

Type AU: 3.5 inch height, 15,000rpm
AT: 3.5 inch height, 10,025rpm
AV: 2.5 inch height, 10,025rpm

Decimal numbers are represented normally.

Hexadecimal numbers are represented as shown in the following examples: X’17B9’, 17B9h, 17B9$_H$, or 17B9H.

Binary number is represented as "010", 010b.

An X is used to represent mode parameters that are ignored by the MODE SELECT and MODE SELECT EXTENDED commands. An X is also used to represent mode parameters reported by the MODE SELECT and MODE SELECT EXTENDED commands and that vary depending on conditions at the time.

## Conventions for Alert Messages

This manual uses the following conventions to show the alert messages. An alert message consists of an alert signal and alert statements. The alert signal consists of an alert symbol and a signal word or just a signal word.

The following are the alert signals and their meanings:

| | |
|---|---|
| ⚠DANGER | This indicates a hazardous situation *likely* to result in *serious personal injury* if the user does not perform the procedure correctly. |
| ⚠WARNING | This indicates a hazardous situation *could* result in *serious personal injury* if the user does not perform the procedure correctly. |
| ⚠CAUTION | This indicates a hazardous situation *could* result in *minor* or *moderate personal injury* if the user does not perform the procedure correctly. This alert signal also indicates that damages to the product or other property, *may* occur if the user does not perform the product correctly. |
| **IMPORTANT** | This indicates information that could help the user use the product more efficiently. |

In the text, the alert signal is centered, followed below by the indented message. A wider line space precedes and follows the alert message to show where the alert message begins and ends. The following is an example:

(Example)

**IMPORTANT**

It is possible to use bit 7 and bit 6 of the control byte as an inherent control field in future product specifications. It is recommended that the INIT specify zero in this field.

## Attention

Please forward any comments you may have regarding this manual.

To make this manual easier for users to understand, opinions from readers are needed. Please write your opinions or requests on the Comment at the back of this manual and forward it to the address described in the sheet.

## MANUAL ORGANIZATION

| | |
|---|---|
| Product Manual | 1. Outline<br>2. Specifications<br>3. Data Format<br>4. Installation Conditions<br>5. Installation Procedure<br>6. Diagnosis and Maintenance |
| Interface Specifications<br>(This Manual) | 1. Serial Attached SCSI (SAS) Interface<br>2. Command Processing<br>3. Data Buffer Management<br>4. Command Specifications<br>5. Sense Data and Error Recovery Methods<br>6. Disk Media Management |
| Maintenance Manual | 1. Specifications and Equipment Configuration<br>2. Maintenance and Diagnosis<br>3. Troubleshooting<br>4. Removal and Replacement Procedures<br>5. Operating Theory |

# REFERENCED STANDARDS

The product specifications and functions described in this manual conform to the following standards:

| Specification (document) number | Name | Concerned organization |
|---|---|---|
| T10/1562-D<br>Revision 05 | Serial Attached SCSI (SAS) | American national Standards Institute (ANSI) |
| T10/1601-D<br>Revision 07 | Serial Attached SCSI-1.1 (SAS-1.1) | American national Standards Institute (ANSI) |
| T10/1236D<br>Revision 20 | Information technology SCSI Primary Commands-2 (SPC-2) | American national Standards Institute (ANSI) |
| T10/996D<br>Revision 8C | Information Technology SCSI-3 Block Commands (SBC) | American national Standards Institute (ANSI) |
| T10/1157D<br>Revision 24 | Information technology SCSI-3 Architecture Model (SAM-2) | American national Standards Institute (ANSI) |
| T10/1561<br>Revision 13 | Information technology SCSI-3 Architecture Model (SAM-3) | American national Standards Institute (ANSI) |

# Contents

# Illustrations

## Figures

## Tables

# CHAPTER 1 SAS Interface

This chapter describes the topology, interface protocol, and operation of the SAS interface.

## 1.1 Topologies in SAS Interface

As shown in Figure 1.1, SAS drives have two connection patterns: point-to-point connection and expander connection.

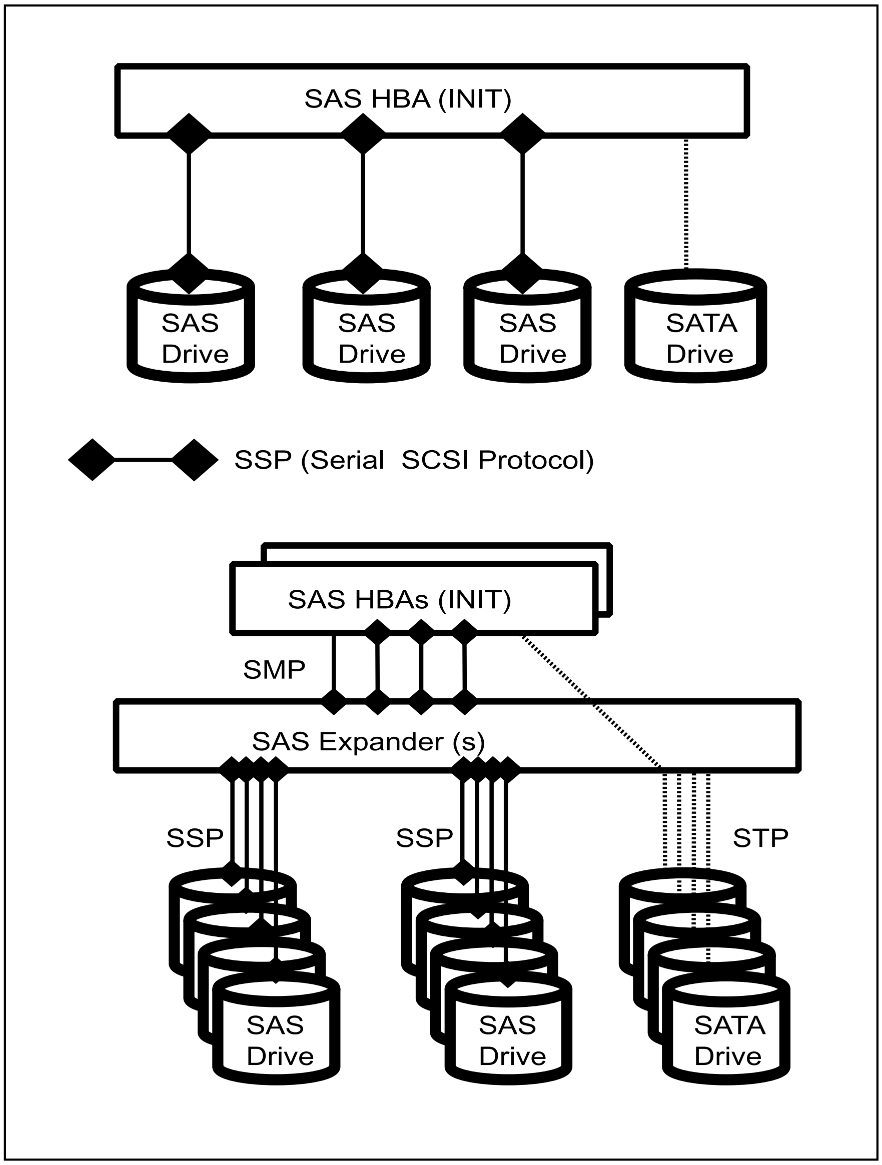


**Figure 1.1 SAS drive connection patterns**

SAS supports the three protocols listed below. Among these protocols, SAS drives support only SSP.

- Serial SCSI Protocol (SSP)
- Serial ATA Tunneling Protocol (STP)
- Serial Management Protocol (SMP)

### 1.1.1 SAS Layering

As shown in Figure 1.2, for SAS, the following six control layers are defined:

- Physical layer: Electric properties related to cables, connectors, and signals
- Phy (transceiver) layer: 8B/10B code, OOB, and speed negotiation
- Link layer: Primitives, address frames, and connection control
- Port layer: Wide port control
- Transport layer: Frame control
- Application layer: SCSI commands, mode pages, and log pages

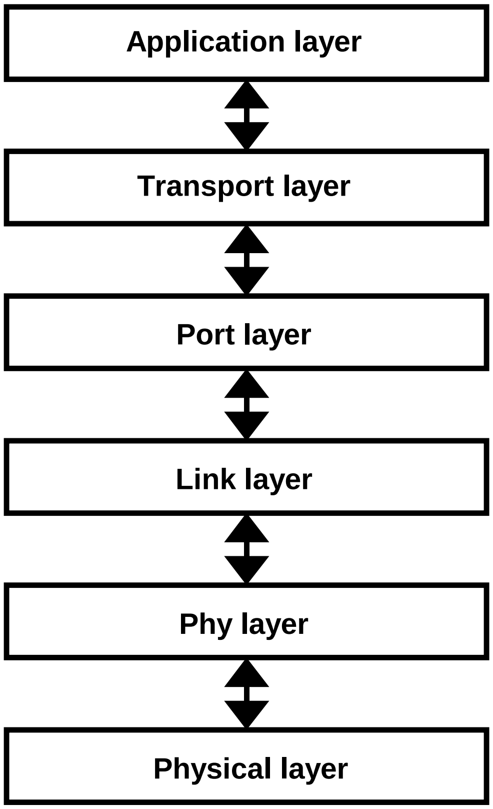


**Figure 1.2 SAS control layers**

### 1.1.2 Physical links and phys

A physical link is a set of four wires used as two differential signal pairs. One differential signal transmits in one direction while the other differential signal transmits in the opposite direction. Data may be transmitted in both directions simultaneously.

A physical phy contains a transceiver which electrically interfaces to a physical link, which attaches to another physical phy.

Phys are contained in ports. Phys interface to the service delivery subsystem. Figure 1.3 shows two phys attached with a physical link.

An attached phy is the phy to which a phy is attached over a physical link. A device may contain one or more phys. Each phy has a phy identifier which is unique within the device.

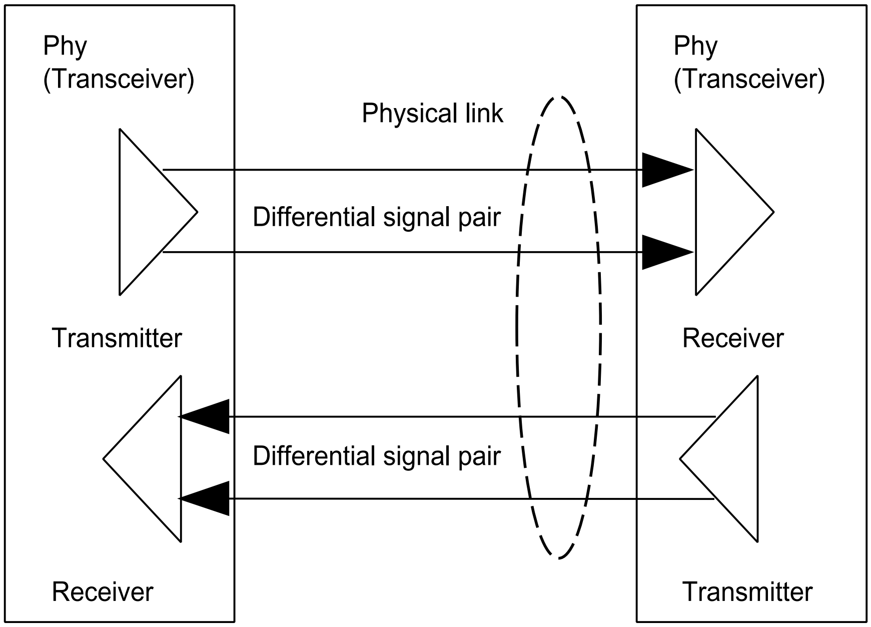


**Figure 1.3 Physical links and phys**

### 1.1.3 Ports (narrow ports and wide ports)

A port contains one or more phys. Ports in a device are associated with physical phys based on the identification sequence. A port is created from a set of physical phys if one or more physical phys contained within a device:

a) transmit the same SAS address during the identification sequence; and

b) receive the same SAS address during the identification sequence (i.e., the corresponding attached phy or phys transmit the same SAS address).

A wide port is created if there is more than one phy in the port. A narrow port is a port with only one phy.

A wide link is the set of physical links that attach a wide port to another wide port. A narrow link is the physical link that attaches a narrow port to another narrow port.

Figure 1.4 shows examples of narrow ports and wide ports, with a representation of the SAS address transmitted during the identification sequence. Although several phys on the left transmit SAS addresses of B, only phys attached to the same SAS addresses become part of the same ports. The set of phys with SAS address B attached to the set of phys with SAS address D become one port, while the set of phys with SAS address B attached to the set of phys with SAS address E become another port.

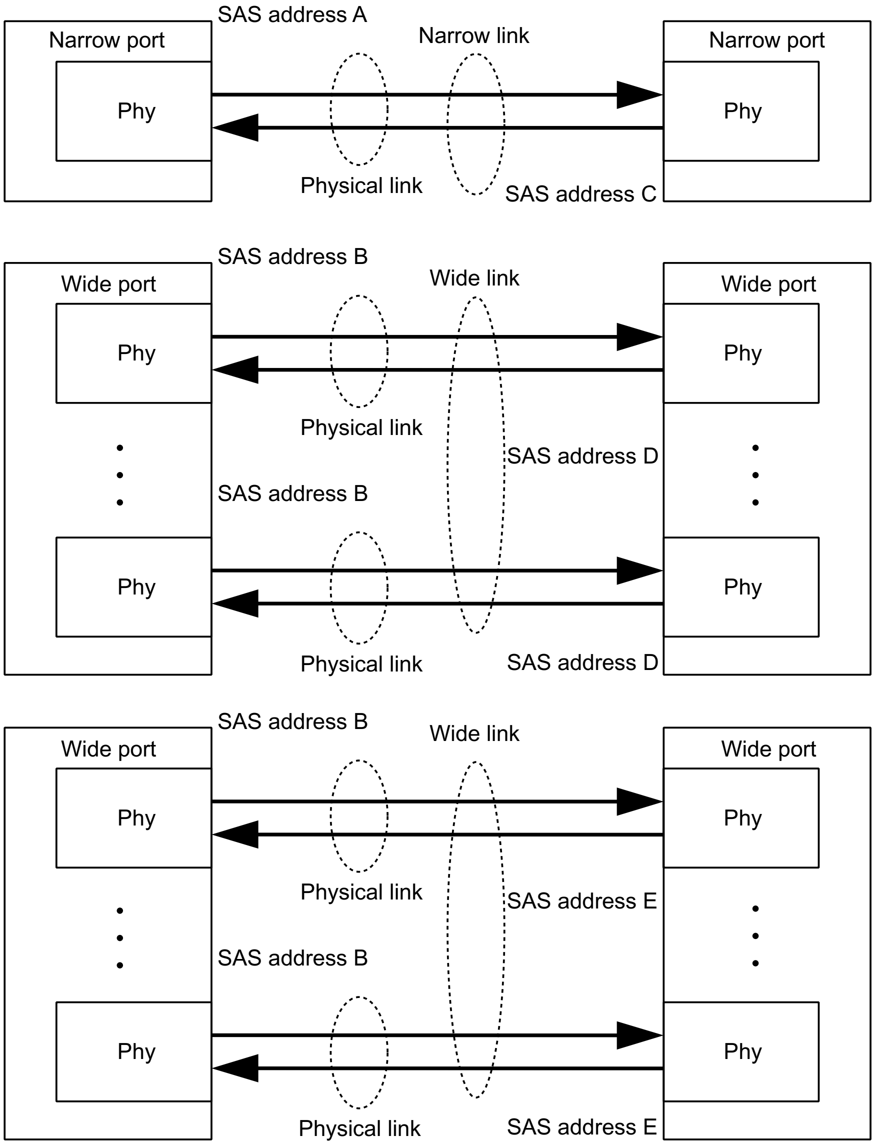


**Figure 1.4 Ports (narrow ports and wide ports)**

### 1.1.4 SAS devices

A SAS device contains one or more SAS ports, each containing one or more phys (i.e., a SAS port may be a narrow port or a wide port).

Each single HDD unit is a separate SAS device. Usually, it is a single port or dual port device, but does not use a wide port.

Figure 1.5 shows examples of SAS devices with different port and phy configurations.

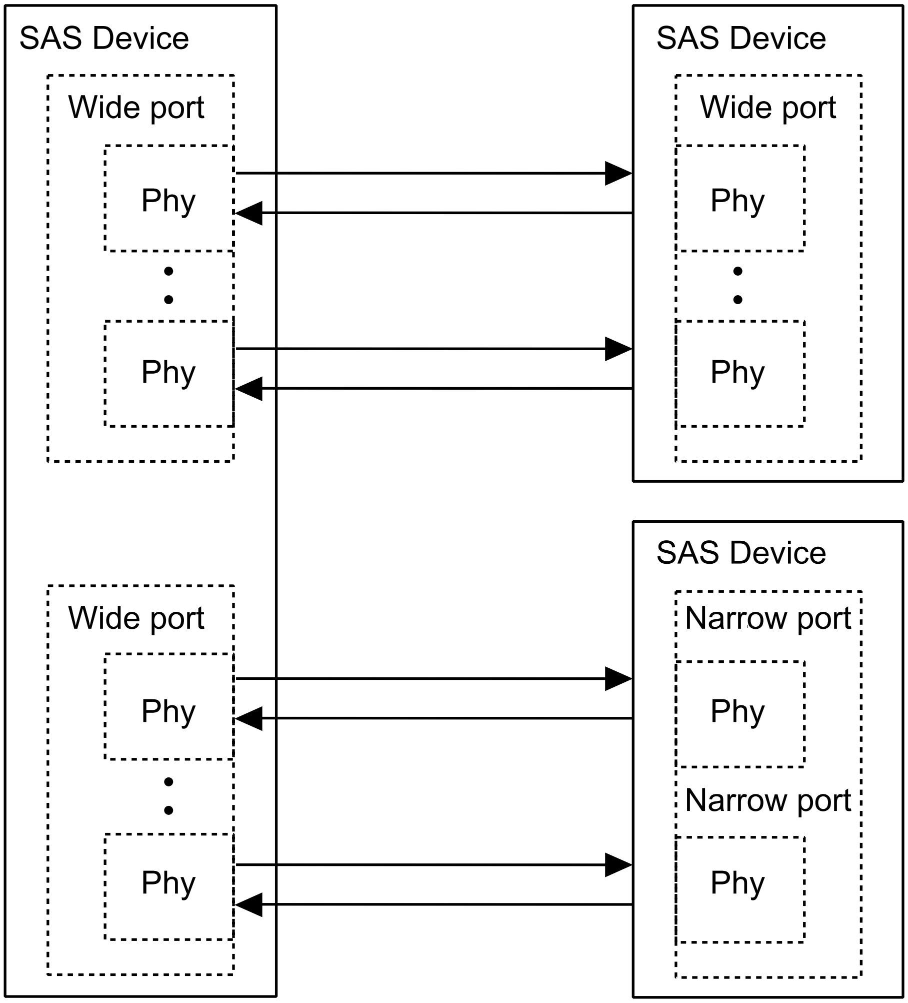


**Figure 1.5 SAS devices**

### 1.1.5 Pathways

A potential pathway is a set of physical links between a SAS INIT phy and a SAS TARG phy. When a SAS INIT phy is directly attached to a SAS TARG phy, there is one potential pathway. When there are expander devices between a SAS INIT phy and a SAS TARG phy, there are multiple potential pathways, each consisting of a set of physical links between the SAS INIT phy and the SAS TARG phy. The physical links may or may not be using the same physical link rate.

A pathway is a set of physical links between a SAS INIT phy and a SAS TARG phy being used by a connection.

Figure 1.6 shows examples of potential pathways.

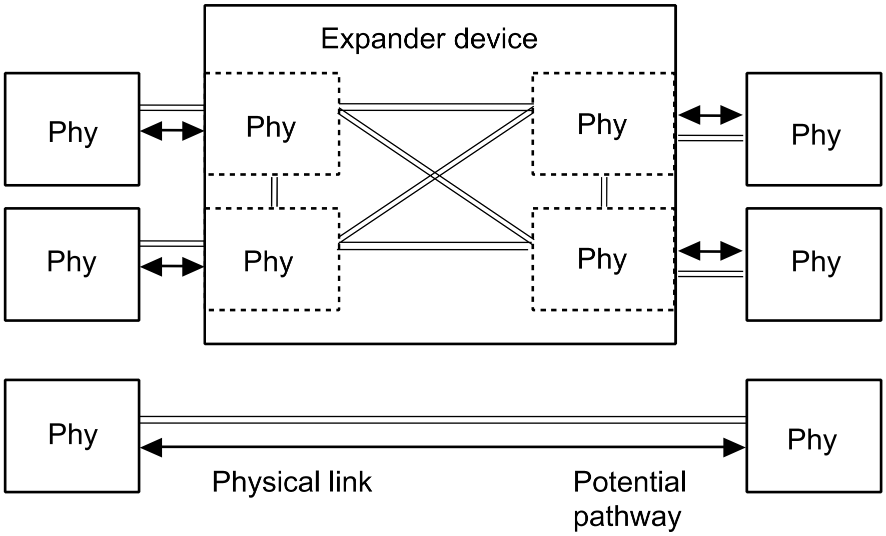


**Figure 1.6 Example of potential pathways**

A partial pathway is the set of physical links participating in a connection request that has not reached the destination phy (e.g., the OPEN address frame has been transmitted by the source phy but the OPEN address frame has not yet reached the destination phy).

A partial pathway is blocked when path resources it requires are held by another partial pathway.

### 1.1.6 Connections

A connection is a temporary association between a SAS INIT port and a SAS TARG port. During a connection all dwords from the SAS INIT port are forwarded to the SAS TARG port, and all dwords from the SAS TARG port are forwarded to the SAS INIT port.

A connection is pending when an OPEN address frame has been delivered along a completed pathway to the destination phy but the destination phy has not yet responded to the connection request. A connection is established when an OPEN_ACCEPT is returned to the source phy.

A connection enables communication for one protocol: SSP, STP, or SMP. For SSP and STP, connections may be opened and closed multiple times during the processing of a command.

The connection rate is the effective rate of dwords through the pathway between a SAS INIT phy and a SAS TARG phy, established through the connection request. Every phy shall support a 1,5 Gbps connection rate regardless of its physical link rate.

One connection may be active on a physical link at a time. If the connection is an SSP or SMP connection and there are no dwords to transmit associated with that connection, idle dwords are transmitted.

The number of connections established by a SAS port shall not exceed the number of SAS phys within the SAS port (i.e., only one connection per SAS phy is allowed). There shall be a separate connection on each physical link.

If multiple potential pathways exist between the SAS INIT port(s) and the SAS TARG port(s), multiple connections may be established by a SAS port between the following:

a) one SAS INIT port to multiple SAS TARG ports;

b) one SAS TARG port to multiple SAS INIT ports; or

c) one SAS INIT port to one SAS TARG port.

Once a connection is established, the pathway used for that connection shall not be changed (i.e., all the physical links that make up the pathway remain dedicated to the connection until it is closed).

## 1.2 Names and identifiers

Device names are worldwide unique names for devices within a transport protocol. Port names are worldwide unique names for ports within a transport protocol. Port identifiers are the values by which ports are identified within a domain, and are used as SAS addresses. Phy identifiers are unique within a device.

### 1.2.1 SAS addresses

Table 1.1 defines the SAS address format. SAS addresses shall be compatible with the NAA (Name Address Authority) IEEE Registered format identification descriptor defined in SPC-3. The SAS address shall be worldwide unique. A SAS address of 00000000_00000000h indicates an invalid SAS address.

**Table 1.1 SAS address format**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | (MSB) | | | |
| 1 | IEEE COMPANY ID | | | | | | | |
| 2 | | | | | | | | |
| 3 | (LSB) | | | | (MSB) | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | (LSB) | | | | | | | |

SAS addresses represent any of three types of WWNs: a device SAS address representing a device address, a port SAS address representing Port-A, or a port SAS address representing Port-B.

The INQUIRY (page 83 command reports the device SAS address, while the mode parameter (page 19) and log parameter (page 18) report port SAS addresses.

– device SAS address: 5CCC CCCX XXXX XXX yy00
– port SAS address (Port-A): 5CCC CCCX XXXX XXX yy10
– port SAS address (Port-B): 5CCC CCCX XXXX XXX yy11

C = 4 bits: Company ID
X = 4 bits: Serial number for WWN
y = 1 bit: Reserved

### 1.2.2 Hashed SAS address

SSP frames include a hashed version of the SAS address to provide an additional level of verification of proper frame routing.

The code used for the hashing algorithm is a cyclic binary Bose, Chaudhuri, and Hocquenghem (BCH) (63, 39, 9) codes. Table 1.2 lists the parameters for the code.

**Table 1.2 Hashed SAS address code parameter**

| Parameter | Value |
|---|---|
| Number of bits per codeword | 63 |
| Number of data bits | 39 |
| Number of redundant bits | 24 |
| Minimum distance of the code | 9 |

The generator polynomial for this code is:

$$G(x) = (x^{6} + x + 1)(x^{6} + x^{4} + x^{2} + x + 1)(x^{6} + x^{5} + x^{2} + x + 1)(x^{6} + x^{3} + 1)$$

After multiplication of the factors, the generator polynomial is:

$$G(x) = x^{24} + x^{23} + x^{22} + x^{20} + x^{19} + x^{17} + x^{16} + x^{13} + x^{10} + x^{9} + x^{8} + x^{6} + x^{5} + x^{4} + x^{2} + x + 1$$

# 1.3 Phy layer

In the phy layer, 8b10b coding and the link reset sequence are defined.

## 1.3.1 8b10b coding

All information transferred in SAS is encoded into 10-bit characters using 8b10b encoding. Information includes data bytes representing data in a frame and control characters used for frame delimiters.

Ten-bit characters are transferred in units of dwords, where a dword contains four ten-bit characters.

A primitive is a dword that consists of a control character at the beginning and the other three data characters.

In the SAS specifications, a primitive that starts with the K28.5 control character and another one that starts with the K28.6 control character are defined. Table 1.3 shows the usage of special characters.

**Table 1.3 Usage of special characters**

| Beginning character | Usage in SAS | Usage in SATA |
|---|---|---|
| K28.3 | Primitive to be used only within STP connection | All the primitives except ALIGN |
| K28.5 | ALIGN and most primitives that are defined in SAS | ALIGN |
| K28.6 | SATA_ERROR<br>(used on the physical link layer of SATA) | Not used. |
| Dxx.y | Data | Data |

A single data dword is a dword that starts with a data character.

Running disparity shall be maintained separately on each physical link. During a connection, expander devices shall convert incoming 10-bit characters to 8-bit bytes and generate the 10-bit character with correct disparity for the output physical link. Phys within a device may or may not begin operation with the same disparity after the reset sequence.

Information to be transmitted across a physical link shall be encoded eight bits at a time into a 10-bit character and then transmitted serially bit-by-bit across the physical link. Information received over the physical link shall be collected ten bits at a time, and those characters that are used for data, called data characters, shall be decoded into the correct 8-bit data bytes. The 10-bit characters support all 256 8-bit combinations. 8b10b coding ensures that sufficient transitions are present in the serial bit stream to make clock recovery possible at the receiver.

Such encoding also greatly increases the likelihood of detecting any single or multiple bit errors that may occur during transmission and reception of information. In addition, some of the control characters of the transmission code contain a distinct and easily recognizable bit pattern called a comma pattern which assists a receiver in achieving character and dword alignment on the incoming bit stream.

## 1.3.2 Link reset sequence

The link reset sequence consists of the phy reset sequence and the identification sequence. The phy reset sequence consists of the out of band (OOB) sequence and speed negotiation sequence. The hard reset sequence is performed only when the HARD_RESET primitive is detected after the completion of the speed negotiation. The HARD_RESET primitive detected at any time later than the identification sequence is invalid. The hard reset sequence corresponds to the reset condition of pSCSI.

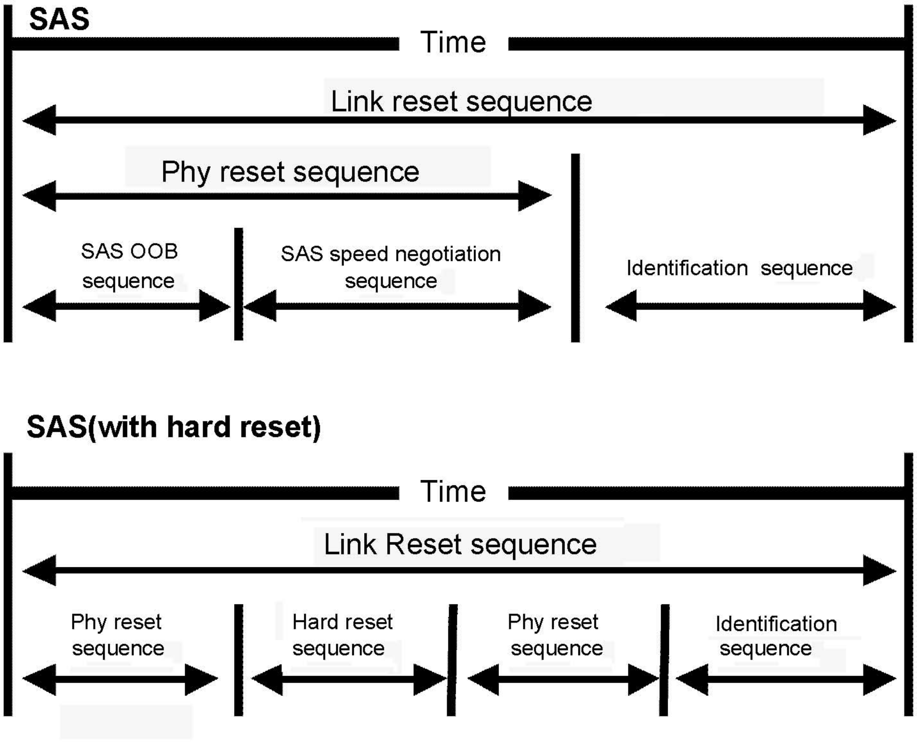


**Figure 1.7 Reset-related terminology**

### 1.3.3 Start conditions of the link reset sequence

Drives start the link reset sequence when they detect any of the following conditions:

- The power is turned on.
- A loss of signal is detected (OOB from the INIT).
- A loss of sync is detected.
- A HARD_RESET primitive is received during the link reset sequence.
- A hot-plug timeout (500 ms) is detected during the link reset sequence.
- The IDENTIFY address frame could not be received.
- A BREAK timeout is detected.

### 1.3.4 Out of band (OOB) signals

Out of band (OOB) signals are low-speed signal patterns detected by the phy that do not appear in normal data streams. They consist of defined amounts of idle time followed by defined amounts of burst time. During the idle time, D.C. idle is transmitted. During the burst time, ALIGN (0) primitives are transmitted repeatedly. The signals are differentiated by the length of idle time between the burst times.

**Table 1.4 OOB signal timing specifications**

| Parameter | Minimum | Nominal | Maximum | Comments |
|---|---|---|---|---|
| OOB interval (OOBI) *1 | 666,600 ps | 666,666 ps | 666,733 ps | The time basis for burst times and idle times used to create OOB signals. Based on 1,5 Gbps clock tolerance. |
| COMSAS detect timeout | 13,65 μs | – | – | The minimum time a receiver shall allow to detect COMSAS after transmitting COMSAS.<br>Derived from: OOBI × 512 × 40 |

*1 The OOBI is different from the UI (OOB) defined in SATA (for example, stricter clock tolerance applies to SAS). This is because the OOBI is a fixed value that is equal to the UI value of G1, and that does not depend on actual transfer speed used to set up the burst time.

Table 1.5 describes the OOB signal transmitter requirements for the burst time, idle time, and negation times that comprise each OOB signal.

**Table 1.5 OOB signal transmitter requirements**

| Signal | Burst time | Idle time | Negation time |
|---|---|---|---|
| COMINIT/RESET | 160 OOBI | 480 OOBI | 800 OOBI |
| COMSAS | 160 OOBI | 1440 OOBI | 2400 OOBI |

To transmit an OOB signal, a transmitter shall repeat these steps six times:

1) transmit D.C. idle for an idle time; and

2) transmit an ALIGN burst for a burst time.

It shall then transmit D.C. idle for an OOB signal negation time.

The ALIGNs used in OOB signals should be at generation 1 (G1) physical link rates (i.e., 1,5 Gbps). The ALIGNs are only required to generate an envelope for the detection circuitry, as required for any signaling that may be A.C. coupled. If G2 ALIGNs are used, the number of ALIGNs doubles compared with G1 ALIGNs.

A SAS transmitter should transmit ALIGNs at the G1 physical link rate to create the burst portion of the OOB signal, but may transmit ALIGNs at its lowest supported physical link rate if it is not able to transmit at the G1 physical link rate and shall not transmit them at a physical link rate faster than its lowest supported physical link rate.

Figure 1.8 describes OOB signal transmission by the SP transmitter.

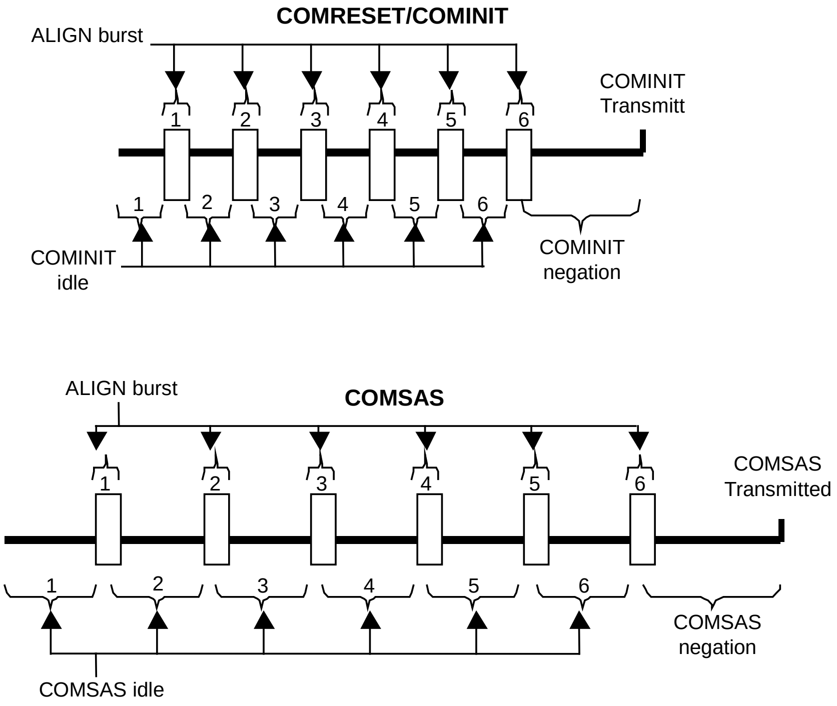


**Figure 1.8 OOB signal transmission**

Table 1.6 describes the OOB signal receiver requirements for detecting burst times, assuming Tburst is the length of the detected burst time. The burst time is not used to distinguish between signals.

**Table 1.6 OOB signal receiver burst time detection requirements**

| Signal | Detection requirements | |
|---|---|---|
| | may detect | shall detect |
| COMINIT/COMRESET | Tburst ≤ 100 ns | Tburst > 100 ns |
| COMSAS | Tburst ≤ 100 ns | Tburst > 100 ns |

Table 1.7 describes the OOB signal receiver requirements for detecting idle times, assuming Tidle is the length of the detected idle time.

**Table 1.7 OOB signal receiver idle time detection requirements**

| Signal | Detection requirements | |
|---|---|---|
| | may detect | shall detect |
| COMINIT/COMRESET | 175 ns ≤ Tidle < 525 ns | 304 ns ≤ Tidle < 336 ns |
| COMSAS | 525 ns ≤ Tidle < 1575 ns | 911,7 ns ≤ Tidle < 1008 ns |

Table 1.8 describes the OOB signal receiver requirements for detecting negation times, assuming Tidle is the length of the detected idle time.

**Table 1.8 OOB signal receiver negation time detection requirements**

| Signal | Detection requirements |
|---|---|
| COMINIT/COMRESET | Tidle > 525 ns |
| COMSAS | Tidle > 1575 ns |

A receiver shall detect an OOB signal after receiving four consecutive idle time/burst time pairs. It is not an error to receive more than four idle time/burst time pairs. A receiver shall not detect the same OOB signal again until it has detected the corresponding negation time (i.e., a COMINIT negation time for a COMINIT) or has detected a different OOB signal.

A SAS receiver shall detect OOB signals comprised of ALIGNs transmitted at any rate up to its highest supported physical link rate. This includes physical link rates below its lowest supported physical link rate (e.g., a SAS receiver supporting only 3,0 Gbps detects 1,5 Gbps based ALIGNs, providing interoperability with a SAS transmitter supporting both 1,5 Gbps and 3,0 Gbps).

Figure 1.9 describes SAS OOB signal detection by the SP receiver.

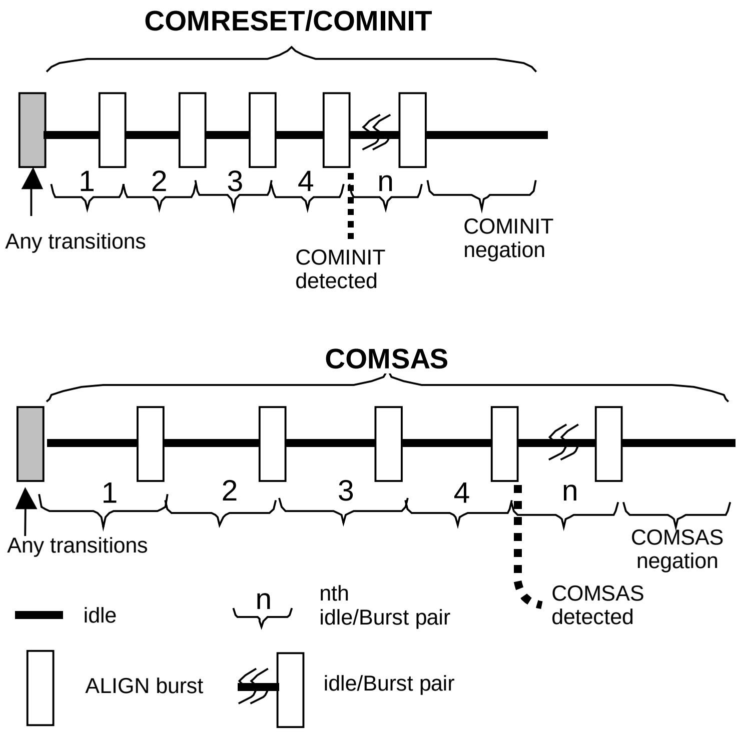


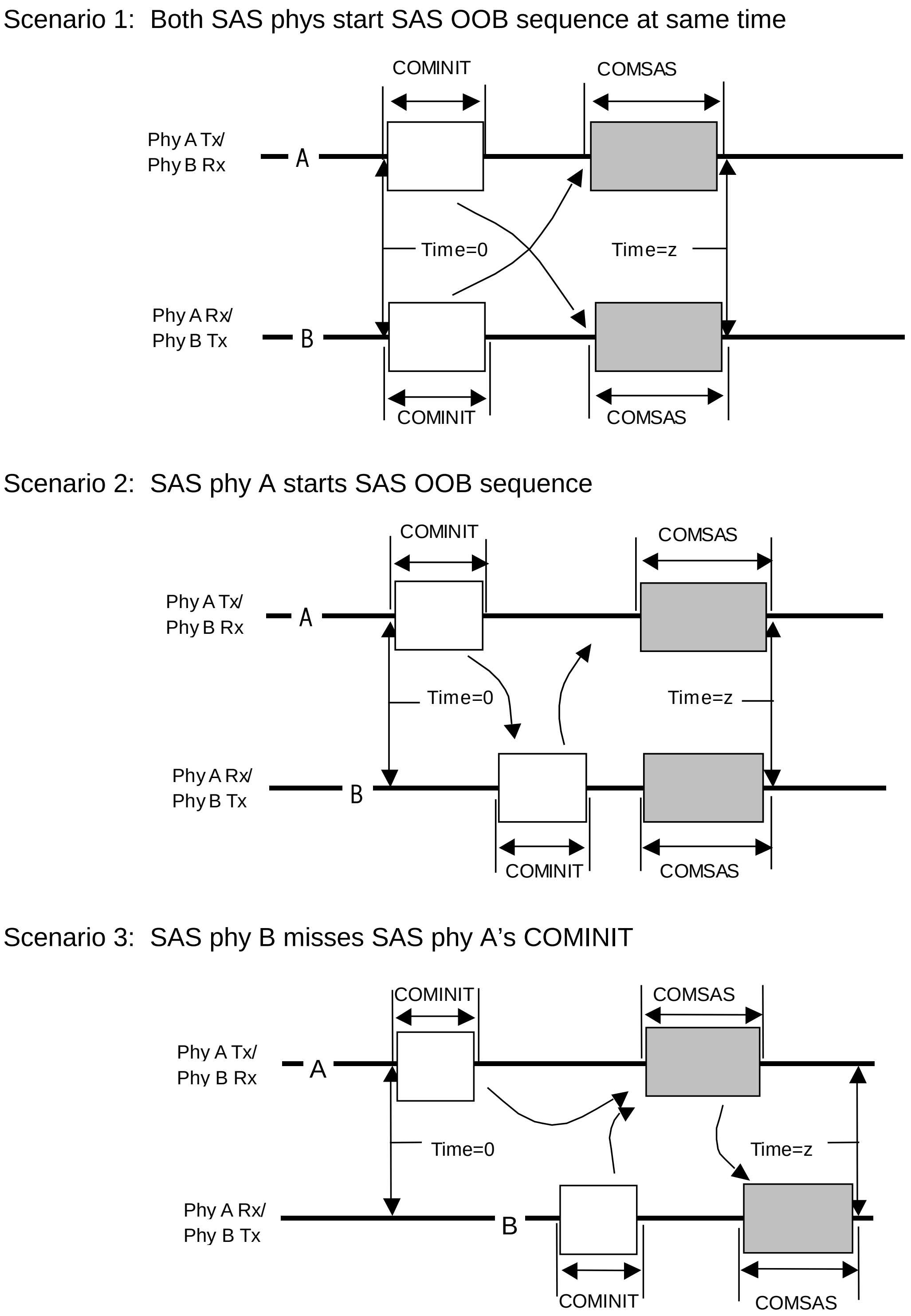
**Figure 1.9 OOB signal detection**

### 1.3.5 SAS OOB sequency

During the OOB sequence, the INIT and the drive first send the COMINIT signal to each other, then the COMSAS signal. When they both have received the COMSAS signal from each other, the OOB sequence is recognized as having been performed successfully. Depending on the power-on timing, reception of the COMINIT signal from the other side may not be detected. In such a case, however, the OOB sequence is recognized as having been performed successfully if the COMINIT and COMSAS signals have been sent by the time the COMSAS signal from the other side is received.

When the OOB sequence is successful, the SAS speed negotiation sequence starts.

Figure 1.10 shows several different SAS OOB sequences between phy A and phy B, with phy A starting the SAS OOB sequence at the same time as phy B, before phy B, and before phy B powers on.


Scenario 1: Both SAS phys start SAS OOB sequence at same time

Scenario 2: SAS phy A starts SAS OOB sequence

Scenario 3: SAS phy B misses SAS phy A's COMINIT

A: SAS phy A power on
B: SAS phy B power on
Time 0 : SAS phy reset sequence begins
Time z: SAS speed negotiation sequence begins

**Figure 1.10 SAS to SAS OOB sequence**

### 1.3.5.1 Exception handling in the OOB sequence

- When the COMINIT signal cannot be detected

  When a drive sends the COMINIT signal but the COMINIT signal from the other side cannot be detected, the drive waits for the reception of the COMINIT signal from the INIT or expander until the hot-plug timeout time (500 ms) elapses. If the hot-plug timeout time elapses before the COMINIT signal from the other side has been received, the drive sends the COMINIT signal again to start a new link reset sequence. If the drive receives the COMSAS signal while waiting for the COMINIT signal, it sends the COMSAS signal and takes the OOB sequence as having been performed successfully in spite of the fact that it has not received the COMINIT signal.

- When the COMSAS signal cannot be detected

  When a drive sends the COMSAS signal but the COMSAS signal from the other side cannot be detected, the drive waits for the reception of the COMSAS signal from the INIT or expander until the hot-plug timeout time (500 ms) elapses. If the hot-plug timeout time elapses before the COMSAS signal from the other side has been received, the drive sends the COMSAS signal again to start a new link reset sequence.

## 1.3.6 SAS speed negotiation sequence

The SAS speed negotiation sequence is a peer-to-peer negotiation technique that does not assume initiator and target (i.e., host and device) roles. The sequence consists of a set of speed negotiation windows for each physical link rate, starting with 1,5 Gbps, then 3,0 Gbps, then the next rate. The length of the speed negotiation sequence is determined by the number of physical link rates supported by the phys.

Figure 1.11 defines the speed negotiation window, including:

a) speed negotiation window time;

b) rate change delay time (RCDT);

c) speed negotiation transmit time (SNTT); and

d) speed negotiation lock time (SNLT).

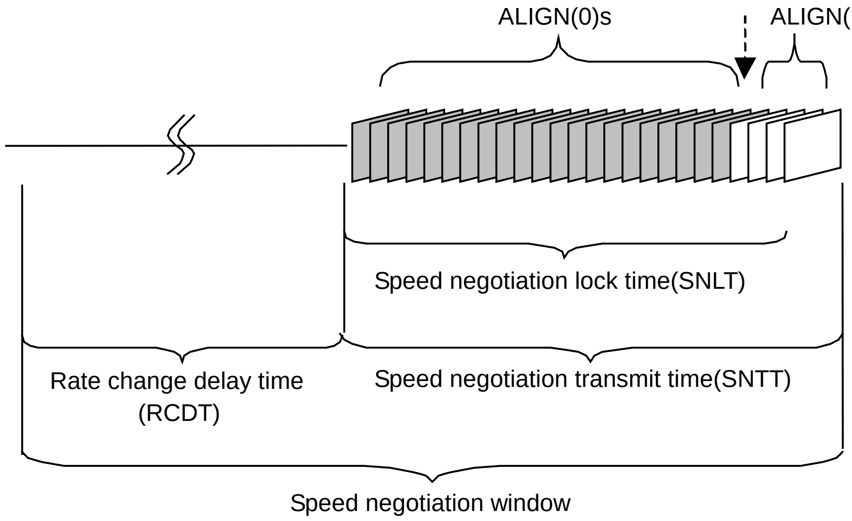

ALIGN(0)s
ALIGN(1)s
Speed negotiation lock time(SNLT)
Rate change delay time
(RCDT)
Speed negotiation transmit time(SNTT)
Speed negotiation window

**Figure 1.11 SAS speed negotiation window**

Table 1.9 defines the timing specifications for the SAS speed negotiation sequence.

**Table 1.9 SAS speed negotiation sequence timing specifications**

| Parameter | Time | Comments |
|---|---|---|
| Rate change delay time (RCDT) | 750 000 OOBI | The time the transmitter shall transmit D.C. idle between rates during speed negotiation. |
| Speed negotiation transmit time (SNTT) | 163 840 OOBI | The time during which ALIGN(0) or ALIGN(1) is transmitted at each physical link rate during the speed negotiation sequence. Derived from: OOBI x 4096 x 40. |
| Speed negotiation lock time (SNLT) | 153 600 OOBI | The maximum time during the speed negotiation window for a transmitter to reply with ALIGN(1). Derived from:<br>OOBI x 3840 x 40 |
| Speed negotiation window time | 913 840 OOBI | The duration of a speed negotiation window. Derived from: RCDT + SNTT. |

The speed negotiation sequence shall consist of the following transmission sequence:

1) a transmission of D.C. idle for an RCDT; and

2) if the phy supports the physical link rate, a transmission of ALIGNs at that physical link rate for the remainder of the entire speed negotiation window. If the phy does not support the physical link rate, transmission of D.C. idle for the remainder of the entire speed negotiation window.

If the phy supports the physical link rate, it shall attempt to synchronize on an incoming series of dwords at that rate for the SNLT. The received dwords may be ALIGN (0) or ALIGN (1) primitives. If the phy achieves dword synchronization within the SNLT, it shall change from transmitting ALIGN (0) primitives to transmitting ALIGN (1) primitives for the remainder of the SNTT (i.e., the remainder of the speed negotiation window). If the phy does not achieve dword synchronization within the SNLT, it shall continue transmitting ALIGN (0)s for the remainder of the SNTT (i.e., the remainder of the speed negotiation window).

At the end of the SNTT, if a phy is both transmitting and receiving ALIGN (1) primitives, it shall consider that physical link rate valid. The phy shall then proceed to the next speed negotiation window. A phy shall participate in all speed negotiation windows:

a) up to its highest supported physical link rate plus one; or

b) until it runs a speed negotiation window that does not detect a valid physical link rate after having detected a valid physical link rate in a previous speed negotiation window.

If the phy has detected a valid physical link rate in the previous speed negotiation window, it shall enter the final speed negotiation window using the highest previously successful link rate.

Figure 1.12 shows speed negotiation between a phy A that supports G1 through G3 link rates and a phy B that only supports the G2 link rate. Both phys run:

1) the G1 speed negotiation window, supported by phy A but not by phy B;

2) the G2 speed negotiation window, supported by both phys; and

3) the G3 speed negotiation window, supported by phy A but not by phy B.

Both phys then select G2 for the final speed negotiation window to establish the negotiated physical link rate.

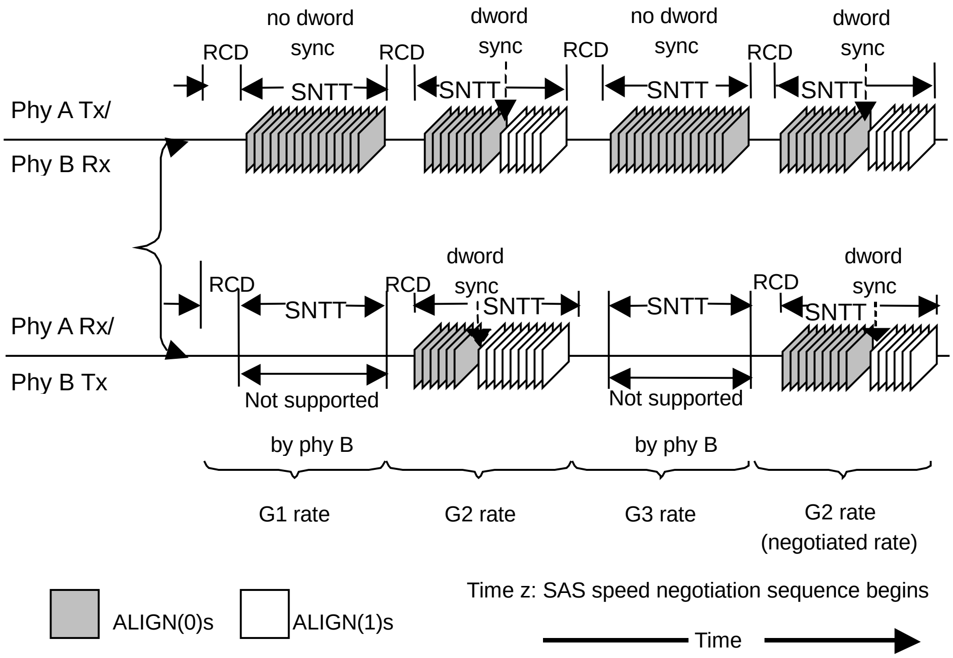


**Figure 1.12 SAS speed negotiation sequence (Example 1)**

If the phy does not obtain dword synchronization during the final speed negotiation window, the SAS speed negotiation sequence fails.

Figure 1.13 shows the same speed negotiation sequence as in Figure 1.12 when phy B does not obtain dword synchronization during the final speed negotiation window. If this occurs, the handshake is not complete and the OOB sequence shall be retried starting with COMINIT, forcing the phy to retry the whole reset sequence.

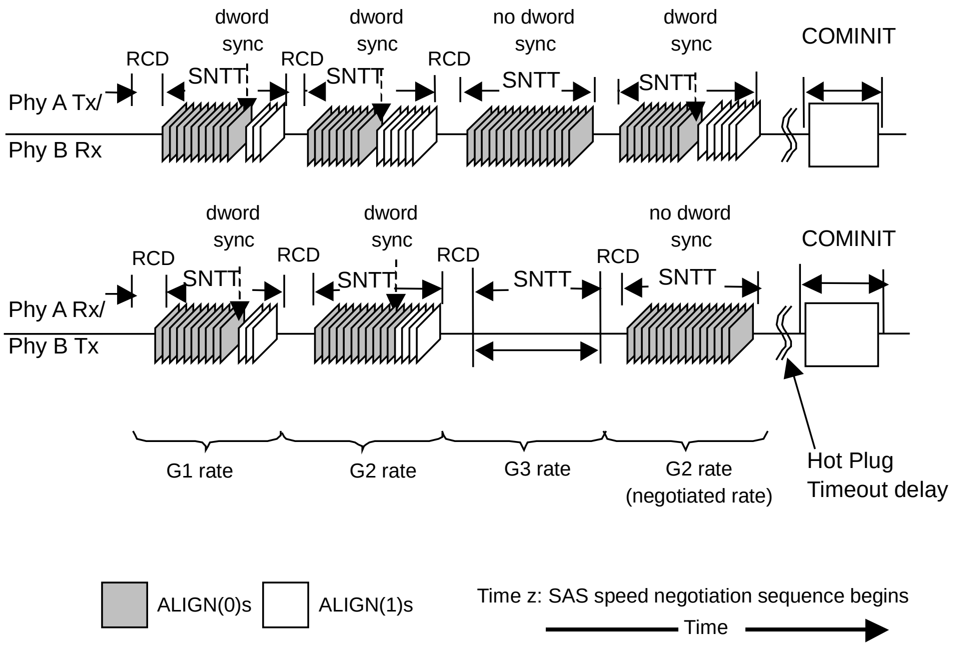
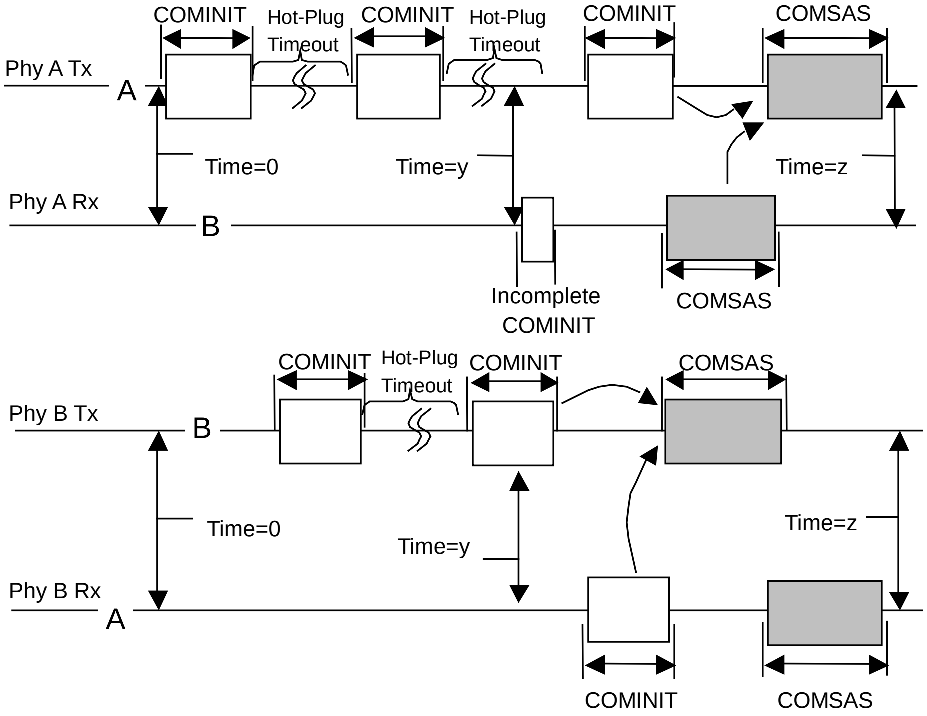


**Figure 1.13 SAS speed negotiation sequence (Example 2)**

### 1.3.6.1 Phy reset sequence after devices are attached

Since SAS signal cable connector does not include power lines, it is not possible to detect the physical insertion of the signal cable connector onto a plug. Non-cabled environments may similarly not have a way to detect physical insertion of a device. As a result, every time a phy reset sequence is originated:

Figure 1.14 shows how two phys complete the phy reset sequence if the phys are not attached at power on. In this example, phy A and phy B are attached some time before phy B's second hot-plug timeout occurs. Phy B's OOB detection circuitry detects a COMINIT after the attachment, and therefore phy B transmits COMSAS, since it has both transmitted and received a COMINIT. Upon receiving COMSAS, phy A transmits its own COMSAS. The SAS speed negotiation sequence follows.



| | |
|---|---|
| A: | SAS phy A power on |
| B: | SAS phy B power on |
| Time y : | SAS phy A attached to SAS phy B |
| Time z: | SAS phy A and SAS phy B start the SAS speed negotiation sequence |

**Figure 1.14 Phy reset sequence (Example)**

#### 1.3.6.2 When the speed negotiation sequence is successful

When the speed negotiation sequence is successful, the identification sequence (sending and receiving the IDENTIFY frame) is performed subsequently. However, the INIT may have started the hard reset sequence at the time when the drive starts the identification sequence. In this case, the drive will start the link reset sequence, because it receives the HARD_RESET.

#### 1.3.6.3 Exception handling in the speed negotiation sequence

- When synchronization cannot be established at the G1 or G2 rate
- When synchronization cannot be established at the last negotiated rate

In both of the cases referred to above, the speed negotiation sequence is considered to have failed. The drive waits for the reception of the COMINIT signal from the INIT or expander until the hot-plug timeout time (500 ms) elapses. When the hot-plug timeout time elapses before the signal has been received from the other side, the drive sends the COMINIT signal again to start a new link reset sequence. At the same time, the value in the PHY RESET PROBLEM field of the Protocol-Specific log page (page 18) is incremented when synchronization cannot be established at the last negotiated rate.

### 1.3.7 Phy layer dword synchronization (DWS)

The dword synchronization monitoring performed by the drive after the completion of the speed negotiation sequence has the following characteristics:

1) In the idle state (the state where random data is being sent and/or received without the transfer of frames or primitives), invalid dwords received are ignored.

2) The DWS reset timeout timer (1 ms) is not supported.

3) When four invalid dwords are detected in a frame (address frame or SSP frame), the dword synchronization is considered to have been lost. At this time, the drive starts the link reset sequence without monitoring whether any valid primitive is received (and without trying to establish re-synchronization).

# 1.4 Link layer

The link layer defines primitives, address frames, and connections.

## 1.4.1 Primitives

Table 1.10 defines the primitives not specific to the type of connection.

**Table 1.10 Primitives not specific to type of connection (1/2)**

| Primitive | USE (*4) | From | | | To | | | Sequence | SAS 1.1 rev7 supported prim | FJ supported prim |
|---|---|---|---|---|---|---|---|---|---|---|
| | | I | E | T | I | E | T | Type | | |
| AIP (NORMAL) | NoConn | - | E | - | I | E | T | single | supported | supported |
| AIP (RESERVED 0) | NoConn | - | - | - | I | E | T | single | ↑ | Supported (*1) |
| AIP (RESERVED 1) | NoConn | - | - | - | I | E | T | single | ↑ | Supported (*1) |
| AIP (RESERVED 2) | NoConn | - | - | - | I | E | T | single | ↑ | Supported (*1) |
| AIP (WAITING ON CONNECTION) | NoConn | - | E | - | I | E | T | single | supported | supported |
| AIP (WAITING ON DEVICE) | NoConn | - | E | - | I | E | T | single | supported | supported |
| AIP (WAITING ON PARTIAL) | NoConn | - | E | - | I | E | T | single | supported | supported |
| AIP (RESERVED WAITING ON PARTIAL) | NoConn | - | - | - | I | E | T | single | ↑ | Supported (*1) |
| ALIGN (0) | ALL | I | E | T | I | E | T | single | supported | supported |
| ALIGN (1) | ALL | I | E | T | I | E | T | single | supported | supported |
| ALIGN (2) | ALL | I | E | T | I | E | T | single | supported | supported |
| ALIGN (3) | ALL | I | E | T | I | E | T | single | supported | supported |
| BREAK | ALL | I | E | T | I | E | T | redundant | supported | supported |
| BROADCAST (CHANGE) | NoConn | I | E | - | I | E | T | redundant | supported | ignored |
| BROADCAST (RESERVED CHANGE 0) | NoConn | - | - | - | I | E | T | redundant | ↑ | ignored |
| BROADCAST (RESERVED CHANGE 1) | NoConn | - | - | - | I | E | T | redundant | ↑ | ignored |
| BROADCAST (SES) | NoConn | - | - | T | I | E | T | redundant | supported | ignored |
| BROADCAST (RESERVED 1) | NoConn | - | - | - | I | E | T | redundant | reserved | ignored |
| BROADCAST (RESERVED 2) | NoConn | - | - | - | I | E | T | redundant | reserved | ignored |
| BROADCAST (RESERVED 3) | NoConn | - | - | - | I | E | T | redundant | reserved | ignored |
| BROADCAST (RESERVED 4) | NoConn | - | - | - | I | E | T | redundant | reserved | ignored |
| CLOSE (NORMAL) | Conn | I | - | T | I | - | T | triple | supported | supported |
| CLOSE (RESERVED 0) | Conn | - | - | - | I | - | T | triple | ↑ | ignored |
| CLOSE (RESERVED 1) | Conn | - | - | - | I | - | T | triple | ↑ | ignored |
| CLOSE (CLEAR AFFILIATION) | STP | I | - | - | - | - | T | triple | ↑(Not STP) | ignored |

### Table 1.10 Primitives not specific to type of connection (2/2)

| Primitive | USE (*4) | From | | | To | | | Sequence | SAS 1.1 rev7 supported prim | FJ supported prim |
|---|---|---|---|---|---|---|---|---|---|---|
| | | I | E | T | I | E | T | Type | | |
| EOAF | NoConn | I | E | T | I | E | T | single | supported | supported |
| ERROR | ALL | - | E | - | I | E | T | single | supported | supported |
| HARD RESET | NoConn | I | E | - | I | E | T | redundant | supported | supported |
| NOTIFY (ENABLE SPINUP) | ALL | I | E | - | I | E | T | single | supported | supported |
| NOTIFY (RESERVED 0) | ALL | - | - | - | I | E | T | single | reserved | ignored |
| NOTIFY (RESERVED 1) | ALL | - | - | - | I | E | T | single | reserved | ignored |
| NOTIFY (RESERVED 2) | ALL | - | - | - | I | E | T | single | reserved | ignored |
| OPEN_ACCEPT | NoConn | I | - | T | I | - | T | single | supported | supported |
| OPEN_REJECT (RETRY) | NoConn | I | - | T | I | - | T | single | supported | supported |
| OPEN_REJECT (RESERVED CONTINUE 0) | NoConn | - | - | - | I | - | T | single | ↑ | ↑ |
| OPEN_REJECT (RESERVED CONTINUE 1) | NoConn | - | - | - | I | - | T | single | ↑ | ↑ |
| OPEN_REJECT (BAD DESTINATION) | NoConn | - | E | - | I | - | T | single | supported | supported |
| OPEN_REJECT (CONNECTION RATE NOT SUPPORTED) | NoConn | I | E | T | I | - | T | single | supported | supported |
| OPEN_REJECT (NO DESTINATION) | NoConn | - | E | - | I | - | T | single | supported | supported |
| OPEN_REJECT (RESERVED INITIALIZE 0) | NoConn | - | - | - | I | - | T | single | ↑ | ↑ |
| OPEN_REJECT (RESERVED INITIALIZE 1) | NoConn | - | - | - | I | - | T | single | ↑ | ↑ |
| OPEN_REJECT (PATHWAY BLOCKED) | NoConn | - | E | - | I | - | T | single | supported | supported |
| OPEN_REJECT (RESERVED STOP 0) | NoConn | - | - | - | I | - | T | single | ↑ | ↑ |
| OPEN_REJECT (RESERVED STOP 1) | NoConn | - | - | - | I | - | T | single | ↑ | ↑ |
| OPEN_REJECT (PROTOCOL NOT SUPPORTED) | NoConn | I | - | T | I | - | T | single | supported | supported |
| OPEN_REJECT (STP RESOURCES BUSY) | NoConn | - | E | T | I | - | - | single | supported | supported (*2) |
| OPEN_REJECT (WRONG DESTINATON) | NoConn | I | - | T | I | - | T | single | supported | supported |
| OPNE_REJECT (RESERVED ABANDON 0) | NoConn | - | - | - | I | - | T | single | ↑ | ↑ |
| OPNE_REJECT (RESERVED ABANDON 1) | NoConn | - | - | - | I | - | T | single | ↑ | ↑ |
| OPNE_REJECT (RESERVED ABANDON 2) | NoConn | - | - | - | I | - | T | single | ↑ | ↑ |
| OPNE_REJECT (RESERVED ABANDON 3) | NoConn | - | - | - | I | - | T | single | ↑ | ↑ |
| SOAF | NoConn | I | E | T | I | E | T | single | supported | supported |

Table 1.11 defines the primitives used only inside SSP and SMP connections.

## Table 1.11 Primitives used only inside SSP and SMP connections

| Primitive | USE (*4) | From | | | To | | | Sequence | SAS 1.1 rev7 supported prim | FJ supported prim |
|---|---|---|---|---|---|---|---|---|---|---|
| | | I | E | T | I | E | T | Type | | |
| ACK | Conn | I | - | T | I | - | T | single | supported | supported |
| CREDIT_BLOCKED | Conn | I | - | T | I | - | T | single | supported | supported |
| DONE (NORMAL) | Conn | I | - | T | I | - | T | single | supported | supported |
| DONE (RESERVED 0) | Conn | - | - | - | I | - | T | single | ↑ | supported (*3) |
| DONE (RESERVED 1) | Conn | - | - | - | I | - | T | single | ↑ | supported (*3) |
| DONE (ACK/NAK TIMEOUT) | Conn | I | - | T | I | - | T | single | supported | supported |
| DONE (RESERVED TIMEOUT 0) | Conn | - | - | - | I | - | T | single | ↑ | supported (*3) |
| DONE (RESERVED TIMEOUT 1) | Conn | - | - | - | I | - | T | single | ↑ | supported (*3) |
| DONE (CREDIT TIMEOUT) | Conn | I | - | T | I | - | T | single | supported | supported |
| EOF | Conn | I | - | T | I | - | T | single | supported | supported |
| NAK (CRC ERROR) | Conn | I | - | T | I | - | T | single | supported | supported |
| NAK (RESERVED 0) | Conn | - | - | - | I | - | T | single | ↑ | ignored |
| NAK (RESERVED 1) | Conn | - | - | - | I | - | T | single | ↑ | ignored |
| NAK (RESERVED 2) | Conn | - | - | - | I | - | T | single | ↑ | ignored |
| RRDY (NORMAL) | Conn | I | - | T | I | - | T | single | supported | supported |
| RRDY (RESERVED 0) | Conn | - | - | - | I | - | T | single | ↑ | ignored |
| RRDY (RESERVED 1) | Conn | - | - | - | I | - | T | single | ↑ | ignored |
| SOF | Conn | I | - | T | I | - | T | single | supported | supported |

(*1) These primitives are received as AIP primitives.

(*2) When this primitive is received, the connection request is canceled and the command is aborted.

(*3) These primitives are received as DONE primitives.

(*4) When a primitive falling under "NoConn" is received during the inside connection, this primitive is discarded. When a primitive falling under "NoConn" is received during the outside connection, this primitive is also discarded. As for the HARD_RESET primitive, when it is received at any time except during the period between the completion of the speed negotiation and the reception of the first valid address frame, the received HARD_RESET primitive is discarded as well.

## 1.4.2 Primitive sequences

Table 1.12 summarizes the types of primitive sequences.

**Table 1.12 Primitive sequences**

| Primitive sequence type | Number of times the transmitter transmits the primitive to transmit the primitive sequence | Number of times the receiver receives the primitive to detect the primitive sequence |
|---|---|---|
| Single | 1 | 1 |
| Triple | 3 | 3 |
| Redundant | 6 | 3 |

Any number of ALIGNs and NOTIFYs may be sent inside primitive sequences without affecting the count or breaking the consecutiveness requirements. Rate matching ALIGNs and NOTIFYs shall be sent inside primitive sequences inside of connections if rate matching is enabled.

## 1.4.3 Primitives not specific to type of connections

### 1.4.3.1 AIP (Arbitration in progress)

AIP is sent by an expander device after a connection request to specify that the connection request is being processed and specify the status of the connection request.

A drive performs the following processing when an AIP primitive is received:

1) When the drive receives an AIP primitive after sending the OPEN frame, the drive initializes the open timer held in the drive, and restarts it.

2) When the drive receives an AIP primitive before sending the OPEN frame, the received AIP primitive is discarded.

3) In a case of OPEN cross (a case where both the drive and initiator send the OPEN frame), when the drive receives an AIP primitive after sending the OPEN frame and, then, receives the OPEN frame from the expander, the drive does not perform the arbitration fairness procedure. Instead, the attempt from the drive is treated as unsuccessful, and the drive sends the OPEN_ACCEPT or an OPEN_REJECT primitive.

### 1.4.3.2 ALIGN

ALIGNs are used for:

a) OOB signals;

b) character and dword alignment during the speed negotiation sequence;

c) clock skew management after the phy reset sequence;

d) rate matching during connections; and

Phys shall use ALIGN (0) to construct OOB signals as described in 6.6. Phys shall use ALIGN (0) and ALIGN (1) during the speed negotiation sequence as described in 6.7.4.2. Phys shall rotate through ALIGN (0), ALIGN (1), ALIGN (2), and ALIGN (3) for all ALIGNs sent after the phy reset sequence.

### 1.4.3.3 BREAK

The BREAK primitive is used to cancel the connection request, or to cancel the connection. The BREAK primitive is sent in cases 1) to 4) shown below.

1) When the connection request is to be canceled after sending an OPEN frame

2) When neither OPEN_ACCEPT nor OPEN_REJECT primitive is received within 1 ms of sending an OPEN frame

3) When neither a DONE primitive nor an SSP frame is received within 1 ms of sending a DONE primitive

4) When a CLOSE primitive is not received within 1 ms of sending a CLOSE primitive

When the BREAK primitive is sent in any of the cases above, the BREAK timer (1 ms) is started in anticipation of the reception of the BREAK primitive within 1 ms. If the BREAK primitive is not received within 1 ms, the connection is regarded as having been closed.

After the BREAK primitive is sent, when any primitives and/or frames other than the BREAK primitive are received, all of these (except NOTIFY primitives) are discarded.

When the BREAK primitive is not received within 1 ms of sending the BREAK primitive, a drive may start the link reset sequence.

### 1.4.3.4 BROADCAST

BROADCASTs are used to notify all SAS ports in a domain of an event.

When an expander port receives a BROADCAST it shall transmit the same BROADCAST on at least one phy in all other expander ports. BROADCAST shall only be sent outside of connections after the phy reset sequence has completed.

BROADCAST (CHANGE) is sent by an expander device to notify SAS INIT ports and other expander devices that a configuration change has occurred. BROADCAST (CHANGE) may also be transmitted by SAS INIT ports. BROADCAST (CHANGE) shall be ignored by SAS TARG ports.

BROADCAST (SES) is sent by a SAS TARG port to notify SAS INIT ports that an asynchronous event has occurred in an enclosure, and SSP INIT ports should poll all the SCSI enclosure services logical units in the SAS domain. BROADCAST (SES) shall be ignored by SAS TARG ports.

The drive ignores all received BROADCAST primitives.

#### 1.4.3.5 CLOSE

A CLOSE primitive is used to close a connection. When a CLOSE primitive is sent, the close timer (1 ms) is started. If a CLOSE primitive is not received within 1 ms of sending CLOSE primitive, the BREAK primitive is sent. The recipient must send a CLOSE primitive within 1 ms of receiving a CLOSE primitive.

Drives support only the CLOSE (NORMAL) primitive as a CLOSE primitive, while the CLOSE (CLEAR AFFILIATION), CLOSE (RESERVED 0), and CLOSE (RESERVED 1) primitives are ignored.

#### 1.4.3.6 EOAF (End of address frame)

EOAF specifies the end of an address frame.

#### 1.4.3.7 ERROR

ERROR should be sent by an expander device when it is forwarding dwords from a SAS physical link or SATA physical link to a SAS physical link and it receives an invalid dword or an ERROR.

When a drive receives an ERROR primitive, the drive discards it. When a received address frame contains the ERROR primitive, the whole address frame is discarded even if CRC is correct.

When a drive receives an SSP frame containing the ERROR primitive, the drive discards the whole SSP frame even if CRC is correct, and sends the NAK primitive.

#### 1.4.3.8 HARD_RESET

HARD_RESET is used to force a phy to generate a hard reset to its port. This primitive is only valid after the phy reset sequence without an intervening identification sequence and shall be ignored at other times.

Upon receipt of the HARD_RESET primitive, a drive clears all the commands it is currently holding.

In a dual port drive, the HARD_RESET primitive received at one port (e.g., at port A) affects the other port (e.g., at port B).

Meanwhile, as can be expected, a link reset sequence that occurs at one port (e.g., port A) does not affect the other port (e.g., port B).

### 1.4.3.9 NOTIFY

The NOTIFY (ENABLE SPINUP) primitive is sent by a SAS INIT device or expander device. When receiving the NOTIFY (ENABLE SPINUP) primitive in the active wait state of SCSI power conditions, a drive enters the active state.

A NOTIFY primitive is sometime used as a substitute for an ALIGN primitive, and it is sent by the initiator or expander at regular intervals.

A SAS TARG device with multiple SAS TARG ports treats the NOTIFY (ENABLE SPINUP) primitives from all the SAS TARG ports equally (for example, the NOTIFY (ENABLE SPINUP) primitive received through SAS TARG port A is treated as the wakeup for the START STOP UNIT command received through SAS TARG port B).

The NOTIFY (RESERVED 0), NOTIFY (RESERVED 1), and NOTIFY (RESERVED 2) primitives are ignored by all devices.

### 1.4.3.10 OPEN_ACCEPT

The OPEN_ACCEPT primitive indicates the acceptance of a connection request. The recipient of an OPEN frame must send the OPEN_ACCEPT primitive within 1 ms, when it can accept the connection request.

### 1.4.3.11 OPEN_REJECT

An OPEN_REJECT primitive indicates the rejection of a connection request. Among the OPEN_REJECT primitives, there are those indicating that the connection request cannot be continued (OPEN_REJECT abandon primitives) and those indicating that the connection request can be retried (OPEN_REJECT retry primitives).

The OPEN_REJECT primitives defined in Table 1.13 direct the recipients to abandon the connection request.

**Table 1.13 OPEN_REJECT abandon primitives**

| Primitive | Issuer | Processing by the drive that receives the OPEN_REJECT primitive |
|---|---|---|
| OPEN_REJECT<br>(BAD DESTINATION) | Expander phy | Cancels the connection request, and aborts the TASK (command). |
| OPEN_REJECT<br>(CONNECTION RATE NOT SUPPORTED) | Any phy | 1) When the physical link rate is 3.0 Gbps and the connection link rate is 3.0 Gbps, the drive changes the connection rate to 1.5 Gbps, and resends the OPEN frame.<br>2) When the physical link rate is 3.0 Gbps and the connection link rate is 1.5 Gbps, the drive changes the connection rate to 3.0 Gbps, and resends the OPEN frame.<br>3) When the physical link rate is 1.5 Gbps and the connection link rate is 1.5 Gbps, the drive cancels connection request, and aborts the TASK (command).<br>* After sending an OPEN frame in case 1) or 2), if the drive receives this OPEN_REJECT primitive again, the drive cancels the connection request, and aborts the TASK (command). |
| OPEN_REJECT<br>(PROTOCOL NOT SUPPORTED) | Destination phy | If the driver receives this OPEN_REJECT primitive, it cancels the connection request, and aborts the TASK (command). |
| OPEN_REJECT<br>(RESERVED ABANDON 0) | Unknown | Performs the same processing as the OPEN_REJECT (WRONG DESTINATION). |
| OPEN_REJECT<br>(RESERVED ABANDON 0) | Unknown | Performs the same processing as the OPEN_REJECT (WRONG DESTINATION). |
| OPEN_REJECT<br>(RESERVED ABANDON 0) | Unknown | Performs the same processing as the OPEN_REJECT (WRONG DESTINATION). |
| OPEN_REJECT<br>(RESERVED ABANDON 0) | Unknown | Performs the same processing as the OPEN_REJECT (WRONG DESTINATION). |
| OPEN_REJECT<br>(STP RESOURCES BUSY) | Destination phy | Performs the same processing as the OPEN_REJECT (WRONG DESTINATION). |
| OPEN_REJECT<br>(WRONG DESTINATION) | Destination phy | If the driver receives this OPEN_REJECT primitive, it cancels the connection request, and aborts the TASK (command). |

All of the OPEN_REJECT versions defined in Table 1.14 shall result in the originating device retrying the connection request.

**Table 1.14 OPEN_REJECT retry primitives**

| Primitive | Issuer | Processing by the drive that receives the OPEN_REJECT primitive |
|---|---|---|
| OPEN_REJECT<br>(NO DESTINATION) | Expander phy | 1) If the I_Tnexus loss timer is working, the drive leaves the timer working. If the I_Tnexus loss timer has expired, the drive aborts all the commands of the relevant initiator. Otherwise, if the timer has not expired, the drive resends the OPEN frame.<br>2) If the I_Tnexus loss timer is stopped and it has expired, the drive aborts all the commands of the relevant initiator. Otherwise, if the timer has not expired, the drive initializes the timer and resends the OPEN frame. |
| OPEN_REJECT<br>(PATHWAY BLOCKED) | Expander phy | 1) If the I_Tnexus loss timer is working, the drive leaves the timer working. If the I_Tnexus loss timer has expired, the drive aborts all the commands of the relevant initiator. Otherwise, if the timer has not expired, the drive resends the OPEN frame. At this time, the drive increments the PATHWAY BLOCKED COUNT field in the OPEN frame. |
| OPEN_REJECT<br>(RESERVED CONTINUE 0) | Unknown | Performs the same processing as the OPEN_REJECT (RETRY). |
| OPEN_REJECT<br>(RESERVED CONTINUE 1) | Unknown | Performs the same processing as the OPEN_REJECT (RETRY). |
| OPEN_REJECT<br>(RESERVED INITIALIZE 0) | Unknown | Performs the same processing as the OPEN_REJECT (NO DESTINATION). |
| OPEN_REJECT<br>(RESERVED INITIALIZE 1) | Unknown | Performs the same processing as the OPEN_REJECT (NO DESTINATION). |
| OPEN_REJECT<br>(RESERVED STOP 0) | Unknown | Performs the same processing as the OPEN_REJECT (PATHWAY BLOCKED). |
| OPEN_REJECT<br>(RESERVED STOP 1) | Unknown | Performs the same processing as the OPEN_REJECT (PATHWAY BLOCKED). |
| OPEN_REJECT (RETRY) a | Destination phy | Otherwise, if the I_Tnexus loss timer is working, the drive stops the timer and resends the OPEN frame. |

When an INIT sends an OPEN frame to a drive but the drive cannot accept the connection request, the drive sends an OPEN_REJECT within 1ms. A drive sends an OPEN_REJECT primitive in any of the following cases:

1) When the INIT port bit in a received OPEN frame is 0, the drive sends the OPEN_REJECT (PROTOCOL NOT SUPPORTED) primitive.

2) When the PROTOCOL field in a received OPEN frame is not SSP, the drive sends the OPEN_REJECT (PROTOCOL NOT SUPPORTED) primitive.

3) When the CONNECTION RATE field in the received OPEN frame is not "1.5G or 3.0G", the drive sends the OPEN_REJECT (CONNECTION RATE NOT SUPPORTED) primitive.

4) When, in contradiction to the fact that the physical link rate is 1.5 Gbps, the CONNECTION RATE field in a received OPEN frame is 3.0G, the drive sends the OPEN_REJECT (CONNECTION RATE NOT SUPPORTED) primitive.

5) A single port drive may process requests from up to eight INITs at the same time. When a single port drive holds commands from eight initiators, and if it receives a connection request from a ninth initiator, the drive sends the OPEN_REJECT (RETRY) primitive.

6) A dual port drive may process requests from up to four INITs at a time for each port. When a dual port drive holds commands from four INITs for one of its ports, and if it receives a connection request from a fifth INIT through the same port, the drive sends the OPEN_REJECT (RETRY) primitive.

7) When the drive cannot receive an SSP frame temporarily due to the recovery processing of an internal drive error, the drive sends the OPEN_REJECT (RETRY) primitive.

8) When the SAS address of a drive does not match the DESTINATION SAS ADDRESS field in a received OPEN frame, the drive sends the OPEN_REJECT (WRONG DESTINATION) primitive.

#### 1.4.3.12 SOAF (Start of address frame)

SOAF specifies the start of an address frame.

## 1.4.4 Primitives used only inside SSP and SMP connections

### 1.4.4.1 ACK (acknowledge)

The ACK primitive indicates that an SSP frame is received normally. When a drive receives an SSP frame, and the CRC field in the received SSP frame is correct, the drive sends the ACK primitive within 1 ms.

### 1.4.4.2 CREDIT_BLOCKED

The CREDIT_BLOCKED primitive indicates that no more credits can be sent during this connection. When a drive determines that it can give out no more credits during the connection, the drive sends the CREDIT_BLOCKED primitive to avoid credit timeout. A drive sends the CREDIT_BLOCKED primitive in any of the following cases:

1) When the drive sends an OPEN frame and, then, receives the OPEN_ACCEPT primitive from the initiator during the abort processing in the drive, the drive sends the CREDIT_BLOCKED primitive instead of an RRDY primitive.

2) When the drive determines during the connection that it has entered a condition where abort processing inside the drive is necessary, if an SSP frame is received from the initiator, the drive sends the CREDIT_BLOCKED primitive instead of an RRDY primitive.

After sending the CREDIT_BLOCKED primitive,the drive must wait until the connection is closed before it can send an RRDY primitive.

Meanwhile, when a drive receives the CREDIT_BLOCKED primitive from the initiator, the drive performs any of the following processing:

1) At the time of the receipt of the CREDIT_BLOCKED primitive, if the drive holds credits that have been given before and has frames to send, the drive can send as many frames as there are credits being held at this time.

2) At the time of the receipt of the CREDIT_BLOCKED primitive, if the drive holds credits that have been given before but has no frames to send, the drive sends the DONE (CREDIT TIMEOUT) primitive and starts the close processing.

3) At the time of the receipt of the CREDIT_BLOCKED primitive, if the drive holds no credits, it sends the DONE (CREDIT TIMEOUT) primitive and starts the close processing.

### 1.4.4.3 DONE

A DONE primitive indicates the start of the close processing of an SSP connection. In the close processing, in principle, when no frame for processing remains on the side of the OPEN frame sender (recipient of the OPEN_ACCEPT primitive), a DONE primitive is sent. However, there is no rule concerning which side should first start the close processing.

Table 1.15 contains DONE primitive definitions.

**Table 1.15 DONE primitives**

| primitive | Description |
|---|---|
| DONE<br>(ACK/NAK TIMEOUT) | When the sender of an SSP frame does neither receive the ACK nor the NAK primitive after sending the SSP frame, the sender sends the DONE (ACK/NAK TIMEOUT) primitive. |
| DONE<br>(RESERVED TIMEOUT 0) | This primitive is processed in the same manner as the DONE (ACK/NAK TIMEOUT) primitive. |
| DONE<br>(RESERVED TIMEOUT 1) | This primitive is processed in the same manner as the DONE (ACK/NAK TIMEOUT) primitive. |
| DONE (NORMAL) | Indicates that all frames have been sent. |
| DONE (RESERVED 0) | This primitive is processed in the same manner as the DONE (NORMAL) primitive. |
| DONE (RESERVED 1) | This primitive is processed in the same manner as the DONE (NORMAL) primitive. |
| DONE (CREDIT TIMEOUT) | When the wait time for an RRDY primitive has exceeded 1 ms, or the CREDIT BLOCKED primitive is received before an RRDY primitive is received, if the close processing is performed, the DONE (CREDIT TIMEOUT) primitive is sent. |

A drive sends a DONE primitive in any of the following cases:

1) When the drive sends an OPEN frame and establishes connection, and it becomes that there are no frame to be sent, the drive sends the DONE (NORMAL) primitive.

2) When credit timeout is detected before the drive sends an SSP frame, the drive sends the DONE (CREDIT TIMEOUT) primitive.

3) When the drive receives the CREDIT_BLOCKED primitive during an inside connection, the drive sends the DONE (CREDIT TIMEOUT) primitive during the close processing.

4) When an OPEN frame is sent by an initiator, connection is established, and no SSP frame has been sent for more than 1 ms, the drive sends the DONE (NORMAL) primitive.

5) When the drive sends a read DATA frame, and data burst size of the data that has been sent by the drive since connection establishment reaches 64 Kbytes, the drive sends the DONE (NORMAL) primitive to temporarily close the connection.

6) When the drive detects Ack/Nak timeout, the drive sends the DONE (ACK/NAK TIMEOUT) primitive.

Before sending the DONE primitive, a drive starts the done timer (1 ms). Later, when receiving an SSP frame from the initiator, the drive initializes the done timer and restarts it. If the drive has received neither the SSP frame nor the DONE primitive for 1 ms since sending the DONE primitive, the drive sends the BREAK primitive.

Meanwhile, when a drive receives the DONE primitive, the drive performs the following processing:

1) If the drive has SSP frames to send at the time of the receipt of the DONE primitive from the initiator, the drive can send as many SSP frames as there are credits being held at this time.

2) If the drive has no SSP frames to send at the time of the receipt of the DONE primitive from the initiator, the drive sends the DONE (NORMAL) primitive.

The side that has sent the DONE primitive cannot send the SSP primitive until connection is established again after the current connection is temporarily closed.

### 1.4.4.4 EOF (End of frame)

EOF specifies the end of an SSP or SMP frame.

### 1.4.4.5 NAK (negative acknowledgement)

The NAK primitive indicates that an SSP frame cannot be received normally. When a drive receives an SSP frame, and the drive detects a CRC error after checking the CRC field in the SSP frame, the drive sends the NAK primitive.

If a received SSP frame contains the ERROR primitive or an invalid dword, the drive sends the NAK primitive even if the CRC field in the SSP field is correct.

### 1.4.4.6 RRDY

During connection, when a drive detects the state where it can receive an SSP frame, the drive sends an RRDY primitive to indicate that the connecting companion can send the SSP frame. According to the ANSI specifications, the sender of the OPEN_ACCEPT primitive must provide at least one RRDY primitive within 1 ms.

When the OPEN_ACCEPT primitive is transferred, the maximum number of RRDY primitives to be sent by a drive is as follows:

- For a single port drive: four
- For a dual port drive: three

The sending side of the SSP frame cannot send the SSP frame before sending RRDY primitives (before the sending side obtains credits). If a drive receives more SSP frames than the RRDY primitives it has sent, the drive discards the surplus SSP frames.

### 1.4.4.7 SOF (Start of frame)

SOF specifies the start of an SSP or SMP frame.

### 1.4.5 Clock skew management

The internal clock for a device is typically based on a PLL with its own clock generator and is used when transmitting dwords on the physical link. When receiving, however, dwords need to be latched based on a clock derived from the input bit stream itself. Although the input clock is nominally a fixed frequency, it may differ slightly from the internal clock frequency up to the physical link rate tolerance. Over time, if the input clock is faster than the internal clock, the device may receive a dword and not be able to forward it to an internal buffer; this is called an overrun. If the input clock is slower than the internal clock, the device may not have a dword when needed in an internal buffer; this is called an underrun.

To solve this problem, transmitting devices insert ALIGNs or NOTIFYs in the dword stream.

A phy that is the original source for the dword stream (i.e., a phy that is not an expander phy forwarding dwords from another expander phy) shall insert one ALIGN or NOTIFY for clock skew management as described in Table 1.16.

**Table 1.16 Clock skew management ALIGN insertion requirement**

| Physical link rate | requirement |
|---|---|
| 1.5 Gbps | One ALIGN or NOTIFY within every 2 048 dwords |
| 3.0 Gbps | Two ALIGNs or NOTIFYs within every 4 096 dwords |

In the clock skew management of a drive, one ALIGN primitive is always inserted every 1024 dwords regardless of the physical link rate.

### 1.4.6 Idle physical link

In any of the conditions below, when there is no dword to be sent, an idle dword is sent. This idle dword is scrambled.

1) In an outside connection

2) The SSP or SMP connection is an inside connection.

## 1.4.7 Scrambling

Scrambling is used to reduce the probability of long strings of repeated patterns appearing on the physical link.

All data dwords are scrambled. Table 1.17 lists the scrambling for different types of data dwords.

**Table 1.17 Scrambling for different data dword types**

| connection state | Data dword type | Description of scrambling |
|---|---|---|
| Outside connections | SAS idle dword | When a connection is not open and there are no other dwords to transmit, vendor-specific scrambled data dwords shall be transmitted. |
| | Address frame | After an SOAF, all data dwords shall be scrambled until the EOAF. |
| Inside SSP connection | SSP frame | After an SOF, all data dwords shall be scrambled until the EOF. |
| | SSP idle dword | When there are no other dwords to transmit, vendor-specific scrambled data dwords shall be transmitted. |

To generate scrambled values that are to be encoded and transferred on the physical link layer, dwords to be sent are XOR-ed with the predefined pattern. If there is no transmission error, the received data of the dwords is XOR-ed with the same pattern after being decoded so that the dword values of the original data can be obtained.

The pattern that is XORed with the data dwords is defined by the output of a linear feedback shift register implemented with the following polynomial:

$$G(x) = x^{16} + x^{15} + x^{13} + x^{4} + 1$$

The value of the linear feedback shift register shall be initialized at each SOF and SOAF to FFFFh.

# 1.5 Address frames

## 1.5.1 Address frames overview

Address frames are used for the identification sequence and for connection requests. The address frame follows an SOAF and ends with an EOAF. Address frames shall only be sent outside connections. Address frames shall not be terminated early. All data dwords in an address frame shall be scrambled.

Table 1.18 defines the address frame format.

**Table 1.18 Address frame format**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | ADDRESS FRAME TYPE | | | |
| 1 | Frame Type dependent bytes | | | | | | | |
| 27 | | | | | | | | |
| 28 | (MSB) CRC | | | | | | | |
| 31 | | | | | | | | (LSB) |

The ADDRESS FRAME TYPE field indicates the type of the address frame as follows:

- An ADDRESS FRAME TYPE field value of "0" indicates an IDENTIFY address frame.
- An ADDRESS FRAME TYPE field value of "1" indicates an OPEN address frame.

The CRC field contains the CRC value calculated for all the data of an address frame (data from the beginning of the frame to the byte preceding the CRC field). If an address frame has an undefined ADDRESS FRAME TYPE, has an incorrect frame length (longer or shorter than 7 dwords + the CRC length), or has a CRC error, the recipient discards the frame.

## 1.5.2 IDENTIFY address frame

Table 1.19 defines the IDENTIFY address frame format used for the identification sequence. The IDENTIFY address frame is sent after the phy reset sequence completes if the physical link is a SAS physical link.

**Table 1.19 IDENTIFY address frame format**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Restricted (for Open address frame) | DEVICE TYPE | | | ADDRESS FRAME TYPE (0h) | | | |
| 1 | Restricted (for OPEN address frame) | | | | | | | |
| 2 | Reserved | | | | SSP INITIATOR PORT | STP INITIATOR PORT | SMP INITIATOR PORT | Restricted (for Open address frame) |
| 3 | Reserved | | | | SSP TARGET PORT | STP TARGET PORT | SMP TARGET PORT | Restricted (for Open address frame) |
| 4 | Restricted (for Open address frame) | | | | | | | |
| 11 | | | | | | | | |
| 12 | SAS ADDRESS | | | | | | | |
| 19 | | | | | | | | |
| 20 | PHY IDENTIFIYR | | | | | | | |
| 21 | Reserved | | | | | | | |
| 27 | | | | | | | | |
| 28 | (MSB) Reserved | | | | | | | |
| 31 | | | | | | | | (LSB) |

The DEVICE TYPE field specifies the type of device containing the phy, and is defined in Table 1.20.

**Table 1.20 DEVICE TYPE field**

| Code | Description |
|---|---|
| 001b | End device |
| 010b | Edge expander device |
| 011b | Fanout expander device |
| All others | Reserved |

The ADDRESS FRAME TYPE field shall be set to 0h.

An SSP INITIATOR PORT bit set to one specifies that an SSP INIT port is present. An SSP INITIATOR PORT bit set to zero specifies that an SSP INIT port is not present. Expander devices shall set the SSP INITIATOR PORT bit to zero.

An SSP TARGET PORT bit set to one specifies that an SSP TARG port is present. An SSP TARGET PORT bit set to zero specifies that an SSP TARG port is not present. Expander devices shall set the SSP TARGET PORT bit to zero.

For SAS ports, the SAS ADDRESS field specifies the port identifier of the SAS port transmitting the IDENTIFY address frame. For expander ports, the SAS ADDRESS field specifies the device name of the expander device transmitting the IDENTIFY address frame.

The PHY IDENTIFIER field specifies the phy identifier of the phy transmitting the IDENTIFY address frame.

A wide port shall set the DEVICE TYPE field, SSP INITIATOR PORT bit, STP INITIATOR PORT bit, SMP INITIATOR PORT bit, SSP TARGET PORT bit, STP TARGET PORT bit, and SMP TARGET PORT bit to the same set of values on each phy in the wide port. Recipient ports need not check the consistency of these fields across phys.

The contents of the IDENTIFY address frame sent by a drive are as follows:

| | | |
|---|---|---|
| a) | ADDRESS FRAME TYPE: | 0h |
| b) | DEVICE TYPE: | 001b |
| c) | SSP INITIATOR PORT bit: | 0b |
| d) | STP INITIATOR PORT bit: | 0b |
| e) | SMP INITIATOR PORT bit: | 0b |
| f) | SSP TARGET PORT bit: | 1b |
| g) | STP TARGET PORT bit: | 0b |
| h) | SMP TARGET PORT bit: | 0h |
| i) | SAS ADDRESS: | Refer to the Section 1.2.1, "SAS address." |
| j) | PHY IDENTIFIER: | Single port: 0h<br>Dual port: port A (0h)/port B (1h) |
| k) | Reserved: | 0h |

### 1.5.3 OPEN address frame

Table 1.21 defines the OPEN address frame format used for connection requests.

**Table 1.21 OPEN address frame format**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | INITIATOR PORT | PROTOCOL | | | ADDRESS FRAME TYPE (1h) | | | |
| 1 | FEATURES | | | | CONNECTION RATE | | | |
| 2 | (MSB) | INITIATOR CONNECTION TAG | | | | | | |
| 3 | | | | | | | | (LSB) |
| 4 | | DESTINATION SAS ADDRESS | | | | | | |
| 11 | | | | | | | | |
| 12 | | SOURCE SAS ADDRESS | | | | | | |
| 19 | | | | | | | | |
| 20 | COMPATIBLE FEATURES | | | | | | | |
| 21 | PATHWAY BLOCKED COUNT | | | | | | | |
| 22 | (MSB) | ARBITRARION WAIT TIME | | | | | | |
| 23 | | | | | | | | (LSB) |
| 24 | | MORE COMPATIBLE FEATURES | | | | | | |
| 27 | | | | | | | | |
| 28 | (MSB) | CRC | | | | | | |
| 31 | | | | | | | | (LSB) |

An INITIATOR PORT bit set to one specifies that the source port is acting as a SAS INIT port. An INITIATOR PORT bit set to zero specifies that the source port is acting as a SAS TARG port.

The PROTOCOL field specifies the protocol for the connection being requested and is defined in Table 1.22.

**Table 1.22 PROTOCOL field**

| Code | Description |
|---|---|
| 000b | SMP |
| 001b | SSP |
| 010b | STP |
| All others | Reserved |

The ADDRESS FRAME TYPE field shall be set to 1h.

The FEATURES field shall be set to zero.

The CONNECTION RATE field specifies the connection rate being requested between the source and destination, and is defined in Table 1.23.

**Table 1.23 CONNECTION RATE field**

| Code | Description |
|---|---|
| 8h | 1,5 Gbps |
| 9h | 3,0 Gbps |
| All others | Reserved |

When requesting a connection to a SAS TARG port, a SAS INIT port shall set the CONNECTION RATE field to a value supported by at least one potential pathway.

When requesting an SSP connection to an SSP INIT port, an SSP TARG port shall set the CONNECTION RATE field to the connection rate in effect when the command was received unless it has received an OPEN_REJECT (CONNECTION RATE NOT SUPPORTED).

The INITIATOR CONNECTION TAG field is used when the SAS TARG port issues a connection request. This field is used as a substitute for the SAS address of the SAS TARG port when the SAS INIT port searches for processing in progress. If the initiator port does not require field support from the SAS TARG port, the INITIATOR CONNECTION TAG field is set to FFFFh. If the initiator port requires field support, the INITIATOR CONNECTION TAG field should be set to the value that is peculiar to the SAS TARG port. When the SAS TARG port issues a connection request to the SAS INIT port, the SAS TARG port must set the INITIATOR CONNECTION TAG field to any of the following: the last received value, the uncompleted command that has been received from the SAS INIT port, or the value that has been set at the time of the connection request of the task management. For all connection requests, the SAS INIT port must use the same INITIATOR CONNECTION TAG value for the same SAS TARG port. The SAS INIT port can change the INITIATOR CONNECTION TAG value only when there is no command processing in progress or task management in the SAS TARG port. The SAS TARG port does not check for consistency among INITIATOR CONNECTION TAG fields of different connection requests from the same SAS INIT port.

The DESTINATION SAS ADDRESS field indicates the port identifier of the SAS port to which a connection request is being made.

The SOURCE SAS ADDRESS field indicates the port identifier of the SAS port that has been issued an OPEN address frame.

The COMPATIBLE FEATURES field is set to zero. The destination device ignores the COMPATIBLE FEATURES field.

The PATHWAY BLOCKED COUNT field specifies the number of times the port has retried this connection request due to receiving OPEN_REJECT (PATHWAY BLOCKED). The port shall not increment the PATHWAY BLOCKED COUNT value past FFh. If the port changes connection requests, it shall use a PATHWAY BLOCKED COUNT of 00h.

The ARBITRATION WAIT TIME field specifies how long the port transmitting the OPEN address frame has been waiting for a connection request to be accepted or rejected. This time is maintained by the port layer in an Arbitration Wait Time timer. For values from 0000h to 7FFFh, the Arbitration Wait Time timer increments in one microsecond steps. For values from 8000h to FFFFh, the Arbitration Wait Time timer increments in one millisecond steps. The maximum value represents 32767 ms + 32768 µs. Table 1.24 describes several values of the ARBITRATION WAIT TIME field.

**Table 1.24 ARBITRATION WAIT TIME field**

| Code | Description |
|---|---|
| 0000h | 0 µs |
| 0001h | 1 µs |
| ... | ... |
| 7FFFh | 32 767 µs |
| 8000h | 0 ms + 32 768 µs |
| 8001h | 1 ms + 32 768 µs |
| ... | ... |
| FFFFh | 32 767 ms + 32 768 µs |

The MORE COMPATIBLE FEATURES field shall be set to zero. The destination device shall ignore the MORE COMPATIBLE FEATURES field.

The contents of an OPEN address frame sent by a drive are as follows:

- INITIATOR PORT bit: 0b
- PROTOCOL: 001b
- CONNECTION RATE:
  The CONNECTION RATE value when an initiator makes a connection request
- INITIATOR CONNECTION TAG:
  The INITIATOR CONNECTION TAG value when an initiator makes a connection request

- DESTINATION SAS ADDRESS:
  The SAS address when an initiator makes a connection request

- SOURCE SAS ADDRESS:
  The SAS address of the drive

- PATHWAY BLOCKED COUNT:
  At the time of the first connection request, this field is set to 0h. Otherwise, it indicates how many times the OPEN_REJECT (PATHWAY BLOCKED) primitive has been received.

- ARBITRATION WAIT TIME:
  At the time of the first connection request, this field is set to 0h. When a drive's connection request is unsuccessful due to arbitration fairness at the time of sending an OPEN frame, this field of the next OPEN frame indicates the time that has elapsed since the first connection request.

### 1.5.4 Identification and hard reset sequence

After the phy reset sequence has been completed indicating the physical link is using SAS rather than SATA, each phy transmits either:

a) an IDENTIFY address frame; or

b) a HARD_RESET.

Each phy receives an IDENTIFY address frame or a HARD_RESET from the phy to which it is attached. The combination of a phy reset sequence, an optional hard reset sequence, and an identification sequence is called a link reset sequence (See Section 1.3.2).

If a device supports more than one phy, it shall transmit the same SAS address on all phys for which it is capable of sharing within a port.

If a device detects the same SAS address incoming on different phys, it shall consider those phys part of the same wide port.

If a device detects different SAS addresses incoming on different physical links, it shall consider those physical links as independent physical links and consider those phys part of different ports.

If a device does not receive a valid IDENTIFY address frame within 1 ms of phy reset sequence completion, it shall restart the phy reset sequence.

If a device receives an additional IDENTIFY address frame after receiving the first one, without an intervening phy reset sequence, it shall ignore the additional IDENTIFY address frame.

If a phy receives a HARD_RESET, it shall be considered a reset event and cause a hard reset (device initialization of the port) of the port containing that phy. After a hard reset, a phy begins a link reset sequence.

## 1.5.5 Connections

### 1.5.5.1 Connections overview

A connection is opened between a SAS INIT port and a SAS TARG port before communication begins. A connection is established between one SAS INIT phy in the SAS INIT port and one SAS TARG phy in the SAS TARG port.

SSP INIT ports open SSP connections to transmit SCSI commands, task management functions, or transfer data. SSP TARG ports open SSP connections to transfer data or transmit status.

Also at the SSP TARG port, an SSP connection must be established before data or a status is sent.

The OPEN address frame is used to request that a connection be opened. AIP, OPEN_ACCEPT and OPEN_REJECT are the responses to an OPEN address frame. BREAK is used to abort connection requests and to unilaterally break a connection. CLOSE is used for orderly closing a connection.

Connections use a single pathway from the SAS INIT phy to the SAS TARG phy. While a connection is open, only one pathway shall be used for that connection.

A wide port may have separate connections on each of its phys.

### 1.5.5.2 Connection request

The OPEN address frame is used to open a connection from a source port to a destination port using one source phy and one destination phy.

To make a connection request, the source port shall transmit an OPEN address frame through an available phy. The source phy shall transmit idle dwords after the OPEN address frame until it receives a response or aborts the connection request with BREAK.

After transmitting an OPEN address frame, the source phy shall initialize and start a 1 ms Open Timeout timer. Whenever an AIP is received, the source phy shall reinitialize and restart the Open Timeout timer. Source phys are not required to enforce a limit on the number of AIPs received before aborting the connection request. When any connection response is received, the source phy shall reinitialize the Open Timeout timer. If the Open Timeout timer expires before a connection response is received, the source phy may assume the destination port does not exist and shall transmit BREAK to abort the connection request.

The OPEN address frame flows through expander devices onto intermediate physical links. If an expander device on the pathway is unable to forward the connect request because none of the prospective physical links support the requested connection rate, the expander device shall return OPEN_REJECT (CONNECTION RATE NOT SUPPORTED). If the OPEN address frame reaches the destination, it shall return either OPEN_ACCEPT or OPEN_REJECT.
Rate matching shall be used on any physical links in the pathway with negotiated physical link rates that are faster than the requested connection rate.

### 1.5.5.3 Connection responses

Table 1.25 lists the responses to an OPEN address frame being transmitted.

**Table 1.25 Connection responses**

| Response | Description |
|---|---|
| AIP | Arbitration in progress. When an expander device is trying to open a connection to the selected destination port, it returns an AIP to the source phy. The source phy shall reinitialize and restart its Open Timeout timer when it receives an AIP. AIP is sent by an expander device while it is internally arbitrating for access to an expander port. |
| OPEN_ACCEPT | Connection request accepted. This is sent by the destination phy. |
| OPEN_REJECT | Connection request rejected. This is sent in response by the destination phy or by an expander device. |
| OPEN address frame | If the AIP primitive has been detected just before the OPEN address frame, this indicates a top-priority connection request, meaning that the OPEN_ACCEPT primitive or an OPEN_REJECT primitive must be sent. If an AIP primitive has not been detected yet, this indicates that two connection requests have crossed over the physical link. At this time, arbitration fairness is used to determine which request should take priority. |
| BREAK | The destination port or expander port may reply with BREAK indicating the connection is not being established. |
| Open Timeout timer expires | The source phy shall abort the connection request by transmitting BREAK. |

After an OPEN_REJECT (CONNECTION RATE NOT SUPPORTED) has been received by a SAS TARG port, the SAS TARG device shall set the connection rate for future requests for that I_T_L_Q nexus to:

a) the last value received in a connection request from the SAS INIT port;

b) 1,5 Gbps; or

c) the connection rate in effect when the command was received.

### 1.5.5.4 Arbitration fairness

SAS supports least-recently used arbitration fairness.

(This is a service equalization method that lowers the priority of the most recently used device, that is to say, gives higher priority to devices that have been in the wait state for a long period of time.)

Each SAS port and expander port shall include an Arbitration Wait Time timer which counts the time from the moment when the port makes a connection request until the request is accepted or rejected. The Arbitration Wait Time timer shall count in microseconds from 0 µs to 32 767 µs and in milliseconds from 32 768 µs to 32 767 ms + 32 768 µs. The Arbitration Wait Time timer shall stop incrementing when its value reaches 32 767 ms + 32 768 µs.

SAS ports (i.e., SAS INIT ports and SAS TARG ports) shall start the Arbitration Wait Time timer when they transmit the first OPEN address frame for the connection request. When the SAS port retransmits the OPEN address frame (e.g., after losing arbitration and handling an inbound OPEN address frame), it shall set the ARBITRATION WAIT TIME field to the current value of the Arbitration Wait Time timer.

SAS ports should set the Arbitration Wait Time timer to zero when they transmit the first OPEN address frame for the connection request. A SAS INIT port or SAS TARG port may be unfair by setting the ARBITRATION WAIT TIME field in the OPEN address frame to a higher value than its Arbitration Wait Time timer indicates. However, unfair SAS ports shall not set the ARBITRATION WAIT TIME field to a value greater than or equal to 8000h; this limits the amount of unfairness and helps prevent livelocks.

The expander port that receives an OPEN address frame shall set the Arbitration Wait Time timer to the value of the incoming ARBITRATION WAIT TIME field and start the Arbitration Wait Time timer as it arbitrates for internal access to the outgoing expander port. When the expander device transmits the OPEN address frame out another expander port, it shall set the outgoing ARBITRATION WAIT TIME field to the current value of the Arbitration Wait Time timer maintained by the incoming expander port.

A port shall stop the Arbitration Wait Time timer and set it to zero when it wins arbitration (i.e., it receives either OPEN_ACCEPT or OPEN_REJECT from the destination SAS port rather than from an intermediate expander device). If a port receives a connection request that satisfies its arbitration request (i.e., it receives an OPEN address frame from the destination SAS port with the INITIATOR PORT bit set to the opposite value and a matching PROTOCOL field), it shall stop the Arbitration Wait Time timer unless it accepts the request (i.e., transmits an OPEN_ACCEPT rather than an OPEN_REJECT).

If two connection requests pass on a physical link, the phy shall determine the winner by comparing OPEN address frame field contents using the arbitration priority described in Table 1.26.

**Table 1.26 Arbitration priority for OPEN address frames passing on a physical link**

| Bits 79-64 (79 is MSB) | Bits 63-0 (0 is LSB) |
|---|---|
| ARBITRATION WAIT TIME field value | SOURCE SAS ADDRESS field value |

### 1.5.5.5 Aborting a connection request

BREAK may be used to abort a connection request. The source phy shall transmit a BREAK after the Open Timeout timer expires or if it chooses to abort its request for any other reason.

After transmitting BREAK, the source phy shall initialize a Break Timeout timer to 1 ms and start the Break Timeout timer. Table 1.27 lists the responses to a BREAK being transmitted before a connection response has been received.

**Table 1.27 Abort connection responses**

| Response | Description |
|---|---|
| BREAK | This confirms that the connection request has been aborted. |
| Break Timeout timer expires | The originating phy shall assume the connection request has been aborted. |

Figure 1.15 shows the sequence for a connection request where the Open Timeout timer expires.

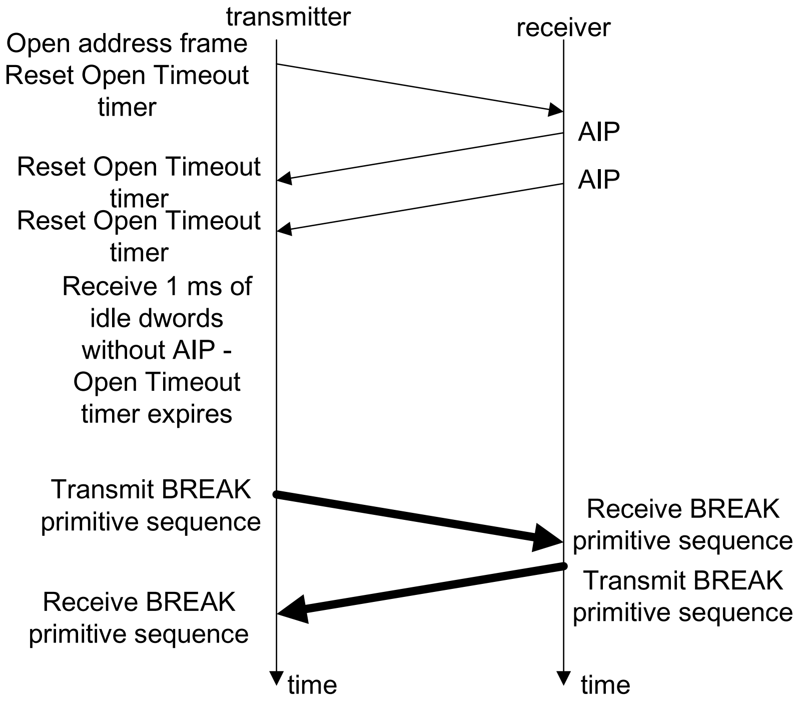

transmitter
receiver
Open address frame
Reset Open Timeout timer
AIP
Reset Open Timeout timer
AIP
Reset Open Timeout timer
Receive 1 ms of idle dwords without AIP - Open Timeout timer expires
Transmit BREAK primitive sequence
Receive BREAK primitive sequence
Transmit BREAK primitive sequence
Receive BREAK primitive sequence
time
time

**Figure 1.15 Connection request timeout example**

### 1.5.5.6 Closing a connection

CLOSE is used to close a connection of any protocol. After transmitting CLOSE, the source phy shall initialize a Close Timeout timer to 1 ms and start the Close Timeout timer. Table 1.28 lists the responses to a CLOSE being transmitted.

**Table 1.28 Close connection responses**

| Response | Description |
|---|---|
| CLOSE | This confirms that the connection has been closed. |
| Close Timeout timer expires | The originating phy shall attempt to break the connection. |

Figure 1.16 shows example sequences for closing a connection.

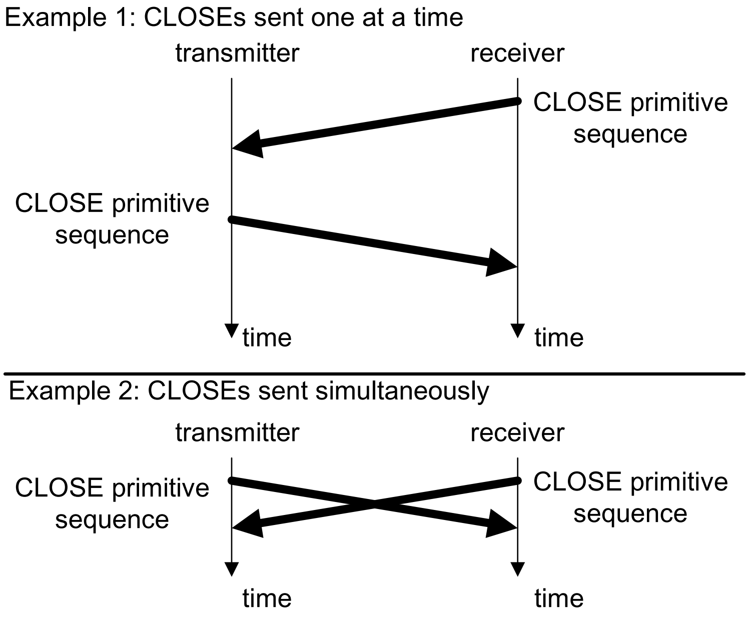


**Figure 1.16 Closing a connection example**

### 1.5.5.7 Breaking a connection

In addition to aborting a connection request, BREAK may also be used to break a connection, in cases where CLOSE is not available. After transmitting BREAK, the originating phy shall ignore all incoming dwords except for BREAKs.

After transmitting BREAK, the source phy shall initialize a Break Timeout timer to 1 ms and start the Break Timeout timer. Table 1.29 lists the responses to a BREAK being transmitted after a connection has been established.

**Table 1.29 Break connection responses**

| Response | Description |
|---|---|
| BREAK | This confirms that the connection has been broken. |
| Break Timeout timer expires | The originating phy shall assume the connection has been broken. The originating phy may perform a link reset sequence. |

In addition to a BREAK, a connection is considered broken due to loss of dword synchronization.

The following shall be the responses by an SSP phy to a broken connection:

a) Received frames having no CRC error may be considered valid regardless of whether an ACK has been transmitted in response to the frame prior to the broken connection;

b) Transmitted frames for which an ACK has been received prior to a broken connection shall be considered successfully transmitted; and

c) Transmitted frames for which an ACK or NAK has not been received prior to a broken connection shall be considered not successfully transmitted.

### 1.5.5.8 Rate matching

In spite of the fact that the physical link is set to 3.0 Gbps, the connection rate (indicated in an OPEN address frame) may be 1.5 Gbps. As shown in Table 1.30, if the transfer rate of the physical link is higher than the connection rate, ALIGN or NOTIFY primitives must be inserted between dwords for each phy of the pathway.

**Table 1.30 Rate matching ALIGN and/or NOTIFY insertion requirements**

| Physical link rate | Connection rate | Requirement |
|---|---|---|
| 1,5 Gbps | 1,5 Gbps | None |
| 3,0 Gbps | 1,5 Gbps | One ALIGN or NOTIFY within every 2 dwords that are not clock skew management ALIGNs or NOTIFYs (i.e., every overlapping window of 2 dwords) |
| | 3,0 Gbps | None |

A phy shall start inserting ALIGNs and/or NOTIFYs for rate matching at the selected connection rate with the first dword that is not an ALIGN or NOTIFY inserted for clock skew management following:

a) transmitting the EOAF for an OPEN address frame; or

b) transmitting an OPEN_ACCEPT.

The source phy transmits idle dwords including ALIGNs and NOTIFYs at the selected connection rate while waiting for the connection response. This enables each expander device to start forwarding dwords from the source phy to the destination phy after forwarding an OPEN_ACCEPT.

A phy shall stop inserting ALIGNs and/or NOTIFYs for rate matching after:

a) transmitting the first dword in a CLOSE;

b) transmitting the first dword in a BREAK;

c) receiving an OPEN_REJECT for a connection request; or

d) losing arbitration to a received OPEN address frame.

### 1.5.6 SSP link layer

An SSP phy that accepts an OPEN address frame shall transmit at least one RRDY in that connection within 1 ms of transmitting an OPEN_ACCEPT. If the SSP phy is not able to grant credit, it shall respond with OPEN_REJECT (RETRY) and not accept the connection request.

SSP is a full duplex protocol. An SSP phy may receive an SSP frame or primitive in a connection while it is transmitting an SSP frame or primitive in the same connection. A wide SSP port may send and/or receive SSP frames or primitives concurrently on different connections (i.e., on different phys).

When a connection is open and an SSP phy has no more SSP frames to transmit on that connection, it transmits a DONE to start closing the connection. The other direction may still be active, so the DONE may be followed by one or more of the following primitives: CREDIT_BLOCKED, RRDY, ACK, or NAK.

#### 1.5.6.1 SSP frame transmission and reception

During an SSP connection, SSP frames are preceded by SOF and followed by EOF. The last data dword after the SOF prior to the EOF always contains a CRC.

An SSP phy checks the frame length and validity of the CRC.

Receiving phys must acknowledge ACK or NAK within 1 ms if there is no condition for discarding frames. The ACK primitive indicates that SSP frames have been received into a frame buffer without errors. The NAK (CRC ERROR) primitive indicates that SSP frames have been received with a CRC error.

#### 1.5.6.2 SSP flow control

An SSP phy uses RRDY to grant credit for permission for the other SSP phy in the connection to transmit frames. Each RRDY increments credit by one frame. Frame transmission decrements credit by one frame. Credit of zero frames is established at the beginning of each connection.

SSP phys shall not increment credit past 255 frames.

To prevent deadlocks where an SSP INIT port and SSP TARG port are both waiting on each other to provide credit, an SSP INIT port shall never refuse to provide credit by withholding RRDY because it needs to transmit a frame itself. It may refuse to provide credit for other reasons (e.g., temporary buffer full conditions).

When the drive sends an OPEN frame and, then, receives the OPEN_ACCEPT primitive from the initiator due to abort processing in the drive (e.g., when receiving the TASK frame), the drive sends the CREDIT_BLOCKED primitive instead of an RRDY primitive. In this way, the drive may refuse to offer credits.

If credit is zero, SSP phys that are going to be unable to provide credit for 1 ms may send CREDIT_BLOCKED. The other phy may use this to avoid waiting 1 ms to transmit DONE (CREDIT TIMEOUT).

If credit is nonzero, SSP phys that are going to be unable to provide additional credit for 1 ms, even if they receive frames per the existing credit, may transmit CREDIT_BLOCKED.

After sending CREDIT_BLOCKED, an SSP phy shall not transmit any additional RRDYs in the connection.

#### 1.5.6.3 Interlocked frames

Table 1.31 shows which SSP frames shall be interlocked and which are non-interlocked.

One approach for successively processing frames and corresponding ACK or NAK (responses to these frames) in a single processing unit consists of ensuring that no new frame is sent until the response to the preceding frame is returned. A frame processed in this way is called an interlocked frame.

**Table 1.31 SSP frame interlock requirements**

| SSP frame type | Interlock requirement |
|---|---|
| COMMAND | Interlocked |
| TASK | Interlocked |
| XFER_RDY | Interlocked |
| DATA | Non-interlocked |
| RESPONSE | Interlocked |

Before transmitting an interlocked frame, an SSP phy shall wait for all SSP frames to be acknowledged with ACK or NAK, even if credit is available. After transmitting an interlocked frame, an SSP phy shall not transmit another SSP frame until it has been acknowledged with ACK or NAK, even if credit is available.

Before sending a non-interlocked frame, an SSP phy must wait for the following frames to be acknowledged with ACK or NAK, even if credit is available:

a) all non-interlocked frames with different tags; and

b) all interlocked frames;

After sending a non-interlocked frame, an SSP phy may send another non-interlocked frame with the same tag if credit is available. The SSP phy must not send the following frames until all SSP frames have been acknowledged with ACK or NAK, even if credit is available:

a) a non-interlocked frame with a different tag; or

b) an interlocked frame;

Interlocking does not prevent sending and receiving interlocked frames simultaneously (e.g., an SSP INIT phy can send a COMMAND frame while receiving XFER_RDY, DATA, or RESPONSE frames for a different command).

An SSP phy may transmit primitives responding to traffic it is receiving (e.g., an ACK or NAK to acknowledge an SSP frame, an RRDY to grant more receive credit, or a CREDIT_BLOCKED to specify that no more RRDYs are going to be transmitted in the connection) while waiting for an interlocked frame it transmitted to be acknowledged. These primitives may also be interspersed within an SSP frame.

Of the primitives that may be inserted in SSP frames sent from the SSP INIT port and expander port, a drive can detect the following:

a) ACK

b) NAK

c) RRDY

d) CREDIT_BLOCKED

e) NOTIFY

f) BREAK

g) ERROR

Meanwhile, the primitives that may be inserted in SSP frames sent from the drive are as follows:

a) ACK

b) NAK

c) RRDY

d) CREDIT_BLOCKED

Figure 1.17 shows an example of the transfer of interlocked frames.

Figure 1.18 shows an example of the transfer of non-interlocked frames with the same tag.

Figure 1.19 shows an example of the transfer of non-interlocked frames with different tags.

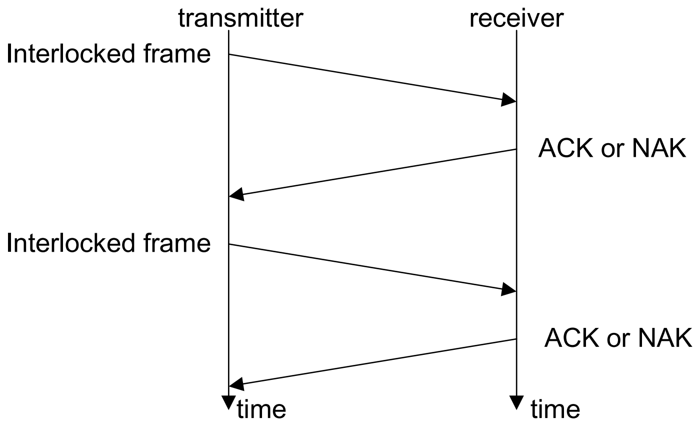


**Figure 1.17 Interlocked frames**

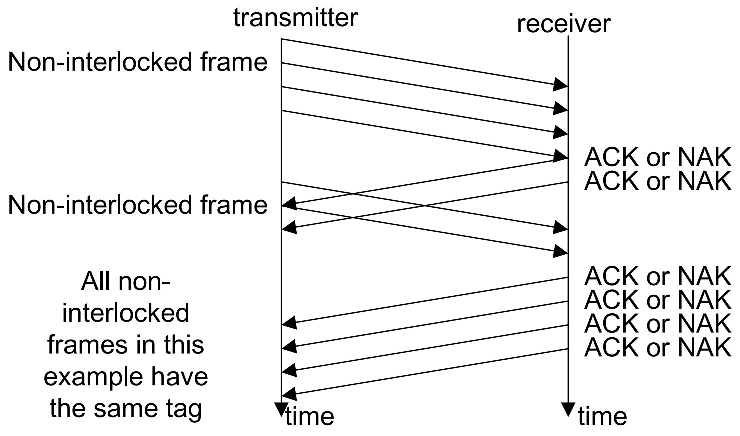


**Figure 1.18 Non-interlocked frames with the same tag**

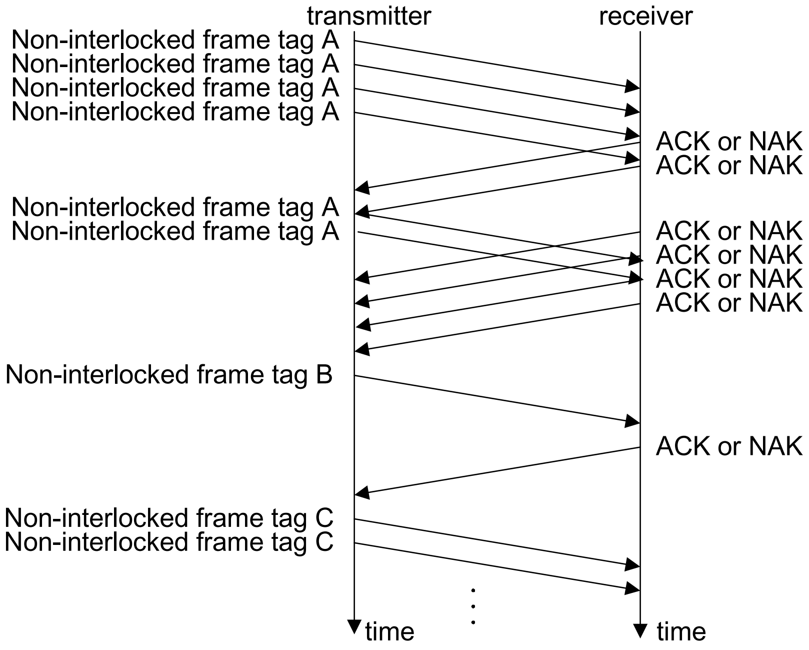

transmitter
receiver
Non-interlocked frame tag A
Non-interlocked frame tag A
Non-interlocked frame tag A
Non-interlocked frame tag A
ACK or NAK
ACK or NAK
Non-interlocked frame tag A
Non-interlocked frame tag A
ACK or NAK
ACK or NAK
ACK or NAK
ACK or NAK
Non-interlocked frame tag B
ACK or NAK
Non-interlocked frame tag C
Non-interlocked frame tag C
time
time

**Figure 1.19 Non-interlocked frames with different tags**

### 1.5.6.4 Closing an SSP connection

DONE shall be exchanged prior to closing an SSP connection. There are several versions of the DONE primitive indicating additional information about why the SSP connection is being closed:

a) DONE (NORMAL) specifies normal completion; the transmitter has no more SSP frames to transmit;

b) DONE (CREDIT TIMEOUT) specifies that the transmitter still has SSP frames to transmit but did not receive an RRDY granting frame credit within 1 ms, or the transmitter has received a CREDIT_BLOCKED and has consumed all RRDYs received; and

c) DONE (ACK/NAK TIMEOUT) specifies that the transmitter transmitted an SSP frame but did not receive the corresponding ACK or NAK within 1 ms. As a result, the ACK/NAK count is not balanced and the transmitter is going to transmit a BREAK in 1 ms unless the recipient replies with DONE and the connection is closed.

If the transmitter has no more SSP frames to transmit and receives a CREDIT_BLOCKED, it may transmit either DONE (NORMAL) or DONE (CREDIT TIMEOUT).

After transmitting DONE, the transmitting phy initializes and starts a 1 ms DONE Timeout timer.

After transmitting DONE, the transmitting phy shall not transmit any more SSP frames during this connection. However, the phy may transmit ACK, NAK, RRDY, and CREDIT_BLOCKED as needed after transmitting DONE if the other phy is still transmitting SSP frames in the reverse direction. Once an SSP phy has both transmitted and received DONE, it shall close the connection by transmitting CLOSE (NORMAL).

Figure 1.20 shows the sequence for a closing an SSP connection.

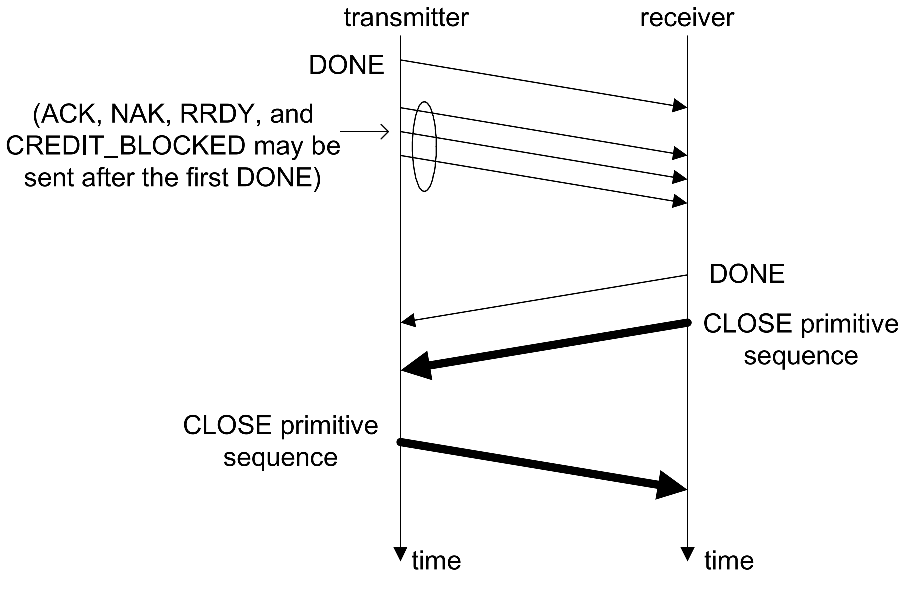


**Figure 1.20 Closing an SSP connection example**

# 1.6 Transport layer

## 1.6.1 SSP frame format

This layer defines the processing of each of a COMMAND frame, TASK frame, DATA frame, XFER_RDY frame and RESPONSE frame.

Table 1.32 contains the definitions of the SSP frame format. An SSP frame consists of the header part, information unit part, and CRC.

**Table 1.32 SSP frame format**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | FRAME TYPE | | | | | | | |
| 1 | (MSB) | HASHED DESTINATION SAS ADDRESS | | | | | | |
| 3 | | | | | | | | (LSB) |
| 4 | Reserved | | | | | | | |
| 5 | (MSB) | HASHED SOURCE SAS ADDRESS | | | | | | |
| 7 | | | | | | | | (LSB) |
| 8 | Reserved | | | | | | | |
| 9 | Reserved | | | | | | | |
| 10 | Reserved | | | | | RETRY DATA FRAMES | RETRANSMIT | CHANGING DATA POINTER |
| 11 | Reserved | | | | | | NUMBER OF FILL BYTES | |
| 12 | Reserved | | | | | | | |
| 13 | Reserved | | | | | | | |
| 15 | | | | | | | | |
| 16 | (MSB) | TAG | | | | | | |
| 17 | | | | | | | | (LSB) |
| 18 | (MSB) | TARGET PORT TRANSFER TAG | | | | | | |
| 19 | | | | | | | | (LSB) |
| 20 | (MSB) | DATA OFFSET | | | | | | |
| 23 | | | | | | | | (LSB) |
| 24 | (MSB) | INFORMATION UNIT | | | | | | |
| m | | | | | | | | (LSB) |
| | Fill bytes (0 to 3bytes) | | | | | | | |
| n-3 | (MSB) | CRC | | | | | | |
| n | | | | | | | | (LSB) |

Table 1.33 defines the FRAME TYPE field.

**Table 1.33 FRAME TYPE field**

| Code | Name of frame | Information Unit | Originator | Information unit size (bytes) |
|---|---|---|---|---|
| 01h | DATA frame | DATA | INIT or TARG | 1 to 1024 |
| 05h | XFER_RDY frame | Transfer ready | SSP TARG port | 12 |
| 06h | COMMAND frame | Command | SSP INIT port | 28 |
| 07h | RESPONSE frame | Response | SSP TARG port | NO_DATA: 24 |
| | | | | RESPONSE_DATA: 28 |
| | | | | SENSE_DATA: 72 |
| 16h | TASK frame | Task management function | SSP INIT port | 28 |
| All others | Reserved (unknown frame) | | | |

The HASHED DESTINATION SAS ADDRESS field contains the hashed value of the destination SAS address.

The HASHED SOURCE SAS ADDRESS field contains the hashed value of the source SAS address

The RETRY DATA FRAMES bit is set to one for XFER_RDY frames and shall be set to zero for all other frame types. When set to one this bit specifies that the SSP INIT port may retry write DATA frames that fail.

The RETRANSMIT bit is set to one for TASK frames, RESPONSE frames, and XFER_RDY frames and shall be set to zero for all other frame types. This bit specifies that the frame is a retransmission after the SSP port failed in its previous attempt to transmit the frame.

The CHANGING DATA POINTER bit is set to one for DATA frames and shall be set to zero for all other frame types. When set to one this bit specifies that the frame is a retransmission after the SSP TARG port failed in its previous attempt to transmit the frame or a subsequent frame and the dataoffset field of the frame may not be sequentially increased from that of the previous frame.

The NUMBER OF FILL BYTES field specifies the number of fill bytes between the INFORMATION UNIT field and the CRC field. The NUMBER OF FILL BYTES field shall be set to zero for all frame types except DATA frames (i.e., all other frame types are already four-byte aligned).

The TAG field contains a value that allows the SSP INIT port to establish a context for commands and task management functions.

For COMMAND frames and TASK frames, the SSP INIT port shall set the TAG field to a value that is unique for the I_T nexus established by the connection. An SSP INIT port shall not reuse the same tag when transmitting COMMAND frames or TASK frames to different LUNs in the same SSP TARG port. An SSP INIT port may reuse a tag when transmitting frames to different SSP TARG ports. The TAG field in a COMMAND frame contains the task tag defined in SAM-3. The TAG field in a TASK frame does not correspond to a SAM-3 task tag, but corresponds to an SAM-3 association. The tag space used in the TAG fields is shared across COMMAND frames and TASK frames (e.g., if a tag is used for a COMMAND frame, it is not also used for a concurrent TASK frame).

For DATA, XFER_RDY, and RESPONSE frames, the SSP TARG port shall set the TAG field to the tag of the command or task management function to which the frame pertains.

The TARGET PORT TRANSFER TAG field provides an optional method for an SSP TARG port to establish the write data context when receiving a write DATA frame (i.e., determine the command to which the write data corresonds).

SSP TARG ports may set the TARGET PORT TRANSFER TAG field to any value when transmitting any SSP frame. SSP TARG ports that use this field should set the TARGET PORT TRANSFER TAG field in every XFER_RDY frame to a value that is unique for the L_Q portion of the I_T_L_Q nexus (i.e., that is unique for every XFER_RDY that is outstanding from the SSP TARG port).

SSP INIT ports shall set the TARGET PORT TRANSFER TAG field as follows:

a) For each write DATA frame that is sent in response to an XFER_RDY frame, the SSP INIT port shall set the TARGET PORT TRANSFER TAG field to the value that was in the corresponding XFER_RDY frame;

b) For frames other than DATA frames, the SSP INIT port sets the TARGET PORT TRANSFER TAG field to FFFFh. However, this setting is not forcibly made.

Remarks: Drives do not support the FIRST BURST SIZE field of the Disconnect-Reconnect mode page (page code 02h).

For DATA frames, the DATA OFFSET field is described later. For all other frame types, the DATA OFFSET field shall be ignored.

The INFORMATION UNIT field contains the information unit, the format of which is defined by the FRAME TYPE field. The maximum size of the INFORMATION UNIT field is 1024 bytes, making the maximum size of the frame 1052 bytes (1024 bytes of data + 24 bytes of header + 4 bytes of CRC).

If necessary, fill bytes are placed after the INFORMATION UNIT field so that the CRC field is aligned on a four-byte boundary. The number of the fill bytes is specified by the NUMBER OF FILL BYTES field. If the transferred bytes in the last DATA frame are not aligned on a four byte boundary, this field is set to the number of the extra bytes (4 - the remainder of (the number of transferred bytes/4) bytes).

The CRC field contains a CRC value that is computed over the entire SSP frame prior to the CRC field including the fill bytes (i.e., all data dwords between the SOF and EOF).

Drives ignore the Reserved fields.

## 1.6.2 Information units

### 1.6.2.1 COMMAND information unit

Table 1.34 defines the command IU. The COMMAND frame is sent by an SSP INIT port to request that a command be processed by the device server in a logical unit.

**Table 1.34 COMMAND information unit**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | (MSB) | LOGICAL UNIT NUMBER | | | | | | |
| 7 | | | | | | | | (LSB) |
| 8 | Reserved | | | | | | | |
| 9 | ENABLE FIRST BURST | Reserved | | | | TASK ATTRIBUTE | | |
| 10 | Resered | | | | | | | |
| 11 | ADDITIONAL CDB LENGTH (n dwords) | | | | Reserved | | | |
| 12 | (MSB) | CDB | | | | | | |
| 27 | | | | | | | | (LSB) |
| 28 | ADDITIONAL CDB BYTES | | | | | | | |
| 27+ n x 4 | | | | | | | | |

The LOGICAL UNIT NUMBER field contains the address of the logical unit.

An ENABLE FIRST BURST bit set to "1" specifies that the first burst data item is transferred as defined by the FIRST BURST SIZE field in the Disconnect-Reconnect mode page. However, drives do not support this bit. Therefore, a drive ignores the FIRST BURST SIZE field of the Disconnect-Reconnect mode page.

Table 1.35 contains the definitions of the TASK ATTRIBUTE field. However, drives do not support ACA in Table 1.35. Moreover, when a reserved TASK

ATTRIBUTE code is specified, a drive will treat the task as one with the SIMPLE task attribute.

**Table 1.35 TASK ATTRIBUTE field**

| Code | Task attribute |
|---|---|
| 000b | SIMPLE |
| 001b | HEAD OF QUEUE |
| 010b | ORDERED |
| 011b | Reserved |
| 100b | ACA (not supported) |
| 101b-111b | Reserved |

The ADDITIONAL CDB LENGTH field contains the length of the ADDITIONAL CDB field in dwords (four bytes). However, drives do not support this ADDITIONAL CDB LENGTH field. Therefore, a drive expects a 28-byte long COMMAND frame.

The CDB and ADDITIONAL CDB BYTES fields together contain the CDB to be interpreted by the addressed logical unit.

The contents of the CDB are defined in the SCSI command standards (e.g., SPC-3).

When a drive receives a COMMAND frame, the following items are checked:

- HASHED DESTINATION SAS ADDRESS field

  When this field contains a value different from the Hashed SAS address of the drive, the drive sends the ACK and CREDIT_BLOCKED primitives, and discards the COMMAND frame.

- HASHED SOURCE SAS ADDRESS field

  When this field contains a value different from the SOURCE SAS ADDRESS field of the OPEN frame, the drive sends the CREDIT_BLOCKED primitive, and discards the COMMAND frame.

- TAG field

  The drive checks for duplication of tags. If a tag is found to be duplicated in the SAS address of the port, the drive sends the ACK primitive to temporarily close the connection. Then, after re-establishing a connection, the drive reports the CHECK CONDITION status with the OVERLAPPED COMMANDS DETECTS error. At this time, the drive aborts processing of all the commands received from the SAS address of the port.

- CRC field

  When a CRC error is detected, the drive sends the NAK primitive, and discards the COMMAND frame.

- Frame length

  When the IU length is other than 28 bytes, the drive discards the COMMAND frame.

- Command queue count value

  If the drive receives a command when the queue is full, the drive sends the ACK primitive to temporarily close the connection. Then, after re-establishing a connection, the drive reports the QUEUE FULL status.

- LOGICAL UNIT NUMBER field

- TASK ATTRIBUTE field

- CDB field

  Refer to Chapter 2, "Command Processing," and Chapter 4, "Command Specification."

- Reserved field

  The drive ignores the Reserved fields except the CDB field.

- Management of the command queue count (supplementary explanation)

  The maximum command queue count (the upper limit of the number of commands to be accepted) of a drive is 128. However, if the drive is a dual port drive and, for example, has already queued 128 commands at port A, the drive can receive another command at port B without causing the Queue full error. In other words, at least one command can be received at each port of the drive even when the drive is in the Queue full state.

### 1.6.2.2 TASK information unit

Table 1.36 defines the task management function IU. The TASK frame is sent by an SSP INIT port to request that a task management function be processed by the task manager in a logical unit.

**Table 1.36 TASK information unit**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | (MSB) | LOGICAL UNIT NUMBER | | | | | | |
| 7 | | | | | | | | (LSB) |
| 8 | Reserved | | | | | | | |
| 9 | Reserved | | | | | | | |
| 10 | TASK MANAGEMENT FUNCTION | | | | | | | |
| 11 | Reserved | | | | | | | |
| 12 | (MSB) | TAG OF TASK TO BE MANAGED | | | | | | |
| 13 | | | | | | | | (LSB) |
| 14 | Reserved | | | | | | | |
| 27 | | | | | | | | |

The LOGICAL UNIT NUMBER field contains the address of the logical unit.

Table 1.37 contains the definition of the TASK MANAGEMENT FUNCTION field. However, drives do not support the CLEAR ACA task management function listed in Table 1.37.

**Table 1.37 TASK MANAGEMENT FUNCTION field**

| Code | Task Management function | LOGICAL UNIT NUMBER field | TAG OF TASK TO BE MANAGED Field | Description |
|---|---|---|---|---|
| 01h | ABORT TASK | yes | yes | Aborts a task that matches with respect to I-T-L-Q. |
| 02h | ABORT TASK SET | yes | no | Aborts all the tasks that match with respect to I-T-L. |
| 04h | CLEAR TASK SET | yes | no | Aborts all the tasks of the INIT.<br>Reports UNIT ATTENTION (06/2F/00) to the INIT other than nexus that performed abort processing. |
| 08h | LOGICAL UNIT RESET | yes | no | Aborts all the tasks of the INIT.<br>Reports UNIT ATTENTION (06/29/03) to all the INITs. |
| 20h | Reserved | | | |
| 40h | CLEAR ACA | yes | no | Not supported |
| 80h | QUERY TASK | yes | yes | When maintaining a task that matches with respect to I-T-L-Q, reports TASK MANAGEMENT FUNCTION SUCCEEDED. When not maintaining a task that matches with respect to I-T-L-Q, reports TASK MANAGEMENT FUNCTION COMPLETE. |
| All others | Reserved | | | |

If TASK MANAGEMENT FUNCTION is set to ABORT TASK or QUERY TASK, the TAG OF TASK TO BE MANAGED field specifies the TAG value from the COMMAND frame that contained the task to be aborted or checked. For all other task management functions, the TAG OF TASK TO BE MANAGED field shall be ignored.

When a drive receives a TASK frame, the following fields are checked:

- HASHED DESTINATION SAS ADDRESS field

  When this field contains a value different from the hashed SAS address of the drive, the drive sends the ACK and CREDIT_BLOCKED primitives, and discards the TASK frame.

- HASHED SOURCE SAS ADDRESS field

  When this field contains a value different from that in the SOURCE SAS ADDRESS field of the OPEN frame, the drive sends the CREDIT_BLOCKED primitive, and discards the TASK frame.

- TAG field

  The drive does not check for duplication of tags between multiple TASK frames or between a COMMAND frame and a TASK frame, and the duplication of a tag is therefore ignored.

- CRC field

  When a CRC error is detected, the drive sends the NAK primitive, and discards the TASK frame.

- Frame length

  When the IU length is other than 28 bytes, the drive discards the TASK frame.

- LOGICAL UNIT NUMBER field

  If this field is other than zero, the drive sets the response code to INVALID LOGICAL UNIT NUMBER (0x09), and sends the RESPONSE frame of RESPONSE DATA.

- TASK MANAGEMENT FUNCTION field

  If this field is other than ABORT TASK, ABORT TASK SET, CLEAR TASK SET, LOGICAL UNIT RESET, or QUERY TASK, the drive sets the response code to TASK MANAGEMENT FUNCTION NOT SUPPORTED (0x04), and sends the RESPONSE frame of RESPONSE DATA.

### 1.6.2.3 XFER_RDY information unit

Table 1.38 defines the transfer ready IU. The XFER_RDY frame is sent by an SSP TARG port to request write data from the SSP INIT port.

**Table 1.38 XFER_RDY information unit**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | (MSB) | REQUESTED OFFSET | | | | | | |
| 3 | | | | | | | | (LSB) |
| 4 | (MSB) | WRITE DATA LENGTH | | | | | | |
| 7 | | | | | | | | (LSB) |
| 8 | Reserved | | | | | | | |
| 11 | | | | | | | | |

The REQUESTED OFFSET field contains the application client buffer offset of the segment of write data that is sent to the SSP (initiator port as a logical unit). The requested offset is a multiple of four (i.e., each DATA frame begins transferring data on a dword boundary). The REQUESTED OFFSET field is always zero for the first XFER_RDY frame of a command (drives do not support the ENABLE FIRST BURST field of the COMMAND frame).

If any additional XFER_RDY frames are required, the REQUESTED OFFSET field must be set to the value of the REQUESTED OFFSET in the previous XFER_RDY frame plus the value of the WRITE DATA LENGTH field in the previous XFER_RDY frame.

The WRITE DATA LENGTH field contains the number of bytes of write data the SSP INIT port will send to the logical unit from the application client buffer starting at the requested offset. The SSP TARG port sets the WRITE DATA LENGTH field to a value greater than or equal to 00000001h.

If an SSP TARG port sends a XFER_RDY frame containing a WRITE DATA LENGTH field that is not divisible by four, the SSP TARG port must not send any subsequent XFER_RDY frames for that command (i.e., only the last XFER_RDY for a command may request a non-dword multiple write data length).

When the drive sends a XFER_RDY frame, the following values are set:

- HASHED DESTINATION SAS ADDRESS field

  The hashed SAS address of the COMMAND frame is set.

- HASHED SOURCE SAS ADDRESS field

  The hashed SAS address of the drive is set.

- NUMBER OF FILL BYTES field

  Always set to zero.

- TAG field

  The tag value of the COMMAND frame is set.

- TARGET PORT TRANSFER TAG field

  The drive sets a value between 0 and 7.

- DATA OFFSET field

  Always set to zero.

- REQUESTED OFFSET field

  The first XFER_RDY frame for a command is always set to zero. If multiple XFER_RDY frames are to be sent for a single command, the value set in the field of the second XFER_RDY is increased by the value in the WRITE DATA LENGTH field of the first XFER_RDY frame. However, when transferring multiple XFER_RDY frames for a single command, the drive does not send the additional XFER_RDY frame until it receives the data requested with the first XFER_RDY frame. The value of the REQUESTED OFFSET field is divisible by four.

**Table 1.39 An example of requested offset**

| XFER_RDY frame | REQUESTED OFFSET | WRITE DATA LENGTH |
|---|---|---|
| First frame | 0000h | 0400h |
| Second frame | 0400h | 0400h |
| Third frame | 0800h | 0400h |

- WRITE DATA LENGTH field

  This field is used to set the number of data bytes that the drive can receive. The WRITE DATA LENGTH field indicates the actual number of data bytes to be received by the drive, and may not be divisible by four.

Figure 1.21 shows an example case where multiple XFER_RDY frames are sent.

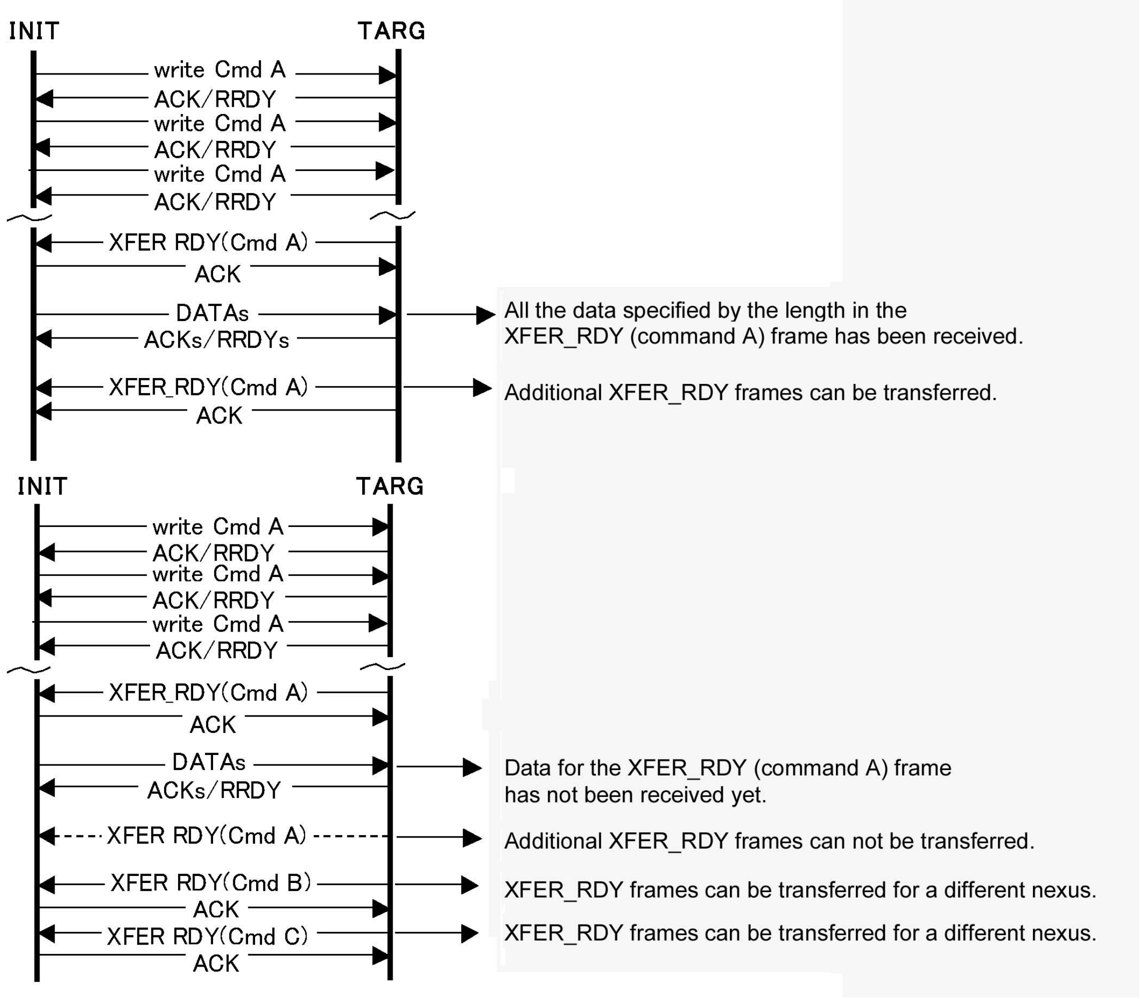

INIT
TARG
write Cmd A
ACK/RRDY
write Cmd A
ACK/RRDY
write Cmd A
ACK/RRDY
XFER RDY(Cmd A)
ACK
DATAs
ACKs/RRDYs
All the data specified by the length in the XFER_RDY (command A) frame has been received.
XFER_RDY(Cmd A)
Additional XFER_RDY frames can be transferred.
ACK
INIT
TARG
write Cmd A
ACK/RRDY
write Cmd A
ACK/RRDY
write Cmd A
ACK/RRDY
XFER_RDY(Cmd A)
ACK
DATAs
ACKs/RRDY
Data for the XFER_RDY (command A) frame has not been received yet.
XFER RDY(Cmd A)
Additional XFER_RDY frames can not be transferred.
XFER RDY(Cmd B)
XFER_RDY frames can be transferred for a different nexus.
ACK
XFER RDY(Cmd C)
XFER_RDY frames can be transferred for a different nexus.
ACK

**Figure 1.21 Example of XFER_RDY frames**

### 1.6.2.4 DATA information unit

Table 1.40 defines the data IU. The DATA frame is sent by an SSP INIT port to deliver write data (i.e., a write DATA frame) and is sent by an SSP TARG port to deliver read data (i.e., a read DATA frame). The maximum size of the data IU is the maximum size of any IU in an SSP frame. The minimum size of the data IU is one byte.

**Table 1.40 DATA information unit**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | DATA (1byte to 1024bytes) | | | | | | | |
| n-1 | | | | | | | | |

An SSP INIT port shall only transmit a write DATA frame:

a) in response to an XFER_RDY frame; or

b) after transmitting a COMMAND frame if the ENABLE FIRST BURST field in the COMMAND frame was set to one and the FIRST BURST SIZE field in the Disconnect-Reconnect mode page is not zero.

However, since drives do not support the FIRST BURST SIZE field, a drive can receive data only when it requests data with XFER_RDY frames.

If the value in the MAXIMUM BURST SIZE field on the Disconnect-Reconnect mode page is not zero, the maximum amount of data that is transferred at one time by an SSP TARG port per I_T_L_Q nexus is limited by the value in the MAXIMUM BURST SIZE field.

Drives do not support the MAXIMUM BURST SIZE field. However, the maximum data amount a drive can request with a single XFER_RDY frame is limited to 64 Kbytes.

An SSP TARG port shall set the NUMBER OF FILL BYTES field to zero in the frame header in all read DATA frames for a command except the last read DATA frame for that command. The SSP TARG port may set the NUMBER OF FILL BYTES field to a non-zero value in the last read DATA frame for a command (i.e., only the last read DATA frame for a command may contain data with a length that is not a multiple of four).

An SSP INIT port may set the NUMBER OF FILL BYTES field to a non-zero value contained in the last DATA frame that is sent as a response to an XFER_RDY frame. In this case, the SSP INIT port must set zeros in the NUMBER OF FILL BYTES fields in the frame headers of all the other data frames to be sent.

The initial read DATA frame for a given command shall set the DATA OFFSET field to zero. If any additional read DATA frames are required, the DATA OFFSET field shall be set to the value of the previous read DATA frame's data offset plus the previous read DATA frame's data length.

The initial write DATA frame for a given command shall set the DATA OFFSET field to zero. If any additional write DATA frames are required, the DATA OFFSET field shall be set to the value of the previous write DATA frame's data offset plus the previous write DATA frame's data length.

When a drive receives a write DATA frame, the following items are checked:

- HASHED DESTINATION SAS ADDRESS field

  When this field contains a value different from the Hashed SAS address of the drive, the drive sends the ACK and CREDIT_BLOCKED primitives, and discards the DATA frame.

- HASHED SOURCE SAS ADDRESS field

  When this field contains a value different from the SOURCE SAS ADDRESS field of the OPEN frame, the drive sends the CREDIT_BLOCKED primitive, and discards the DATA frame.

- CRC field

  When a CRC error is detected, the drive sends the NAK primitive, and discards the DATA frame. At this time, the SENSE DATA for INFORMATION UNIT iuCRC ERROR DETECTED is reported.

- Frame length

  When the IU length is greater than 1024 bytes, the drive discards the DATA frame. At this time, the SENSE DATA for INFORMATION UNIT TOO LONG is reported.

- TAG field

  When a DATA frame in which the same value as that set in the TARGET PORT TRANSFER TAG field of the XFER_RDY frame is received, but the tag is different from the one of the XFER_RDY frame, the drive sends the ACK primitive and CREDIT_BLOCKED primitive, and discards the DATA frame.

- TARGET PORT TRANSFER TAG (TPTT) field

  When a DATA frame with the TPTT field that does not match with the TPTT field of the XFER_RDY frame is received, the drive sends the ACK primitive and CREDIT_BLOCKED primitive, and discards the DATA frame. At this time, after temporarily closing the connection, the drive re-opens a connection and sends the SENSE DATA for TARGET PORT TRANSFER TAG RECEIVED.

- DATA OFFSET field

  The DATA OFFSET field is used to check whether frames are being transferred in the correct order. When the drive receives a frame with an offset value that the drive does not expect, the drive sends the ACK primitive and CREDIT_BLOCKED primitive, and discards the DATA frame. At this time, after temporarily closing the connection, the drive re-opens a connection and sends the SENSE DATA for DATA OFFSET ERROR.

- Received data length

  When a data item with a data length exceeding the value specified in the WRITE DATA LENGTH field of the XFER_RDY frame is received, the drive sends the ACK primitive and CREDIT_BLOCKED primitive, and discards the DATA frame. At this time, after temporarily closing the connection, the drive re-opens a connection and sends the SENSE DATA for TOO MUCH WRITE DATA.

  Meanwhile, when a drive sends a read DATA frame, the following values are set:

- HASHED DESTINATION SAS ADDRESS field

  The hashed SAS address of the COMMAND frame is set.

- HASHED SOURCE SAS ADDRESS field

  The hashed SAS address of the drive is set.

- NUMBER OF FILL BYTES field

  If the transferred bytes in the last DATA frame for the command are not aligned on a four byte boundary, the number of the extra bytes (4 - the remainder of [the number of all transferred bytes/4] bytes) is set in this field.

- TAG field

  The tag value of the COMMAND frame is set.

- TARGET PORT TRANSFER TAG field

  Set to 0xFFFF by the drive.

- DATA OFFSET field

  For the first DATA frame of the command, this field is set to zero. For the second DATA frame, the DATA OFFSET field is increased by the number of the transferred bytes of the first DATA frame.

- Number of transferred bytes

  When the number of bytes to be transferred is greater than or equal to 1024 bytes, this field is set to 1024. When the number of bytes to be transferred is less than 1024 bytes, this field is set to that number of bytes.

### 1.6.2.5 RESPONSE information unit

Table 1.41 defines the response IU. The RESPONSE frame is sent by an SSP TARG port to deliver SCSI status (e.g., GOOD or CHECK CONDITION) and sense data, or to deliver SSP-specific status (e.g., illegal frame format). The maximum size of the RESPONSE frame is the maximum size of any IU in an SSP frame.

**Table 1.41 RESPONSE information unit**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Reserved | | | | | | | |
| 9 | | | | | | | | |
| 10 | Reserved | | | | | | DATAPRES | |
| 11 | STATUS | | | | | | | |
| 12 | Reserved | | | | | | | |
| 15 | | | | | | | | |
| 16 | (MSB) | SENSE DATA LENGTH (n bytes) | | | | | | |
| 19 | | | | | | | | (LSB) |
| 20 | (MSB) | REPONSE DATA LENGTH (m bytes) | | | | | | |
| 23 | | | | | | | | (LSB) |
| 24 | RESPONSE DATA (DATAPRES: 01h) | | | | | | | |
| 23+m | | | | | | | | |
| 24+m | SENSE DATA (DATAPRES: 10b) | | | | | | | |
| 23+m+n | | | | | | | | |

Table 1.42 defines the DATAPRES field.

**Table 1.42 DATAPRES field**

| Code | Name | Description |
|---|---|---|
| 00b | NO_DATA | The SENSE DATA LENGTH field is zero, and the RESPONSE DATA LENGTH is zero. |
| 01b | RESPONSE_DATA | The SENSE DATA LENGTH field is zero, and the RESPONSE DATA LENGTH is four. |
| 10b | SENSE_DATA | The SENSE DATA LENGTH field is 48, and the RESPONSE DATA LENGTH is zero. |
| 11b | Reserved | |

The SSP TARG port shall return a RESPONSE frame with the DATAPRES field set to NO_DATA if a command completes without response data or sense data to return.

The SSP TARG port shall return a RESPONSE frame with the DATAPRES field set to RESPONSE_DATA in response to every TASK frame and in response to errors that occur while the transport layer is processing a COMMAND frame.

The SSP TARG port shall return a RESPONSE frame with the DATAPRES field set to SENSE_DATA if a command completes with sense data to return (e.g., CHECK CONDITION status).

- RESPONSE information unit NO_DATA format

If the DATAPRES field is set to NO_DATA, then:

a) the SSP TARG port shall set the STATUS field to the status code for a command that has ended (see SAM-3 for a list of status codes);

b) the SSP TARG port shall set the SENSE DATA LENGTH field to zero and the RESPONSE DATA LENGTH field to zero;

c) the SSP TARG port shall not include the SENSE DATA field and the RESPONSE DATA field.

- RESPONSE information unit RESPONSE_DATA format

If the DATAPRES field is set to RESPONSE_DATA, then:

a) the SSP TARG port shall set the STATUS field to zero and the SENSE DATA LENGTH field to zero;

b) the SSP TARG port shall not include the SENSE DATA field;

c) the SSP TARG port shall set the RESPONSE DATA LENGTH field to four.

d) the SSP TARG port shall include the RESPONSE DATA field.

Table 1.43 defines the RESPONSE DATA field, which contains information describing protocol failures detected during processing of a request received by the SSP TARG port. The RESPONSE DATA field shall be present if the SSP TARG port detects any of the conditions described by a non-zero value in the RESPONSE CODE field and shall be present for a RESPONSE frame sent in response to a TASK frame.

**Table 1.43 RESPONSE DATA field**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Reserved | | | | | | | |
| 1 | Reserved | | | | | | | |
| 2 | Reserved | | | | | | | |
| 3 | RESPONSE CODE | | | | | | | |

Table 1.44 defines the RESPONSE CODE field, which specifies the error condition or the completion status of a task management function.

**Table 1.44 RESPONSE CODE field**

| Code | Description |
|---|---|
| 00h | TASK MANAGEMENT FUNCTION COMPLETE |
| 02h | INVAILD FRAME |
| 04h | TASK MANAGEMENT FUNCTION NOT SUPPORTED |
| 05h | TASK MANAGEMENT FUNCTION FAILED |
| 08h | TASK MANAGEMENT FUNCTION SUCCEEDED |
| 09h | INVAILD LOGICAL UNIT NUMBER |
| All others | Reserved |

- RESPONSE information unit SENSE_DATA format

If the DATAPRES field is set to SENSE_DATA, then:

a) The STATUS field contains the status code for a command whose processing has ended.

b) The RESPONSE DATA LENGTH field is set to zero.

c) No RESPONSE DATA field exists.

d) The SENSE DATA LENGTH field indicates the length of the SENSE DATA field in bytes by a non-zero value. For a drive, the SENSE DATA LENGTH field is set to 48 bytes.

e) The SENSE DATA field contains sense information (see Chapter 5).

When the drive sends a RESPONSE frame, the following values are set:

- HASHED DESTINATION SAS ADDRESS field

  The hashed SAS address of the COMMAND frame is set.

- HASHED SOURCE SAS ADDRESS field

  The hashed SAS address of the drive is set.

- NUMBER OF FILL BYTES field

  Set to zero.

- RETRANSMIT bit

  When Ack timeout occurs after the drive sends a RESPONSE frame, the drive resends the RESPONSE frame with this bit set to 1.

- TAG field

  The tag value of the COMMAND frame is set.

- TARGET PORT TRANSFER TAG field

  This field is set to 0xFFFF by the drive.

- DATA OFFSET field

  Set to zero.

- DATAPRES field

  Refer to Table 1.44.

- STATUS field

  The SCSI status byte is set (see Chapter 2).

- SENSE DATA LENGTH field

  When sense data is sent, this field is set to 0x30.

- RESPONSE DATA LENGTH field

  When RESPONSE data is sent, this field is set to 0x04.

- RESPONSE DATA field

  Refer to Table 1.43.

- SENSE DATA field

  Refer to Chapter 5.

### 1.6.3 Sequences of SSP frames

Figure 1.22, Figure 1.23, Figure 1.24, and Figure 1.25 show examples of the sequences of frames for single task management functions and commands. Frames may be interleaved in any order when multiple commands and/or task management functions are outstanding. Frames may be transmitted during one or more connections (e.g., the COMMAND frame could be transmitted in a connection originated by the SSP INIT port, and the DATA frames and RESPONSE frame transmitted in one or more connections originated by the SSP TARG port).

Figure 1.22 shows the sequence of SSP frames for a task management function.

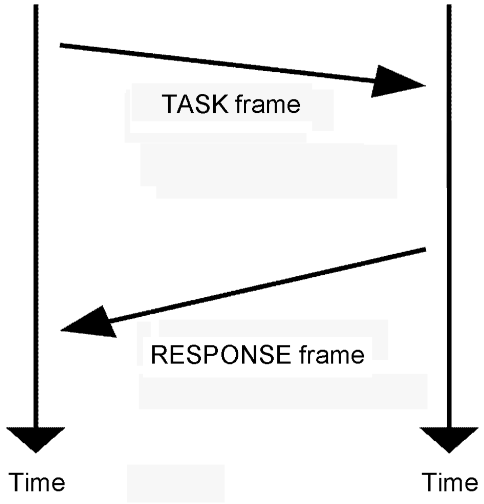


**Figure 1.22 Example of TASK frame**

Figure 1.23 shows the sequence of SSP frames for a write command.

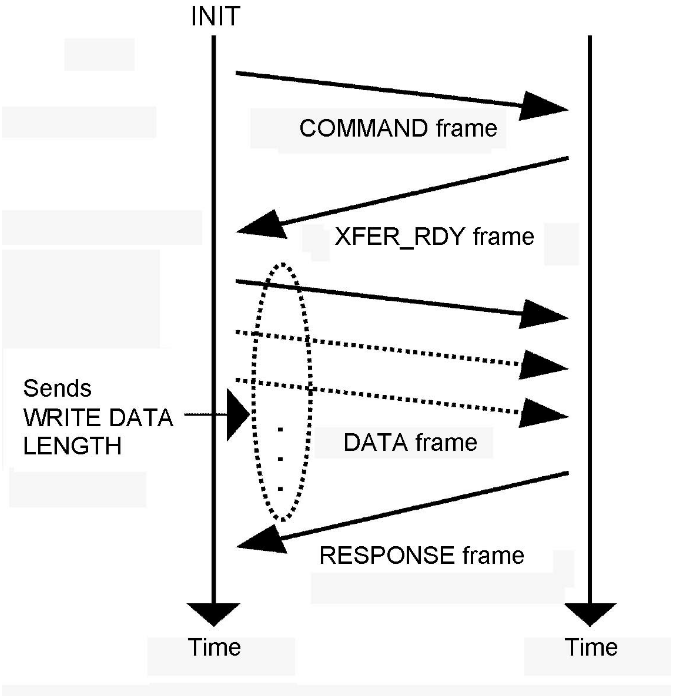


**Figure 1.23 Example of write command**

Figure 1.24 shows the sequence of SSP frames for a read command.

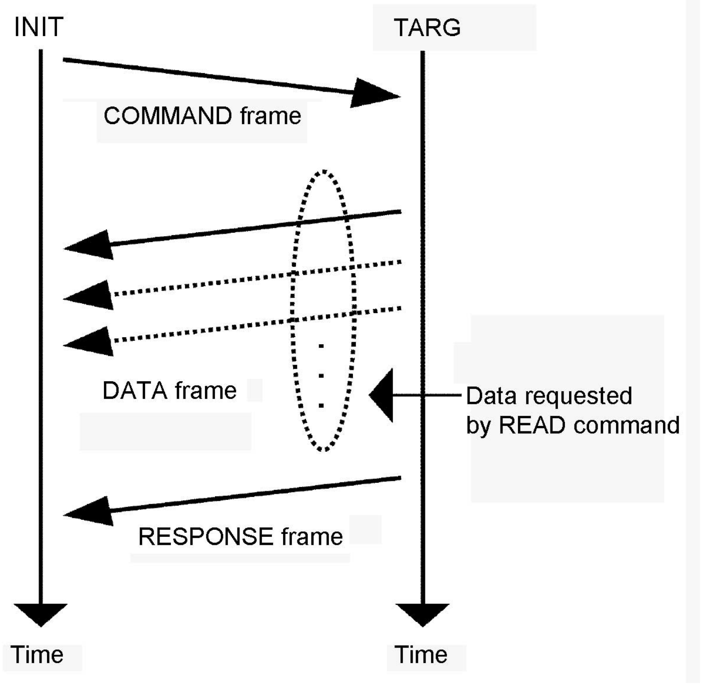


**Figure 1.24 Example of read command**

Figure 1.25 shows the sequence of SSP frames for a bidirectional command.

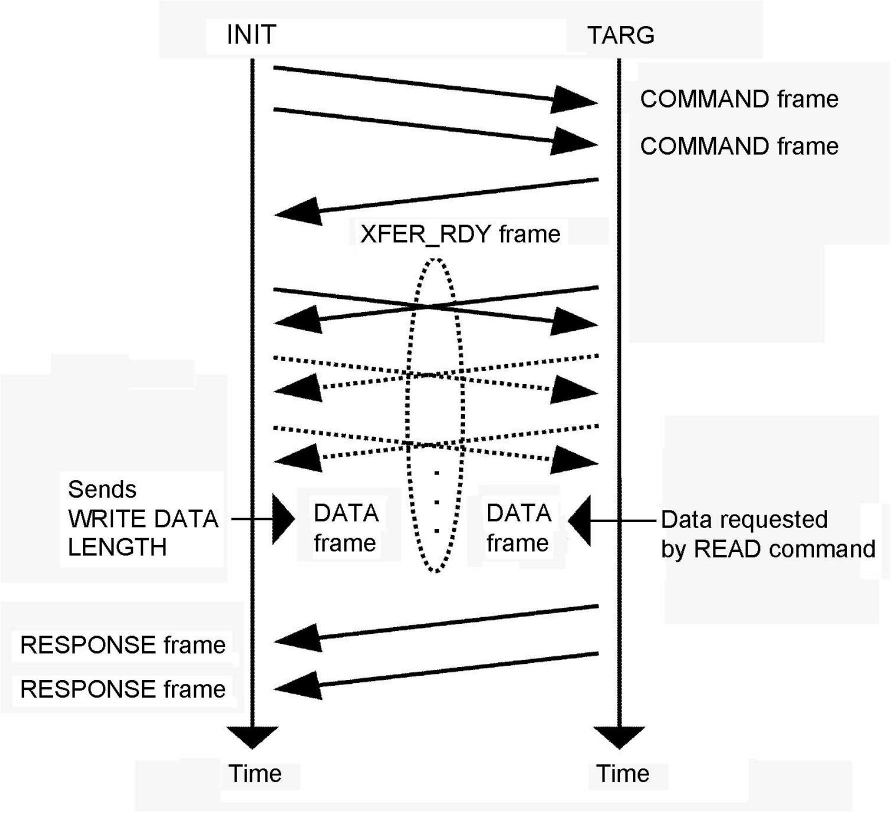


**Figure 1.25 Example of bidirectional command**

### 1.6.4 Exceptional event processing of a drive

If an exceptional event of the SAS protocol system (refer to Table 1.45) occurs in a drive, the drive temporarily rejects an SSP frame from the SSP INIT port due to recovery processing (abort processing). Therefore, the drive may return the OPEN_REJECT (RETRY) primitive for the connection request from an initiator. This is because the drive cannot perform abort processing completely while receiving an SSP frame from the SSP INIT port.

The processing sequence a drive performs for an exceptional event (Table 1.45) is as follows:

1) After an exceptional event occurs, the CREDIT_BLOCKED primitive instead of an RRDY primitive is sent to stop SSP frames from the initiator.

2) The connection is temporarily closed.

3) The recovery processing for the exceptional event (abort processing) is started.

4) If the recovery processing has not been completed, the OPEN_REJECT (RETRY) primitive is sent in response to the connection request from the initiator.

5) After the recovery processing for the exceptional event, an OPEN frame is sent so that the result of the recovery processing can be reported later with a RESPONSE frame.

6) When the OPEN_ACCEPT primitive is received from the initiator, the drive sends the CREDIT_BLOCKED primitive instead of an RRDY primitive.

7) A RESPONSE frame is sent.

8) The connection is closed. This completes the recovery processing for the exceptional event.

Figure 1.26 shows an example of the processing sequence a drive performs for an exceptional event.

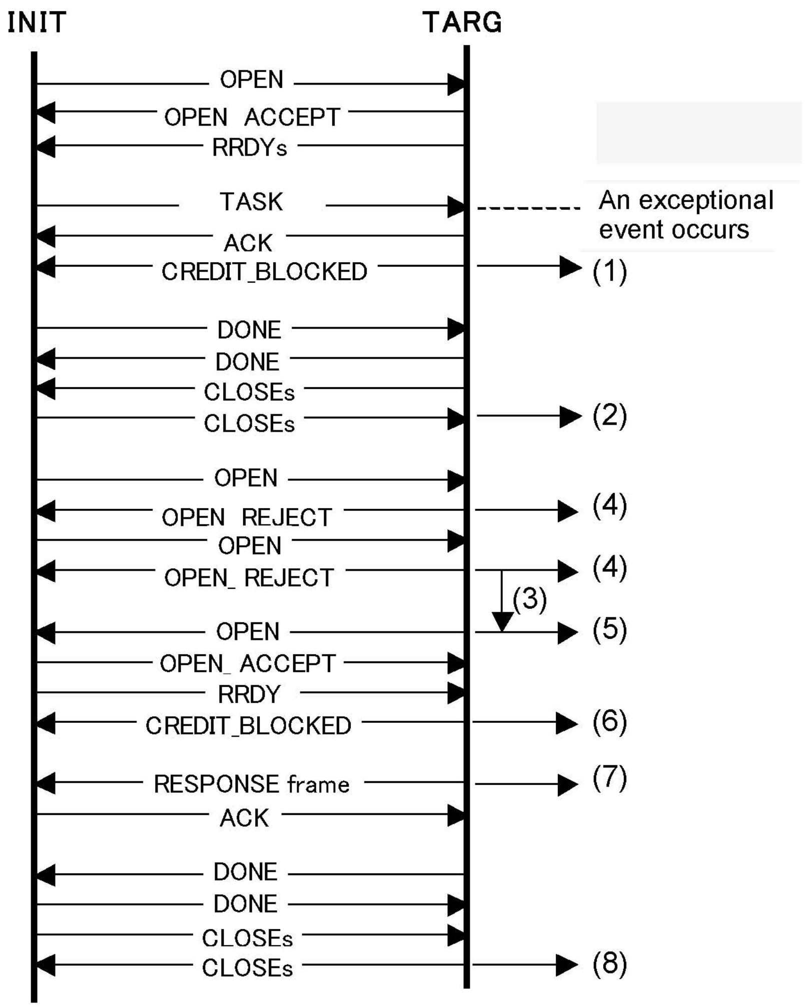


**Figure 1.26 Example of the processing sequence for an exceptional event**

Table 1.45 lists the events for which a drive performs exceptional event processing.

**Table 1.45 Exceptional event processing of a drive (1/2)**

| Exceptional event | | Processing |
|---|---|---|
| TASK management | TASK frame (ABORT TASK) | Aborts a task that matches with respect to I-T-L-Q, and reports TASK MANAGEMENT FUNCTION COMPLETE. |
| | TASK frame (ABORT TASK SET) | Aborts all the tasks that match with respect to I-T-L, and reports TASK MANAGEMENT FUNCTION COMPLETE. |
| | TASK frame (CLEAR TASK SET) | Aborts all the tasks of the INIT, and reports TASK MANAGEMENT FUNCTION COMPLETE.<br>Reports UNIT ATTENTION (06/2F/00) to the INIT other than nexus that performed abort processing. |
| | TASK frame (LOGICAL UNIT RESET) | Aborts all the tasks of the INIT, and reports TASK MANAGEMENT FUNCTION COMPLETE.<br>Reports UNIT ATTENTION (06/29/03) to all the INITs. |
| | TASK frame (QUERY TASK) | Reports TASK MANAGEMENT FUNCTION COMPLETE or TASK MANAGEMENT FUNCTION SUCCEEDED. |
| | TASK frame (CLEAR ACA) | Reports TASK MANAGEMENT FUNCTION NOT SUPPORTED. |
| | TASK frame (LUN ≠ 0) | Reports INVALID LOGICAL UNIT NUMBER. |
| Receiving system | Overlapped TAG | Reports for TAGGED OVERLAPPED COMMANDS (0B/4D/nn or 0B/4E/00). |
| | Queue full | Reports the QUEUE FULL status. |
| | DATA OFFSET error | Reports for DATA OFFSET ERROR (0B/4B/05). |
| | DATA overrun | Reports for TOO MUCH WRITE DATA (0B/4B/02). |
| | DATA frame CRC error | Reports for INFORMATION UNIT iuCRC ERROR DETECTED (0B/47/03). |
| | DATA frame TOO LONG | Reports for INFORMATION UNIT TOO LONG (0B/0E/02). |
| | TPTT error | Reports INVALID TARGET PORT TRANSFER TAG RECEIVED (0B/4B/01). |
| | DATA frame TAG error | Discards the frame. |
| | HASHED DESTINATION SAS ADDRESS error | Discards the frame. |
| | HASHED SOURCE SAS ADDRESS error | Discards the frame. |
| | Unknown IU frame received | Discards the frame. |
| | SSP frame shorter than 6 dwords received (no IU) | Discards the frame. |
| | I_Tnexus loss timer timeout in OPEN frame sending | Aborts all the tasks of the INIT, and reports UNIT ATTENTION (06/29/07). |
| | OPEN_REJECT indicating that operation cannot be continued received | Aborts the task. |

### Table 1.45  Exceptional event processing of a drive (2/2)

| Exceptional event | | Processing |
|---|---|---|
| Transmitting system | Ack timeout in XFER_RDY sending | Reports for ACK/NAK TIMEOUT (0B/4B/03). |
| | NAK reception in XFER_RDY sending | Reports for NAK RECEIVED (0B/4B/04). |
| | ACK timeout in DATA frame sending | Reports for ACK/NAK TIMEOUT (0B/4B/03). |
| | NAK reception in DATA frame sending | Reports for NAK RECEIVED (0B/4B/04). |
| | Buffer CRC error in DATA frame sending | Reports for ERROR TOO LONG TO CORRECT (03/11/02). |
| Others | When Check Status is reported with the setting of Qerr = 01 | Reports, and aborts all the commands in the Queue. |
| | When Check Status is reported with the setting of Qerr = 10 | Reports, and aborts all the commands in the Queue. |
| | When Preemp&Abort is ServiceAction at Persistent Reserve | Seizes Persistent Reservation from another INIT and aborts the command of the INIT. |
| | Firmware download | Enters exceptional event processing mode when downloading firmware. |

# CHAPTER 2 Command Processing

In this chapter, the basic theory and specifications concerning IDD command processing functions are described.

**IMPORTANT**

The IDD operates as the target (TARG). In the explanations given in this chapter, the IDD is labeled “TARG”, except in cases where a particularly clear distinction is necessary.

## 2.1 Command Format

Input/Output commands from the INIT (Initiator) to the IDD are executed by the CDB (Command Descriptor Block). The CDB is information which is transmitted from the INIT to the TARG in the CMND frame. In a number of commands, other than the CDB specifications, parameters which are necessary in executing a command are specified in the DATA frame. Details concerning these commands are described in the specifications for individual commands in Chapter 4.

The CDB used by the IDD has 4 formats, one with a length of 6, 10, 12 bytes and the other with a length of 16 bytes. The basic format of each respective CDB is shown in Tables 2.1, 2.2 and 2.3.

**Table 2.1 6-Byte CDB basic format**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Operation Code | | | | | | | |
| 1 | Reserved | | | Logical Block Address (MSB) | | | | |
| 2 | Logical Block Address | | | | | | | |
| 3 | Logical Block Address (LSB) | | | | | | | |
| 4 | Transfer Data Length | | | | | | | |
| 5 | Control Byte | | | | | | | |

**Table 2.2 10-Byte CDB basic format**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Operation Code | | | | | | | |
| 1 | Reserved | | | 0 | 0 | 0 | 0 | 0 |
| 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 Data Length (MSB) | | | | | | | |
| 8 | Transfer Data Length (LSB) | | | | | | | |
| 9 | Control Byte | | | | | | | |

**Table 2.3 12-Byte CDB basic format**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Operation Code | | | | | | | |
| 1 | Reserved | | | 0 | 0 | 0 | 0 | 0 |
| 2 | Logical Block Address (MSB) | | | | | | | |
| 3 | Logical Block Address | | | | | | | |
| 4 | Logical Block Address | | | | | | | |
| 5 | Logical Block Address (LSB) | | | | | | | |
| 6 | Transfer Data Length (MSB) | | | | | | | |
| 7 | Transfer Data Length (LSB) | | | | | | | |
| 8 | Transfer Data Length (MSB) | | | | | | | |
| 9 | Transfer Data Length (LSB) | | | | | | | |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | Control Byte | | | | | | | |

The meanings of each of the fields in the CDB are explained below. Depending on the type of command, the basic format of the CDB and the definition and meaning of a field may differ. Details are described in the specifications for individual commands in Chapter 4.

### (1) Operation code

**Table 2.4 Operation code**

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

The top byte of all CDBs shows the format and type of command that is being executed.

a. Group code

The group code decides the number of bytes in the CDB and its format. The IDD uses the commands of the groups shown below.

Group 0 (“000”): 6-byte CDB (Shown in Figure 2.1)

Group 1 (“001”): 10-byte CDB (Shown in Figure 2.2)

Group 2 (“010”): 10-byte CDB (Shown in Figure 2.2)

Group 3 (“011”): Reserved Operation Code (Shown in Section (6))

Group 4 (“100”): 16-byte CDB

Group 5 (“101”): 12-byte CDB (Shown in Section 2.3)

Group 6 (“110”): Vendor unique CDB (shown in Section 2.8.3)

Group 7 (“111”): Vendor unique CDB (shown in Section 2.8.3)

b. Command code

The command code specifies the type of command in each group.

### (2) Logical block address

This field shows the top logical data block address of the data block group on the disk medium that is to be processed by the command. In a Group 0 CDB, 21-bit block addressing can be used, and in a Group 1, Group 2 or Group 5 CDB, 32-bit block addressing can be used. Standards for logical data block addressing in the IDD are described in Section 2.9.

### (3) Transfer data length

This field specifies the length of data to be transferred between the INIT and the TARG by execution of the command, either as the number of logical data blocks or the number of bytes. In subsequent descriptions, the former is called the “Number of Transfer Blocks” and the latter is called the “Transfer Byte Length” or the “Parameter List Length”.

Furthermore, depending on the command, use of this field can have other meanings, or no meaning at all. There are also some commands which allocate 3 or more bytes as the transfer data length field. Detailed standards concerning these commands are described in the specifications for individual commands in Chapter 4.

a. Transfer block count

When the “Transfer Data Length” field is specified as the “Number of Transfer Blocks”, this field specifies the number of logical data blocks transferred between the INIT and IDD.

In a command with a 1-byte length, if the value specified in this field is zero, it is regarded that 256 blocks have been specified, and specification in a range of from 1 to 256 blocks is possible. On the other hand, in a command with a 2-byte length, when the value specified in this field is zero, data transfer is not executed. Specification in a range of from 0 to 65,535 blocks is possible.

b. Transfer byte length or parameter list length

When the transfer data length is specified as the “Transfer Byte Length” or “Parameter List Length”, this field specifies the length of the data transferred between the INIT and IDD by that command in number of bytes. When zero is specified in this field, data transfer is not executed, except in cases where it is particularly stipulated in the specifications for individual commands in Chapter 4.

In commands which send the parameters which are necessary for command execution are sent from the INIT to the IDD, this field is called “Parameter List Length” and specifies the total number of bytes of the parameter list sent by the INIT.

On the other hand, with commands which receive information from the IDD (REQUEST SENSE, INQUIRY, etc.), it is called “Transfer Byte Length” and specifies the maximum number of bytes that can be received from the INIT (the number of bytes in the area secured in the INIT for receiving information). The IDD transfers either the number of effective bytes of information specified by the command or the value specified in the “Transfer Byte Length”, whichever value has the smaller number of bytes.

## (4) Control byte

**Table 2.5 Control byte**

| Bit 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

a. Bits 7, 6 (vendor unique)

When any value other than “0” is specified for these bits, the IDD terminates command processing with the CHECK CONDITION status.

b. Bit 0 (Link)

This IDD does not support Link, so this bit should be set on “0”.

## (5) Handling an illegal CDB

If there are errors in the contents of a CDB description (specification), or if there is an error in the specification of a parameter transferred from the INIT in accordance with a CDB specification, that command ends with the CHECK CONDITION status. In the case of a command that changes data on the disk medium, when there is an error in the CDB specification, the disk medium is not changed by that command, but when there is an error in a parameter transferred in a DATA frame, the contents of the disk medium in the area specified in that command may be changed. Also, a DATA frame request may be executed after receiving a DATA frame, but those data are not used.

## 2.2 Status Byte

The format of the status byte and the types of status which the IDD supports are shown in Table 2.6.

The status byte is 1 byte of information in the RESP (response) frame which notifies the INIT from the TARG after a command is completed, and which shows the results of executing the command. Also, when an Input/Output operation request has been received, even if the TARG cannot execute the command, the status byte is reported. However, by forcibly interrupting execution by an abnormal state such as ABORT TASK, ABORT TASK SET, CLEAR TASK SET, LOGICAL UNIT RESET, HARD RESET, or SAS PORT, if the command is cleared, the status byte for that command is not reported.

**Table 2.6 Status**

| Status code | Status |
|---|---|
| 00h | GOOD Status |
| 02h | CHECK CONDITION Status |
| 04h | CONDITION MET Status |
| 08h | BUSY Status |
| 10h | INTERMEDIATE Status |
| 14h | INTERMEDIATE CONDITION MET Status |
| 18h | RESERVATION CONFLICT Status |
| 22h | COMMAND TERMINATED Status |
| 28h | TASK SET FULL Status |

### (1) GOOD status

This status indicates that execution of the command ended normally.

### (2) CHECK CONDITION status

This status is reported in the case of a)~c) below. The IDD generates sense data when this status is reported and displays the detailed cause. The IDD transfers the generated sense data together with this status report in the same RESP frame. Therefore, it is unnecessary to gather sense data using the REQUEST SENSE command.

a) If the sense key in the sense data shows RECOVERED ERROR [= 1], it shows that the last command, which resulted in the CHECK CONDITION status, ended normally in conjunction with error recovery processing by the IDD.

b) If the sense key in the sense data shows UNIT ATTENTION [= 6], it shows that the IDD is being kept in the Unit Attention state. For details of the Unit Attention state, see item 2.4.

c) Any cases other than the above indicate that it was impossible to execute the command or the command ended abnormally.

### (3) CONDITION MET Status

Not supported.

### (4) BUSY status

This status indicates that the IDD is busy, and it cannot accept a new command. Usually, an INIT that has received this status re-issues the same command after an adequate period of time.

The IDD reports the BUSY status when the WRITE BUFFER command is issued to download a microcode while the IDD has commands in its command queue that have not been executed yet.

### (5) INTERMEDIATE status

Not supported.

### (6) INTERMEDIATE CONDITION MET Status

Not supported.

### (7) RESERVATION CONFLICT status

This status indicates that the IDD is currently reserved by another INIT and use is impossible until the reservation status is released. Normally, an INIT that receives this status reissues the original command after waiting for the appropriate period of time only.

### (8) COMMAND TERMINATED status

Not supported.

### (9) TASK SET FULL status

This status is reported when there is no empty space in the command queue and the IDD cannot register tagged commands it has received in the command queue.

## 2.3 Command Queuing Function

The IDD is equipped with the command queuing function. Through command queuing, the IDD can receive multiple commands in advance and can execute them.

Through the tagged queuing function, the IDD can receive multiple commands from the same INIT or from different INITs until the command queue is full. The number of commands that can be received by the IDD is 128 per IDD, without relation to the INIT. When the IDD receives a new command, if the command queue is full, the new command is responded to with the TASK SET FULL status.

The IDD controls the command queue, but it is possible for the INIT to delete commands from the queue by adding a command.

When the IDD adds a command to the queue, an INIT can specify the TASK ATTRIBUTE of the CMND frame to give the IDD instructions about the execution order of commands or the command to be executed next. There are three TASK ATTRIBUTEs: ORDERED, HEAD OF QUEUE, and SIMPLE.

When ORDERED is specified, the IDD executes commands in the order they are received. All the commands received with SIMPLE specified before a command received with ORDERED specified are, regardless of the INIT, executed before the command received with ORDERED specified. All the commands received with SIMPLE specified after a command received with ORDERED specified are executed after the command received with ORDERED specified.

Commands received with a HEAD OF QUEUE are registered at the top of the queue for waiting execution. The IDD does not interrupt the current command execution and executes them after completion of current command execution. When commands with the HEAD OF QUEUE are received continuously, the IDD first executes the command which was received last.

If “0000” or “0001” is specified by the Queue algorithm modifier in the control mode page, the IDD performs reordering processing of commands with respect to commands issued together with the SIMPLE. Reordering processing is performed with the purpose of reducing the total processing time in command processing.

- Conditions for Reordering:

  If commands which are objects of reordering are issued by an INIT which permits reordering together with a SIMPLE.

- Commands which are Objects of Reordering:

  READ, READ EXTENDED, WRITE, WRITE EXTENDED

If the INIT permits command reordering processing, the IDD changes the command processing order. It is necessary for the INIT to control concerning the validity of data.

The RESERVE, RELEASE, RESERVE EXTENDED, and RELEASE EXTENDED commands should be issued with the specification of ORDERED QUEUE. If any of these commands is issued with the specification of HEAD OF QUEUE, the command may cause the duplicated reserved status with a command that has been issued before.

Since the TEST UNIT READY and INQUIRY commands do not affect the IDD status, they can be issued with the specification of HEAD OF QUEUE.

An INIT can specify error recovery options with the QErr bits of the control mode parameter (Page A) of the Mode Select parameters. Deferred errors may be reported for commands whose processing has already ended. Therefore, the queue tag values assigned to those commands are not reported.

Use ABORT TASK, ABORT TASK SET, CLEAR TASK SET, or LOGICAL UNIT RESET to clear some or all of the queued commands.

## 2.4 UNIT ATTENTION Condition

The Unit Attention condition is a function for notifying the INIT asynchronously of events (status changes) which occur in the TARG or logical unit.

### 2.4.1 Generation of the UNIT ATTENTION condition

Events which cause the Unit Attention condition to be generated are any of the following events.

(1) When a Power On or RESET occurs

If the IDD is reset by a power on, HARD RESET, or LOGICAL UNIT RESET, regardless of whether the disk drive is in the ready state or not, the Unit Attention condition is generated to all the INITs.

(2) When I-T Nexus Loss occurs

When I-T Nexus Loss has been detected and command processing of an INIT that has detected the I-T Nexus Loss is aborted, the Unit Attention condition is generated for the INIT.

(3) When drive parameters are changed (if changed by another INIT)

If any of the following parameters is changed from an INIT, the Unit Attention condition is generated for all the INITs except the one that changes that parameter:

- A parameter specified by the MODE SELECT or MODE SELECT EXTENDED command
- A parameter specified by the SET DEVICE IDENTIFIER command

### (4) Commands cleared by another INIT

If the following events have occurred, the command which is currently being executed and commands in the queue are cleared, and this Unit Attention condition is generated.

- The CLEAR TASK SET is issued by any INIT.
- An INIT reports an error when the QErr bits of MODE SELECT parameter page A are set to “01’.

However, the INITs that have issued CLEAR TASK SET and the INITs that have reported errors do not enter the Unit Attention condition holding state.

## 2.4.2 Response and release condition at UNIT ATTENTION condition hold state

A Unit Attention condition generated by the IDD due to the occurrence of one of the above-mentioned events is held for each INIT individually, and this condition is held until the Unit Attention condition is cleared by an INIT which is the object of the hold issues the commands specified below.

When the IDD is holding the Unit Attention condition, if it receives a command from an INIT which is the object of the hold, one of the operations below, depending on the type of command issued, is performed by the IDD.

### (1) Commands other than the INQUIRY, REQUEST SENSE, and REPORT LUNS commands

The IDD reports the CHECK CONDITION status in response to the issued command. Through the CHECK CONDITION status report, the Unit Attention condition with respect to that INIT is cleared. The sense key for the sense data generated at this time is UNIT ATTENTION [= 6] and the additional sense code shows the event which generated the Unit Attention condition, as shown below.

| | |
|---|---|
| • Power on | [=29-01] |
| • Hard Reset | [=29-02] |
| • LOGICAL UNIT RESET | [=29-03] |
| • I-T Nexus Loss Occurred | [=29-07] |
| • Mode parameters changed | [=2A-01] |
| • Reservations Preempted | [=2A-03] |
| • Reservations Released | [=2A-04] |
| • Registrations Preempted | [=2A-05] |
| • Commands cleared by another INIT | [=2F-00] |
| • Micro code has been change | [=3F-01] |
| • Changed Operating Definition | [=3F-02] |
| • Device Identifier Changed | [=3F-05] |

However, if the IDD responds with a TASK SET FULL because the issued command is not received, the Unit Attention condition is not cleared.

(2) INQUIRY command

The INQUIRY command is executed normally, but the Unit Attention condition is not cleared.

(3) REQUEST SENSE command

The IDD executes the REQUEST SENSE command normally, and sends the sense data which show the Unit Attention condition which is currently being held to the INIT. At this time, the Unit Attention condition with respect to that INIT is cleared.

(4) REPORT LUNS command

The REPORT LUN command is executed normally, but the Unit Attention condition is not cleared.

### 2.4.3 UNIT ATTENTION condition multiple hold

If any Unit Attention condition occurs and another Unit Attention condition occurs which is caused by other factors before the first Unit Attention condition is cleared by the INIT for which that condition is held, those multiple Unit Attention conditions are held and the IDD reports multiple unit attention conditions in sequence.

## 2.5 Sense Data Hold State

If the status is the Check Condition status when the status is reported, this IDD adds that sense data to the response frame and notifies the INIT of it.

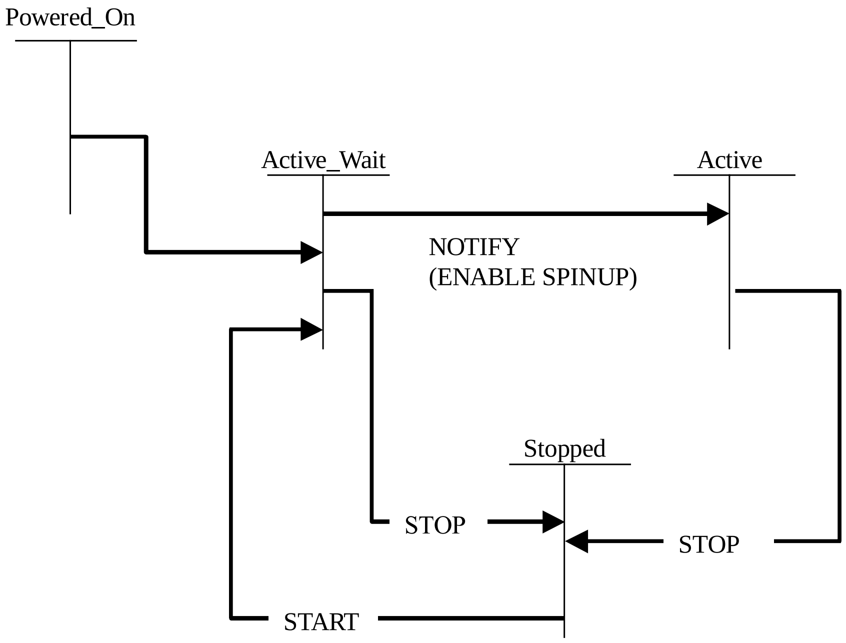
Therefore, the sense data hold state does not occur and the CA status does not occur.

The function which reports sense data automatically is called the Auto Sense function.

This IDD operates with the Auto Sense function activated at all times and this function cannot be deactivated.  Also, since this IDD does not support ACA, it does not enter the ACA state.

## 2.6 Power Condition

The IDD has three power condition states: Active, Active_Wait, and Stopped.



- Active_Wait state

  In this state, the IDD is waiting for motor start with NOTIFY (ENABLE SPINUP). When the IDD receives a command that cannot be executed due to "not ready" during this state, the IDD reports the CHECK CONDITION status. In this case, "NOT READY [= 02]/LOGICAL UNIT NOT READY, NOTIFY (ENABLE SPINUP) REQUIRED [= 04-11]" is reported as sense data.

  When the IDD receives NOTIFY (ENABLE SPINUP), it starts the motor. The IDD enters the Active state after the motor is successfully started. When the IDD receives a command that cannot be executed due to "not ready" while starting the motor, the IDD reports the CHECK CONDITION status. In this case, "NOT READY [= 02]/LOGICAL UNIT IS IN PROCESS OF BECOMING READY [= 04-01]" is reported as sense data.

  When the IDD receives the STOP command, it enters the Stopped state.

- Active state

  In this state, the drive is ready.

- Stopped state

  In this state, the IDD is waiting for the START command. When the IDD receives a command that cannot be executed due to "not ready," the IDD reports the CHECK CONDITION status. In this case, "NOT READY [= 02]/LOGICAL UNIT NOT READY, INITIALIZING COMMAND

REQUIRED [= 04-02]" is reported as sense data. When the IDD receives the START command, it enters the Active_Wait state.

The IDD enters the Active_Wait state after the power is turned on. When the spindle motor reaches the state of steady rotation with NOTIFY for the first time after the power is turned on, the IDD reads the "System Information" from the system space on the disk drive and initializes each type of control information. ("System information" includes such information as information on MODE SELECT parameters and disk media defects). When this operation is completed, the IDD enters the Active state.

If, at this time, the system information fails to be read or the initialization of the disk medium (formatting) does not end normally for some reason, data on the medium cannot be accessed even when the IDD enters the Active state.

- Commands that can be executed even in the Not Ready state

When the IDD receives any of the following commands, the IDD executes the command even in the Not Ready state:

- START/STOP UNIT command
- RESERVE or RESERVE EXTENDED command
- RELEASE or RELEASE EXTENDED command
- WRITE BUFFER command
- READ BUFFER command
- INQUIRY command
- REQUEST SENSE command

When the IDD is in the sense data holding state and the REQUEST SENSE command is executed normally, the IDD sends the sense data held at this time to the INIT. When the IDD is not in the sense data holding state, the IDD sends sense data corresponding to the state of the IDD at this time to the INIT.

- Operation when formatting is not completed normally

While the FORMAT UNIT command is not being executed following a change of parameters related to data format using the MODE SELECT command, or when the operation terminates abnormally for some reason (for example, the power going off or a HARD RESET) during FORMAT UNIT command execution, the data on the disk medium cannot be accessed normally. In this case, the IDD responds to disk media access commands with the CHECK CONDITION status.

The sense data generated in the former case shows MEDIUM ERROR [= 3]/Medium format corrupted [= 31-00], and in the latter case, MEDIUM ERROR [= 3]/FORMAT command failed [= 31-01]. In both cases, the IDD is restored to a usable condition by using the FORMAT UNIT command and initializing the disk medium.

## 2.7 LED Display

Table 2.7 lists the items displayed by the IDD READY LED.

**Table 2.7 LED display**

| | Mode Page 19 Ready LED Meaning | |
|---|---|---|
| | 0 | 1 |
| Active state (power condition) | a) On when a command is not being executed.<br>b) Flashes when a command is being executed (in 50 ms intervals). | a) Off when a command is not being executed.<br>b) Flashes when a command is being executed (in 50 ms intervals). |
| Active_Wait or Stopped state (power condition) | a) Off when a command is not being executed.<br>b) Flashes when a command is being executed (in 50 ms intervals). | |
| Motor being started or stopped (*1) | Flashes (in 0.5 s intervals) | |
| Formatting in progress (*1) | Flashes (in 1.0 s intervals) | |

*1) These display items take priority over display items caused by power conditions. Even if a command is received while "Motor being started or stopped," or "Formatting in progress" is displayed, the LED display stays unchanged.

## 2.8 Command Processing Exceptions

### 2.8.1 Overlapping commands

The IDD recognizes that commands have been overlapped when it receives a command with the same tag from the same INIT as a command being executed or held in its queue, and abnormally terminates command processing.

The execution of a command ends when the TARG reports RESPONSE to the INIT. The execution of a command is also terminated with ABORT TASK, ABORT TASK SET, CLEAR TASK SET, LOGICAL UNIT RESET or HARD RESET.

The IDD terminates abnormally all commands (which are being executed or are being queued) which it has already received from an overlapping INIT and also terminates abnormally both the commands that caused the overlap, in the order described below.

1) If, during execution of a command received from an INIT, the IDD terminates execution of the command. If the command is still in the queue and has not yet been executed, the IDD clears that command.

2) The IDD reports the CHECK CONDITION status with for the command that caused the overlap. The sense data generated by the IDD at this time shows ABORTED COMMAND [= B]/Overlapped commands attempted [= 4E-00] or Tagged Overlapped [= 4D-nn] (nn: tag number).

**IMPORTANT**

1) The INIT is permitted to sent an ABORT TASK, ABORT TASK SET, CLEAR TASK SET, LOGICAL UNIT RESET, or HARD RESET command, specifying the logical unit in order to terminate processing of a command that is currently disconnecting. (Shown in item 2.8.5.)
2) Overlapped command specifications are applicable without dependence on the type of command that was issued second. For example, even if the command that was issued second is an INQUIRY or REQUEST SENSE command, the IDD reports the CHECK CONDITION status and terminates both commands abnormally.

### 2.8.2 Illegal LUN specification

The IDD supports only the logical unit number (LUN) LUN = 0. If a LUN other than this is specified, the IDD operates in one of the following ways, depending on the type of command that is issued at that time.

1) For an INQUIRY command, even if an invalid LUN is specified, the command is executed normally. However, byte 0 of the “Standard INQUIRY Data” transferred to the INIT by that command (the “Qualifier” field and the “Device Type Code” field) shows X‘7F’.

2) If an invalid LUN is specified for any command other than the INQUIRY command or the REQUEST SENSE command, that command is executed normally.

### 2.8.3 Reserved operation code

Group 6, 7 command operation codes (X‘C0’ ~ X‘FF’) are reserved by Fujitsu. When any command which has these operation codes is issued, the IDD may not necessarily respond with the CHECK CONDITION status (ILLEGAL REQUEST [= 5] Invalid command operation code [= 20-00]).

The INIT must not issue commands which have these operation codes.

### 2.8.4 Error recovery processing

When an error which it is possible to retry is detected in the IDD, the IDD attempts error recovery processing of the detected error during command execution.

The INIT can specify whether or not to report detailed parameters and successfully recovered errors related to error recovery processing using either the MODE SELECT or the MODE SELECT EXTENDED command. Also, by the INIT specifying those parameters, they can be saved in the system space on the disk medium and they can be changed temporarily without being saved. After the power is turned on, or after reset, the IDD reads out the saved parameters and initializes the error recovery processing procedure.

See Chapter 4, “Command Specifications” concerning details of the MODE SELECT and MODE SELECT EXTENDED commands.

An outline of the error recovery processing executed by the IDD is shown below.

(1) Recovery procedures for disk drive errors

The IDD executes error recovery processing like that shown in Table 2.8 for errors detected during data access on the disk medium. Caution is necessary when performing these recovery processing procedures, because they are accompanied by rotational delays for repositioning data blocks on the disk medium or by added command processing time due to initialization of the positioning control system, etc.

The INIT can control the number of retries by page 1 (Read/Write error recovery parameters), page 7 (Verify error recovery parameters) or page 21 (Additional error recovery parameters) of the MODE SELECT parameters, but during normal use, it is recommended that the default values specified by the IDD be used.

**Table 2.8 Outline of disk drive error recovery processing**

| Item | Type of Error | Error Recovery Processing |
|---|---|---|
| 1 | Seek Error | Rezero (Return to Zero Cylinder), readjustment of positioning control system, and repositioning to the data block. |
| 2 | Uncorrectable Data Error | Reread |
| 3 | Correctable Data Error | Correct by ECC. |

**IMPORTANT**

The start of execution timing for this automatic readjustment operation is ordinarily impossible for the INIT to predict. The automatic readjustment operation is performed when there is no command being executed or waiting in the queue, but execution of commands issued immediately after the IDD starts a readjustment operation is caused to wait until the readjustment operation is completed.

### 2.8.5 Abort processing

Abort measures which can be performed by the INIT are as shown below.

- HARD RESET
- LOGICAL UNIT RESET
- CLEAR TASK SET
- ABORT TASK SET
- ABORT TASK

**Table 2.9 Comparison between SAS and SCSI about definition**

| Definition by SAS | Definition by SCSI |
|---|---|
| HARD RESET | Comparable to SRST |
| LOGICAL UNIT RESET | Bus Device Reset Message |
| CLEAR TASK SET | Clear Task Set Message |
| ABORT TASK SET | Abort Task Set Message |
| ABORT TASK | Abort Task Message |

Each abort processing operation performs abort processing for the specified nexus.

- Nexus
    - I: INIT
    - T: TARG
    - L: Logical unit
    - Q: Queue tag

Each processing operation is outlined as follows:

### (1) HARD RESET

HARD RESET is used to abort all commands and to initialize the IDD to restore it to the same state as at the time of power-on.

After this reset operation, the UNIT ATTENTION condition with SCSI Reset Occurred [= 06-29-02] is generated for all the INITs.

### (2) LOGICAL UNIT RESET

LOGICAL UNIT RESET TASK can be used to abort an L nexus command specified by an INIT and to initialize TARG to restore it to the same state as at the time of power-on. However, it must be noted that commands that have been issued by other initiators are also cleared in a multi-initiator environment.

After this task is performed, the unit attention condition for Target Reset Function Occurred [= 06-29-03] is generated for all the INITs.

### (3) CLEAR TASK SET

CLEAR TASK SET is used to abort processing of the L nexus commands specified by an INIT. Environment settings and conditions, such as MODE SELECT parameters, that have been specified in advance are not changed.

After this task is performed, the unit attention condition for Command Cleared by Another INIT [= 06-2F-00] is generated for the INITs whose commands have been subject to abortion except for the INIT that has issued this task.

### (4) ABORT TASK SET

ABORT TASK SET is used to abort the I-T-L nexus commands specified by an INIT.

### (5) ABORT TASK

ABORT TASK is used to abort processing of the I-T-L-Q nexus command specified by an INIT.

- Abort processing during write operation

In particular, if a command to write data to the disk medium which is currently being executed is cleared, the IDD aborts processing of that command as shown in Table 2.10. Stopping overlapped commands which are currently being executed (see 2.8.1) is accomplished by the same treatment. The INIT must investigate the command completion status, then if necessary, it must implement data recovery processing.

**Table 2.10 Reset processing during write**

| Type of command | Halting process of command execution |
|---|---|
| WRITE<br>WRITE EXTENDED<br>WRITE AND VERIFY<br>SEND DIAGNOSTIC (Write/Read Test)<br>WRITE LONG<br>WRITE SAME | Data blocks which are currently being written are processed normally, including the ECC portion, and execution of the command is terminated at the point when that processing is completed. Not all the data transferred from the INIT to the IDD will necessarily be written to the disk media. |
| FORMAT UNIT | At the point when processing of the data block that is currently being written (initialized) is completed, execution of the command is halted. Since the formatting results cannot be guaranteed for the entire disk surface, it is necessary for the INIT to reissue the command. |
| REASSIGN BLOCKS | At the point when processing of alternate blocks which are currently being assigned is completed, execution of the command is halted. Not all the alternate blocks specified for reassignment processing by the INIT will necessarily have been processed. |
| MODE SELECT<br>MODE SELECT EXTENDED<br>LOG SENSE (Specifying parameter save) | If a parameter save operation has already started, that command is executed until it is completed. However, since the INIT cannot judge whether the parameters have been saved or not, it is necessary for the INIT to confirm the status by the MODE SENSE command or the LOG SENSE command, or reissue the command. |
| SYNCHRONIZE CACHE | Data blocks which are currently being written are processed normally, including the ECC portion and the command is halted at the point when that processing is completed. Not all the data which is the write object will necessarily be written to the disk media. |

### 2.8.6 Fatal hardware errors

(1) Self-diagnostic errors

If a fatal error was detected in the hardware through an initial self-diagnosis, off-line self-diagnosis or on-line self diagnosis (SEND DIAGNOSTIC Command), turning of the spindle motor is stopped.

When in this state, the IDD reports the CHECK CONDITION status for all Input/Output operation requests except the REQUEST SENSE command. The sense data reported at this time shows HARDWARE ERROR [=4]/Diagnostic failure on component “nn” [= 40-nn]. It is necessary for the INIT to generate a RESET condition or sent a TARGET RESET and attempt recovery of the error state. The recommended procedure for error recovery is explained in 5.2, “INIT Error Recovery Methods (Recommended)”.

See the SEND DIAGNOSTIC Command and RECEIVE DIAGNOSTIC RESULT Command concerning the self-diagnosis function.

(2) Unrecoverable hardware errors

Limited to cases in which a fatal hardware error occurs during execution of a command, and termination processing such as a CHECK CONDITION status report cannot be executed, the IDD may halt rotation of the spindle motor.

After this state occurs, the IDD reports the CHECK CONDITION status for all input/output operation requests except the REQUEST SENSE command. The sense data reported at this time indicate HARDWARE ERROR [=4] / Internal target failure  [=44-nn].  For recommended procedures for error recovery methods, see the explanation in Section 5.2 “INIT's Error Recovery Methods (Recommended)”.

## 2.9 Data Block Addressing

### 2.9.1 Definition of data space

The IDD divides the data storage area on the disk drive into the following two types of data area and controls them as such.

- User space: user data storage area
- System space: IDD exclusive area

Of these two types, the use can clearly gain access to the user space. This space has the same data formatting and defect control methods and it is possible to access it by logical data block addressing, as described in item 2.9.2. The system space is accessed when the power is turned on, or during processing of specific commands, but the user cannot access it directly.

A spare sector area (replacement area) is assured in the user space for replacement of defective sectors. The user can (using the MODE SELECT or MODE SELECT EXTENDED command), allocate several sectors in the final track of each cylinder and several cylinders (replacement cylinders) inside the user space (replacement cylinders) as the replacement area.

For defective sectors on the disk medium, through IDD internal defect management, data blocks for replacement are assigned in defective sector units. Through this defect management, the INIT can regard all the logical data blocks in the user space as error free and can access them.

For details concerning the data format on the disk medium (cylinder configuration, track format and sector format) as well as details on defect management methods and replacement block assignment methods, see Chapter 3, “Data Format” in the “Product Manual”.  Also, see Chapter 6, “Management of the Disk Medium”, for an outline of defect management methods.

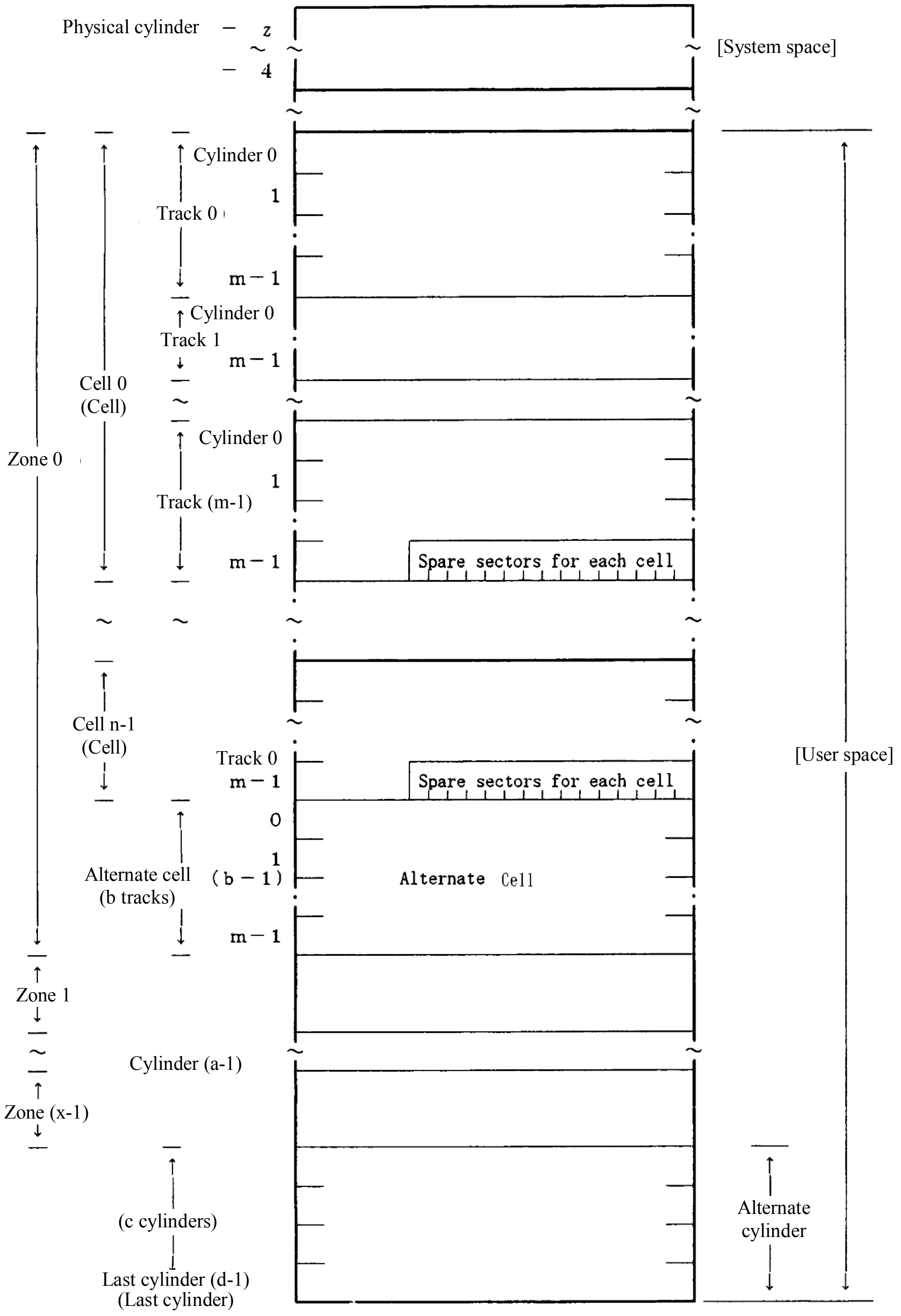


**Figure 2.1 Data space configuration**

### 2.9.2 Logical block addressing

The IDD uses logical data block addressing which is not dependent on the disk drive's physical structure as the method of data access on the disk medium. The IDD makes correspondence between each physical sector and each logical data clock address during formatting. Access to the data on the disk medium is performed in logical data block units and the INIT specifies the logical data block address that is its object during access.

In logical data block addressing, specifying of a data block address is a function which specifies 2 continuous binary numbers for each drive. Furthermore, the INIT can know the logical data block address range in the user space where specification is possible using the READ CAPACITY command.

(1) User space logical block addresses

The top data block in the user space is made logical data block address "0," then continuous logical data block addresses are allocated to each data block until the last data block in the user space.

The IDD makes cylinder 0, track 0, and sector 0 the top logical data block, and allocates subsequent logical data blocks in the order described below to addresses in ascending order.

1) Within the same track, logical data blocks are allocated to sector numbers in ascending order.

2) Within the same head of the same cell, succeeding logical data blocks are allocated to the sectors in each track according to 1) in the ascending order of cylinder numbers.

3) Within the next head of the same cell, succeeding logical data blocks are allocated to the sectors in each track according to 1) and 2) in the ascending order of track numbers.

4) On the last track inside the same cell, succeeding logical data blocks are allocated to sectors except for spare sectors according to 1).

5) After all the allocation in 1) to 4) is completed within the same cell, succeeding logical data blocks are allocated to the next cell beginning with track 0, according to 1) to 3), and so on to each cell number in ascending order until the last cell in each zone (refer to alternate cell b-1 in Figure 1.5) in the user space, with the exception of alternate cells.

(2) Alternate area

The alternate area in user space (spare sectors within each cell and alternate cells) are excluded from the abovementioned logical data block addresses. Access to allocated sectors as alternate blocks within the alternate area is performed automatically by the IDD's defect management (sector slip processing and alternate block processing), so it is not particularly necessary for the user to access the alternate area. Also, data blocks in the alternate area cannot be clearly specified and accessed directly.

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# CHAPTER 3 Data Buffer Management

In this chapter, the configuration of the data buffer with which the IDD is equipped, its operation and the operation of the cache feature are described.

## 3.1 Data Buffer

### 3.1.1 Data buffer configuration and basic operation

The IDD is equipped with a data buffer, which makes it possible to efficiently execute data transfer operations between INIT (initiator) and a disk drive.

The IDD divides data buffer into Pages, which are minimum allocation size for Cache. Actually two or more Pages are linked and a Cache Segment is constructed per the requested data size from INIT. Since IDD automatically controls the best suitable Cache Segment, INIT cannot be changed neither the Page size nor the Segment size.

Each data buffer is a 2 ports of FIFO (First-In First-Out) ring buffer, with one port allocated for transfers with the disk media and the other port for data transfers with the interface (INIT). Mutual ports operate asynchronously and since it is possible to efficiently absorb variations in data transfer speed between the ports, the INIT can perform data transfer operations with the IDD while being virtually unaware of differences between the interface data transfer rate and the disk drive data transfer rate.

Even if the data transfer capacity of the interface (INIT) is lower than the disk drive's data transfer rate, the data buffer can perform data transfers to the system under optimum conditions without using sector interleave. Also, if the data transfer capacity of the interface (INIT) is higher than the disk drive's data transfer rate, it is possible to minimize the occupancy time on the interface by accumulating an appropriate amount of data in the data buffer.

Only one cache segment of the divided data buffer is used by one command and the data in the other cache segments are held.

Figure 3.1 shows the data buffer image.

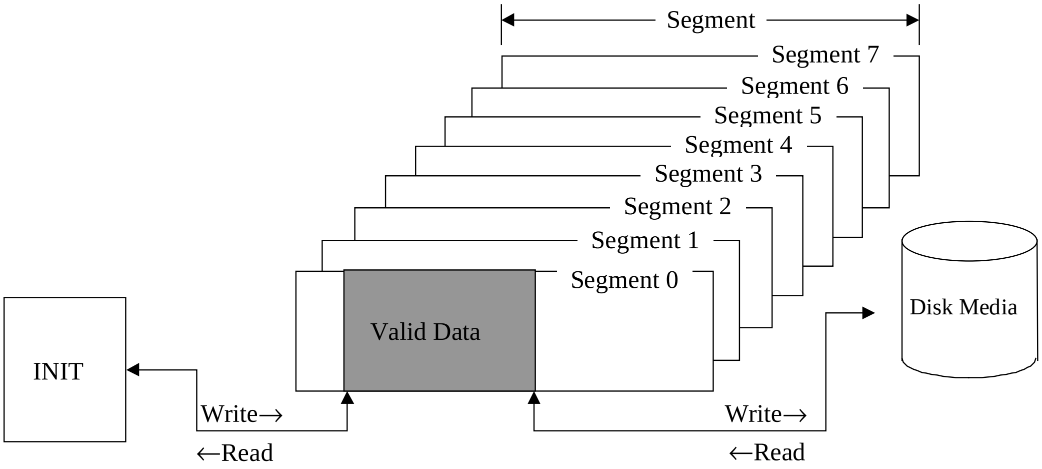

**Figure 3.1 Data buffer configuration (in the case of 8 cache segments)**

The basic functions and operations of the data buffer in a read operation and a write operation are shown below.

## (1) Read operation

Data read from the disk media are temporarily stored in the data buffer. Then, they are transferred to the interface with the timing specified by the IDD. The basic read operation procedure is as shown below.

1) When the IDD receives a command, it temporarily closes the connection and locates the data block specified by the command on the medium.

2) When the target data block has been located, the IDD reads the data form the disk media to the data buffer. At this time, if a recoverable error is detected, the IDD performs error recovery processing according to the specification in the MODE SELECT parameter or corrects the data in the data buffer.

3) When the IDD has read out to the data buffer the amount of data that the IDD itself has specified, it performs reconnection processing with the interface and begins transferring data to the INIT from the data buffer while continuing to read subsequent data blocks out to the data buffer.

4) If the data transfer rate of the INIT is high and the data buffer becomes empty before completing the transfer of the number of data blocks specified by the command, the IDD closes the interface at this point. Thereafter, opening, data transfer, and closing operations (the operations in 3) and 4) above) are repeated until all the data blocks specified in the command have been transferred.

5) If the number of blocks specified in the command to be transferred is larger than the capacity of a cache segment and if the data transfer speed of the INIT is lower than the data transfer speed of the disk drive, the empty space in the data buffer disappears from step 3) and the IDD may soon not be able to read data from the disk media (data overrun). In this case, the IDD relocates the block that caused the data overrun after waiting one disk revolution, and continues the reading process.

When transfer of all the specified data is completed, the IDD reports the status and terminates the command.

### (2) Write operation

After data transferred from the INIT are stored temporarily in the data buffer, they are written to the disk media. The basic write operation procedure is as shown below.

1) When the IDD receives a command, it transfers the XFER_RDY flame to INIT. Later it stores data transferred from the INIT to the data buffer (data pre-fetch). At this time, the IDD locates the position of the data block on the disk media specified by the command in parallel.

   When storing of all the size of data specified in the XFER_RDY flame in the data buffer is completed, the IDD performs CLOSE processing.

2) When locating of the target data block on the disk media is completed, the IDD writes the data in the data buffer to the disk media. If the target data block location operation is completed during the data pre-fetch processing in 1), writing of data to the disk media is performed in parallel with the data pre-fetch to the data buffer.

3) If the data transfer speed of the INIT is lower than the data transfer speed of the disk drive, since the data pre-fetch of data that are to be written to that data block is not completed, it may not be possible to write the data continuously to the disk (data underrun). In this case, the IDD waits one disk revolution while continuing to pre-fetch data from the INIT, then repositions the block that caused the data underrun and continues the writing of data to the disk.

4) If all the blocks of data specified in the command have not yet been transferred from the INIT, as writing of data to the disk media progresses, at the point when the empty space in the data buffer reaches the amount specified by the IDD, the IDD performs OPEN processing and begins transferring the succeeding data (data pre-fetch) after it transfers the XFER_RDY frame.

   Writing of data to the disk media is performed in parallel and data transfer with the INIT continues until the empty space in the data buffer is full or until transfer of all the data specified in the command is completed. From then on, the XFER_RDY data receiving are repeated until transfer of all the blocks of data specified in the command is completed.

5) When writing of all the specified data is completed, the IDD reports the status and terminates the command.

## 3.2 Look-Ahead Cache Feature

In order to use the data buffer more effectively and improve the disk drive's effective access speed, the IDD is equipped with a simple cache feature called a "Look-Ahead Cache Feature." The Look-Ahead cache feature is an effective, simple cache function for an INIT which reads data blocks on the disk media sequentially using multiple commands.

### 3.2.1 Caching operation

When the IDD is executing a READ command or a READ EXTENDED command, it reads the requested data from the disk media and transfers it to the INIT while at the same time reading (looking ahead at) data blocks which are subsequent to the last logical data block specified in that command to the data buffer. Then, when a READ command or READ EXTENDED command issued later specifies any of those Look-Ahead data blocks, the IDD transfers those data directly to the INIT from the data buffer without accessing the disk media. In this way, when continuous logical data blocks are read sequentially by multiple commands, mechanical access operations can be eliminated and effective access time greatly reduced.

An INIT can prohibit the operation of this Look-Ahead cache feature by setting the caching parameter described in section 3.2.2.

(1) Caching object commands

Commands which execute caching operations are the commands shown below:

- READ
- READ EXTENDED

If all the data blocks which are objects of the processing specified in these commands, or a portion of the data blocks, including the top logical data block specified in these commands are relevant data (See item (2)) for caching in the data buffer (if they hit), when the IDD receives a command, it immediately sends the data on the data buffer which can be transferred to the INIT. The caching operation can be disabled by the FUA bit of the READ EXTENDED command. If "1" is specified in the FUA bit, the IDD reads data from the disk media.

On the other hand, if the top logical data block specified in a command is not relevant data for caching in the data buffer (if they miss), reading of data is performed from the disk media using the old cache segment.

(2) Data which are objects of caching

Data which exist in the data buffer and which are objects of caching in item (1) (data which are not accessed from the disk media but are transferred to the INIT from the data buffer) are as described below.

a) Data read by a READ or a READ EXTENDED command and which have been read to the data buffer by Look-Ahead are data which are objects of caching. Depending on the timing for halting Look-Ahead, it is possible that data read by the READ command will be overwritten by Look-Ahead.

b) Data which have been hit by the READ or READ EXTENDED command and transferred to the INIT once are also objects of caching as long as they are not invalidated.

c) Data transferred from the INIT and written to the disk media by the WRITE and WRITE EXTENDED, command are objects of caching.

d) Data transferred from the INIT and written to the disk media by WRITE AND VERIFY command is not the objects of caching.

### (3) Disabling caching data

Various data which are objects of caching in the data buffer are disabled in the following cases.

a) If any of the following commands is issued for the same data block as data which are the object of caching, that data block ceases to be an object of caching.

- WRITE
- WRITE EXTENDED
- WRITE AND VERIFY

b) If any of the following commands is issued, all the data which are objects of caching are disabled.

- LOG SELECT
- MODE SELECT
- MODE SENSE
- READ BUFFER
- READ DEFECT DATA
- READ LONG
- RECEIVE DIAGNOSTIC RESULTS
- SEND DIAGNOSTIC
- START/STOP UNIT
- WRITE LONG
- FORMAT UNIT
- LOG SENSE

- MODE SELECT EXTENDED
- MODE SENSE EXTENDED
- READ CAPACITY
- READ DEFECT DATA (12)
- REASSIGN BLOCKS
- RELEASE EXTENDED
- RESERVE EXTENDED
- WRITE BUFFER
- WRITE SAME

c) If the data buffer where data which are objects of caching are stored is used by any of the following commands, the data existing in that data buffer which are objects of caching are disabled.

- READ
- READ EXTENDED
- WRITE
- WRITE EXTENDED
- WRITE AND VERIFY
- VERIFY

d) If any of the following events occurs, all the data which are objects of caching are disabled.

- Receiving HARD RESET primitive
- Receiving ABORT TASK (TASK IU 0x01)
- Receiving ABORT TASK SET (TASK IU 0x02)
- Receiving CLEAR TASK SET (TASK IU 0x04)
- Automatic alternate processing is executed.
- Read/Write is aborted in something causes.

### 3.2.2 Caching parameters

The IDD supports the MODE SELECT parameters (caching parameters: page code = 8) shown in Table 3.2 for controlling the cache feature. See Section 4.1 concerning details of the MODE SELECT parameters.

### 3.2.3 Look-Ahead operation, Look-Ahead volume

1) Excluding the conditions in 3) and 4) for the amount of data specified as the minimum pre-fetch volume, data are read for look-ahead irrespective of track boundaries or cylinder boundaries. Commands which are already in the queue or commands which are newly received while a look-ahead operation is in progress, are executed after the look-ahead operation is completed. However, if the new command is a READ or READ EXTENDED command, and it is a command in which the first specified logical data block is a sequential access data block, the command is executed without the look-ahead operation being halted. When a newly received command is a command which is not the object of caching, that command is executed immediately in parallel with a look-ahead operation.

   Also, in the case of a command which disables all data which are objects of caching (see Section 3.2.1 (3)), the look-ahead operation is halted and that command is executed immediately.

2) When commands exist in the queue, the look-ahead operation is halted at the point when reading of the specified amount of data at the minimum pre-fetch volume is completed, then execution of the new command starts. When there are no commands that need to be newly executed, the data look-ahead operation is continued, even after the volume of data specified as the minimum amount of pre-fetch data have been read, until one of the following conditions, 1), 3) or 4), occurs.

   – When "1" is specified in the DISC bit, if look-ahead of data equal in volume to a cache segment is completed.

   – When "0" is specified in the DISC bit, if look-ahead of all the data is completed up to the track boundary or the cylinder boundary.

3) During a data look-ahead operation, when any error occurs, the data look-ahead operation is terminated at that point (retry is not executed).

4) When receiving HARD RESET primitive, or when receiving ABORT TASK (TASK IU 0x01), ABORT TASK SET (TASK IU 0x02), or CLEAR TASK SET (TASK IU 0x04), the look-ahead operation is terminated at that point and all the look-ahead data stored in the data buffer are invalidated.

5) During a look-ahead operation, if "sector slip processing" is applied, or defective sectors exist in the same cylinder to which "alternate processing" is applicable, the look-ahead operation is continued without interruption.

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# CHAPTER 4 Command Specifications

This chapter describes detailed specifications of the SCSI commands which the IDD is equipped with and how to use them.

## 4.1 Control/Sense Commands

### 4.1.1 TEST UNIT READY (00)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘00’ | | | | | | | |
| 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 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command checks the status of the disk drive.

If the IDD is in the ready state and it is possible for it to be used by the INIT (initiator) which issues this command, a GOOD status is reported for this command.

If the IDD is not in the ready state, it reports a CHECK CONDITION status for this command. The sense data generated at this time indicate the IDD's state at this time.

### 4.1.2 INQUIRY (12)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘12’ | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | CmdDt | EVPD |
| 2 | Page Code/Operation Code | | | | | | | |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | Transfer Byte Length | | | | | | | |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command transfers the information showing the IDD's characteristics (INQUIRY data) to the application client.

This command is executed normally even in cases where the UNIT ATTENTION condition is held, and the UNIT ATTENTION condition is not cleared.  This command is also executed normally when the disk drive is not in the ready state.

A CHECK CONDITION status is reported for this command and it is terminated abnormally only in the case that one of the following conditions is detected.

- There is an error in the specifications of the CDB.
- It is impossible to send INQUIRY data because of an IDD hardware error.
- Applicability to overlapping command exception conditions (See Section 2.7.1.)

If both the "EVPD" and "CmdDt" bits are one, this command is terminated by a CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid Field in CDB [=24-00]).

(1) EVPD (Enable Vital Product Data)

a) If the specification in this bits is zero, the IDD transfers the standard INQUIRY data or the command supported data, mentioned later, to the INIT.

b) If the specification in this bits is one, product information called VPD (vital product data) is transferred to the INIT.

(2) CmdDt (Command Supported Data)

a) If the specification in this bits is zero, the IDD transfers the standard INQUIRY data, mentioned later, to the INIT.

b) If the specification in this bits is one, the IDD transfers the command supported data, mentioned later, to the INIT.

(3) Page code / Operation code

a) When the "EVPD" bits is one, this field specifies that the IDD transfers the kind of the VPD information.

b) If the "EVPD" bit is zero and the "CmdDt" bits is one, this field specifies the operation code (CDB byte 0) of commands generated command supported data.

(4) Transfer Byte Length

Byte 4 of the CDB, the "Transfer Byte Length" field, shows the number of bytes of standard INQUIRY data or VPD information that the application client can receive by this command.

The IDD transfers data with the byte length specified in the "Transfer Byte Length" field, or the byte length in the standard INQUIRY data or VPD information which it is holding, whichever has the smallest number of bytes, to the application client. When zero is specified in the "Transfer Byte Length" field, this command is normally terminated without anything being transferred.

(5) Standard INQUIRY data

Table 4.1 shows the format and contents of the standard INQUIRY data transferred to the INIT by this command if "0" is specified in the "EVPD" and the “CmdDt” bit.

## Table 4.1 Standard INQUIRY data

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | SCSI mode |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Qualifier | | | Device Type Code | | | | | |
| | (0, 0, 0) or (0, 1, 1) | | | (0, 0, 0, 0, 0) or (1, 1, 1, 1, 1) | | | | | ---- |
| 1 | RMB | Reserved | | | | | | | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | SCSI-3 |
| 2 | Version | | | | | | | | ---- |
| | X’ 04’ (SPC-2) | | | | | | | | SCSI-3 |
| 3 | AERC | Obsolete | NORMACA | HISUP | Response Data Format | | | | ---- |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | SCSI-3 |
| 4 | Additional Data Length | | | | | | | | |
| | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | |
| 5 | SCCS | Reserved | | | | | | | SCSI-3 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 6 | BQue | EncServ | Part | MultiP | MCHNGR | Obsolete | | Addr16 | SCSI-3 |
| | 0 | 0 | 0/1 | 0/1 | 0 | 0 | 0 | 0 | |
| 7 | RelAdr | obsolute | Wbus16 | Sync | Linked | TranDis | CmdQue | VS | SCSI-3 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | |
| 8<br>9<br>15 | FUJITSU<br>(Vendor ID: ASCII) | | | | | | | | ---- |
| 16<br>17<br>31 | (Product ID: ASCII) | | | | | | | | |
| 32<br>33<br>34<br>35 | Microcode Version No. (ASCII)<br>(Product Revision: ASCII) | | | | | | | | ---- |
| 36<br>37<br>47 | Device Serial No. (ASCII) | | | | | | | | |
| 48-55 | X‘00’ (Vendor Specific) | | | | | | | | |
| 56 | Reserved | | | | CLOCKING | | QAS | IUS | SCSI-3 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 57 | X‘00’ (Reserved) | | | | | | | | |
| 58-73 | Version Descriptor | | | | | | | | SCSI-3 |
| 74-95 | X‘00’ (Reserved) | | | | | | | | |

a. Qualifier field

(0,0,0): The specified logical unit shows the type of input/output device shown in the "Device Type Code" field. Even if this code is reported, it does not mean that that logical unit is in the ready state.

(0,0,1): The specified logical unit shows the type of input/output device shown in the "Device Type Code" field, but it shows that an actual input/output device is not connected to that logical unit. The IDD does not report this code.

(0,1,1): Shows that the specified logical unit is not supported. When this code is reported, it X '1F' is shown in the "Device Type Code" field.

b. Device type code

(0,0,0,0,0): Direct access device

(1,1,1,1,1): Undefined device

c. RMB bit

When this bit is "1," it indicates that the storage media is a removable disk device. The IDD is a fixed disk device, so this bit is always reported as "0."

d. Version

The VERSION field indicates the implemented version of this standard and is defined below.

**Table 4.2 VERSION field**

| Code | Description |
|---|---|
| X'01' | ANSI X3.131: 1986 (SCSI-1) |
| X'02' | ANSI X3.131: 1994 (SCSI-2) |
| X'03' | ANSI X3.301: 1997 (SPC Rev.11) |
| X'04' | T10/1236-D (SPC-2)<br>IDD always Responds this value. |

e. Response data format field

This field shows the code which shows the standard INQUIRY data format. The definition of the code is (0,0,0,1) for SCSI-1/CCS mode or (0,0,1,0) for SCSI-2 or SCSI-3 mode.

f. Additional data length

This field shows the length of the INQUIRY data (byte length) after byte 5. This value shows the length in the INQUIRY data held by the IDD without relation to the specification in the transfer byte length field in the CDB, and is always X‘5B’ (total data length = 96 bytes).

g. Supported functions

The bit positions shown below are the functions which the IDD supports are shown in the bit correspondence. "1" indicates that that function is supported and "0" indicates that that function is not supported.

[Byte 3]

- AERC (Asynchronous event reporting capability):
  Asynchronous condition notify function [0]
- NORMACA (Normal ACA supported):
  ACA support [0]
- HISUP (Hierarchical support):
  Defined the hierarchical addressing model to assign LUN [0]

[Byte 5]

- SCCS (SCC support):
  Embedded storage array controller equipment [0]

[Byte 6]

- BQue (Basic queuing):
  Combination with CMDQUE [0]
- EncServ (Enclosure service):
  Enclosure service [0]
- Port:
  Connection port, '0' = connection to port A [0/1]
  '1' = connection to port B
- MultiP (Multi port):
  Supported multi-port [0/1]
- MChngr (Medium changer):
  Medium Changer [0]
- Addr16 (Wide SCSI address 16):
  16 bit SCSI addressing [0]

[Byte 7]

- RelAdr (Relative addressing):
  Relative logical block addressing [0]
- WBus16 (16-bit wide data transfer):
  Data transfer on a 2-byte bus [0]
- Sync (Synchronous data transfer):
  Data transfer on the synchronous mode [0]
- Linked (Linnked command):
  Command link function [0]
- TranDis (Transfer disable):
  Continue task and target transfer disable message [0]
- CmdQue (Command queuing):
  Command queuing function [1]

**Table 4.3 Command queuing**

| Bque | CmdQue | Description |
|---|---|---|
| 0 | 0 | No command queuing of any kink supported |
| 0 | 1 | Command queuing with all types of task tags supported |
| 1 | 0 | Basic task set model supported |
| 1 | 1 | Illegal combination of BQue and CmdQue bits |

- VS (Vendor specific):
  Not defined [0]

h. Vendor ID field

This field indicates the name of the product's supplier in left-justified ASCII code, and always indicates FUJITSU. The unused right end is space for the ASCII code.

i. Product ID field

The product's model name is displayed in left-justified ASCII code in this field.

j. Product Revision field

The IDD's microcode version number is displayed in ASCII code in this field.

k. Device Serial Number field

The value following byte 4 of the device serial number in the VPD information is indicated in this field. Higher order digits which do not contain valid numbers are filled with ASCII code spaces (X '20').

l. Clocking field

"0" as Reserved.

m. QAS (Quick Arbitrate Supported) bit

"0" as Reserved.

n. IUS (Information unit supported) bit

"0" as Reserved.

o. Version Descriptor field

This field is provided for identifying upto eight standards to which the Device claims conformance.
The IDD shall be indicated as shown below.

**Table 4.4 Version descriptor**

| BYTE | Code | Description |
|---|---|---|
| 58 to 59 | OX00, OX40 | SAM2 |
| 60 to 61 | OX0B, OXFC | SAS |
| 62 to 63 | OX01, OX3C | SPC ANSI/3.301:1997 |
| 64 to 65 | OX01, OX9B | SBC T10/0996-D rev08C |
| 66 to 67 | OX00, OX00 | – |
| 68 to 69 | OX00, OX00 | – |
| 70 to 71 | OX00, OX00 | – |
| 72 to 73 | OX00, OX00 | – |

(6) Command support data

Table 4.5 shows the format and contents of the command support data transferred to the INIT by this command if "0" is specified in the "EVPD" bit and "1" is specified in the "CmdDt" bit.

**Table 4.5 Command support data**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Qualifier | | | Device Type Code | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | Support | | |
| 2 | Version | | | | | | | |
| 3 | X'00' (Reserved) | | | | | | | |
| 4 | X'00' (Reserved) | | | | | | | |
| 5 | CDB Size (m-5) | | | | | | | |
| 6 | CDB Usage Data | | | | | | | |
| ~ ~ | | | | | | | | |
| m | | | | | | | | |

a. Qualifier, Device Type Code, Version

These fields are the same as those in the previously mentioned standard INQUIRY data.

b. Support

This field indicates the value defined in Table 4.6.

### Table 4.6 Support

| "Support" Bit | 2 | 1 | 0 | Description |
|---|---|---|---|---|
| | 0 | 0 | 0 | Data about the requested SCSI operation code is not currently available. |
| | 0 | 0 | 1 | The device server does not support the tested SCSI operation code. All data after byte 1 is undefined. |
| | 0 | 1 | 0 | Reserved |
| | 0 | 1 | 1 | The device server supports the tested SCSI operation code in conformance with an SCSI standard. |
| | 1 | 0 | 0 | Vendor-specific (undefined) |
| | 1 | 0 | 1 | The device server supports the tested SCSI operation code in a vendor-specific manner. |
| | 1 | 1 | 0 | Vendor-specific (undefined) |
| | 1 | 1 | 1 | Reserved |

If the "Support" field contains "000b", all data after byte 1 is not valid. One possible reason for "support" being "000b" is the device server's inability to retrieve information stored on the media. When this is the case, a subsequent request for command support data may be successful.

c. CDB size

This field contains the number of bytes in the CDB for the operation code being queried, and the size of the "CDB Usage Data" field in the return data.

d. CDB usage data

This field contains information about the CDB for the operation code being queried. The first byte of the "CDB usage data" contains the operation code for the operation being queried. All bytes except the first byte of the "CDB usage data" contains a usage map for bits in the CDB for the operation code being queried.

The bits in the "Usage map" have a one-for-one correspondence to the CDB for the operation code being queried. If the device server evaluates a bit as all or part of a field in the CDB for the operation code being queried, the usage map contains a one in the corresponding bit position. If the device server ignores or treats as reserved a bit in the CDB for the operation code being queried, the usage map contains a zero in the corresponding bit position. The usage map bits for a given CDB field all have the same value.

Thus, the CDB usage bit map for this command for a device server that implements command support data but not vital product data is: 12h, 02h, FFh, 00h, FFh, 00h.

(7) VPD information

When "1" is specified in the "EVPD" bits of the CDB, the VPD information described below is transferred to the INIT by this command. The INIT specifies the type of VPD information required in the "Page code" field of the CDB. The type of VPD information supported by the IDD and its page code number are as shown in Table 4.7.

**Table 4.7 VPD information**

| Page Code Page (Hex) | Function |
|---|---|
| 00 | Page code list of supported VPD information |
| 80 | Device serial number |
| 83 | Device unique information |
| C0 | Operation mode |

Furthermore, if page codes other than those shown above (VPD information that is not supported by the IDD) are specified in the CDB, that command is terminated with a CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in CBD [=24-00]).

The format and contents of each type of VPD information are shown below.

a. Page code list

This VPD information reports the page code list of VPD information supported by the IDD. The format of this VPD information is shown in Table 4.8.

**Table 4.8 VPD information: VPD identifier list**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Qualifier | | | Device Type Code | | | | |
| 1 | X‘00’ (Page Code) | | | | | | | |
| 2 | X‘00’ | | | | | | | |
| 3 | X‘04’ (Page Length) | | | | | | | |
| 4 | X‘00’ (Page Code List) | | | | | | | |
| 5 | X‘80’ (Device Serial No.) | | | | | | | |
| 6 | X‘83’ (Device unique information) | | | | | | | |
| 7 | X‘C0’ (Operation Mode) | | | | | | | |

The values indicated in the "Qualifier" and "Device Type Code" fields in byte 0 are the same as those in the previously mentioned standard INQUIRY data. The "Page code" field in byte 1 indicates the page code (X '00') of this VPD information itself. Also, the "Page length" field in byte 3 indicates the length (byte length) after byte 4. This value has no relationship to the specification in the "Transfer Byte Length" in the CDB, but indicates the length of this VPD information and is always X '03' (Total data length = 7 bytes).

Byte 4 and subsequent bytes list all the VPD information page codes supported by the IDD, with the VPD page code indicated in ascending order in each byte.

b. Device serial No.

This VPD information reports the device serial number of the IDD. The format of this VPD information is shown in Table 4.9.

**Table 4.9 VPD information: device serial No**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Qualifier | | | Device Type Code | | | | |
| 1 | X‘80’ (Page Code) | | | | | | | |
| 2 | X‘00’ | | | | | | | |
| 3 | X‘0C’ (Page Length) | | | | | | | |
| 4 | Device Serial No. (ASCII) | | | | | | | |
| 5 | | | | | | | | |
| ~ | | | | | | | | |
| 15 | | | | | | | | |

The values indicated in the "Qualifier" and "Device Type Code" fields in byte 0 are the same as those in the previously mentioned standard INQUIRY data. The "Page code" field in byte 1 indicates the page code (X '80') of this VPD information itself. Also, the "Page length" field in byte 3 indicates the length (byte length) after byte 4. This value has no relationship to the specification in the "Transfer Byte Length" in the CDB, but indicates the length of this VPD information and is always X '0C' (Total data length = 16 bytes).

Bytes 4 to 15 indicate the IDD's device serial number in right-justified decimal (ASCII code).

c. Device unique information

This VPD information reports the IDD unique information. The format of this VPD information is shown in Table 4.10.

**Table 4.10 VPD information: device unique information**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Qualifier (‘000b) | | | Device Type Code (‘000b) | | | | |
| 1 | X‘83’ (Page Code) | | | | | | | |
| 2 | X‘00’ | | | | | | | |
| 3 | X‘0C’ (Page Length) | | | | | | | |
| 4 | Protocol Identifier (’0110b’) | | | | Code set (’0001b’) | | | |
| 5 | PIV (’1b’) | Reserv (’0’b) | Association (’00b’) | | Identifier type (’0011’b) | | | |
| 6 | Reserved (x’00’) | | | | | | | |
| 7 | Identifier length (x’08’) | | | | | | | |
| 8 | (LSB) | | | | | | | |
| ~ | Identifier (ID) | | | | | | | |
| 15 | | | | | | | | (LSB) |

- Protocol Identifier

  6h: Indicates that this page conforms to the SAS SCSI device specifications.

- Code Set

  Indicates the type of the code shown in the "Identifier (ID)" field.

  – 0 and 3 - Fh: Reserved

  – 1h: The Identifier is a binary code.

  – 2h: The Identifier is an ASCII code.

- PIV (PROTOCOL IDENTIFIER VALID)

  0h: The "Protocol Identifier" field is invalid.

  1h: The "Protocol Identifier" field is valid.

- Association

  Indicates what the Identifier (ID) value is related to.

  – 0h: The Identifier is related to the connected physical or logical device.

  – 1h: The Identifier is related to the port that has received this request.

  – 2 - Fh: Reserved

- Identifier type

  Indicates the Identifier type and the organization that has issued the Identifier.

  – 0h: No organization issues this Identifier (this is a Vendor Specific ID).

  – 1h: The first eight bytes are the Vendor ID (SPC-2 Annex C).

  The rest of the data depends on the organization indicated in the Vendor ID.

  Fujitsu recommends indicating the Product ID of the Standard INQUIRY followed by the serial number of VPD Page 80.

  – 2h: Indicates a sixty-four-bit long IEEE extended unique ID (EUI-64).

  This information includes a 48-bit long IEEE ID.

  – 3h: FC-PH, FC-PH3, or FC-FS Name-Identifier (the rest is omitted).

  – 4h: Used when Association is 1h (the rest is omitted).

  – 5 - Fh: Reserved

- Identifier length

  Indicates the Identifier (ID) length. Even when a value that is insufficient for transferring all the IDs is specified for the Transfer Byte Length of the CDB, this value indicates the actual byte length.

- Identifier (lD)

  Reports an ID in the format defined by Association, Identifier type, Code set, and Identifier length (device unique WWW).

d. Operation mode

This VPD information reports the IDD's current operation mode. The format of this VPD information is shown in Table 4.11.

**Table 4.11 VPD information: operation mode**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Qualifier | | | Device Type Code | | | | |
| 1 | X‘C0’ (Page Code) | | | | | | | |
| 2 | X‘00’ | | | | | | | |
| 3 | X‘04’ (Page Length) | | | | | | | |
| 4 | 0 | 0 | 0 | 0 | UNTATN | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | X‘00’ (Spindle Motor Start Delay Timing) | | | | | | | |
| 7 | X‘00’ (Reserved) | | | | | | | |

The values indicated in the "Qualifier" and "Device Type Code" fields in byte 0 are the same as those in the previously mentioned standard INQUIRY data. The "Page code" field in byte 1 indicates the page code (X 'C0') of this VPD information itself. Also, the "Page length" field in byte 3 indicates the length (byte length) after byte 4. This value has no relationship to the specification in the "Transfer Byte Length" in the CDB, but indicates the length of this VPD information and is always X '04' (Total data length = 8 bytes).

– UNTATN (UNIT ATTENTION Report Mode)

When the IDD is holding the Unit Attention condition, this specifies methods of response to commands received from the INIT.

"1" (Report): Report the "CHECK CONDITION" status (SCSI standard specifications) for commands other than the INQUIRY and REQUEST SENSE commands.

"0" (Don't Report): Terminates all received commands normally (the "CHECK CONDITION" status caused by the UNIT ATTENTION condition is not reported.)

– Spindle Motor Start Delay Timing

Indicates the delay of the spindle motor startup time. Note, however, that SAS drives do not support the function for delayed startup of the spindle motor and always report X'00.'

### 4.1.3 READ CAPACITY (25)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘25’ | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 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 | 0 | 0 | 0 |

This command transfers information related to the disk drive's capacity and the data block size to the INIT.

When bit 0 "PMI (partial medium indicator)" of CDB byte 8 is "0," the logical block address and block length (byte length) of the final data block which is accessible in the disk drive (user space) are transferred to the INIT. At this time, the "Logical Block address" field in the CDB must specify zero.

When the "PMI" bit is "1," the logical block address and block length (byte length) of data blocks which satisfy either of the following conditions is transferred to the INIT.

- The data block on the track where the specified block exists, which is just before the block where the first alternate sector processing (not including defective block sector slip processing) is implemented. However, when alternate sector processing is being implemented in the specified block, the data block specified in the CDB.
- When no alternate sector processed data block exists in the track where the specified block exists, the last data block in that track.

By using this command with the "PMI" bit specified as "1", the INIT can search for usable data space continuously without being interrupted by data transfers for alternate sector processing or switching of cylinders.

The format of the data transferred to the INIT by this command is shown in Table 4.12.

**Table 4.12 READ CAPACITY data**

| Bit / Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 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) | | | | | | | |

### 4.1.4 MODE SELECT (15)

| Bit / Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘15’ | | | | | | | |
| 1 | 0 | 0 | 0 | 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 | 0 | 0 | 0 |

This command performs setting and changing of each type of parameter related to disk drive physical attributes, data format, timing of FC interface transferring processing and error recovery procedures, etc. The INIT can know the types of parameters, the current settings of each parameter and the types of parameters which can be changed, and the ranges for such changes, etc. by using the MODE SENSE or MODE SENSE EXTENDED command.

The data (MODE SELECT parameters) transferred from the INIT to the IDD by this command, are configured from a "Header," "Block Descriptor" and one or more "Page Descriptors" which describe each parameter, each of which will be explained later.

When the "PF (page format)" bit in CDB byte 1 is "1," it indicates that the MODE SELECT parameters transferred from the INIT by this command are in the "Page Descriptor" format. The IDD disregards the value specified in this bit and regards the MODE SELECT parameters transferred from the INIT as being in the "Page Descriptor" format and executes this command.

The "SP (save pages)" bit in CDB byte 1 specifies whether or not to save the MODE SELECT parameters specified in this command on the disk. It is possible for the IDD to save all the MODE SELECT parameters described in the "Page Descriptor" (except for those on page C), but this bit's specification is valid only for parameters other than "Format parameters (Page 3)" and "Drive parameters (Page 4: excluding byte 17)."

If "1" is specified in the "SP" bit, the parameters transferred from the INIT are saved to the disk when this command is executed, except for "Format parameters (page 3)" and "Drive parameters (Page 4: excluding byte 17)." When the "SP" bit is "0," these parameters are not saved to the disk. On the other hand, as for "Format parameters (Page 3)" and "Drive parameters (Page 4: excluding byte 17)," regardless of the specification of the "SP" bit when this command is executed, these parameters are always saved to the disk when the FORMAT UNIT command is executed.

The "Parameter length" field of the CDB specifies the total byte length of the MODE SELECT parameters transferred from the INIT by this command. If zero is specified in the "Parameter length" field, this command is terminated normally without data transfer being executed with the INIT. The MODE SELECT parameters have specifically defined formats and lengths, as explained by the descriptions of each page descriptor in this item, and the INIT must always specify (transfer) those formats and lengths.

If a "Header," "Block Descriptor" or any "Page Descriptor" cannot be transferred with all the defined length because the total defined length of the MODE SELECT parameters actually transferred from the INIT do not match the value specified in the "Parameter List Length" field, or if the total of the MODE SELECT parameter's defined length transferred from the INIT exceeds the value specified in the "Parameter list length" field, this command is terminated with a CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in CDB [=24-00]) and all the MODE SELECT parameters transferred in the command are disabled.

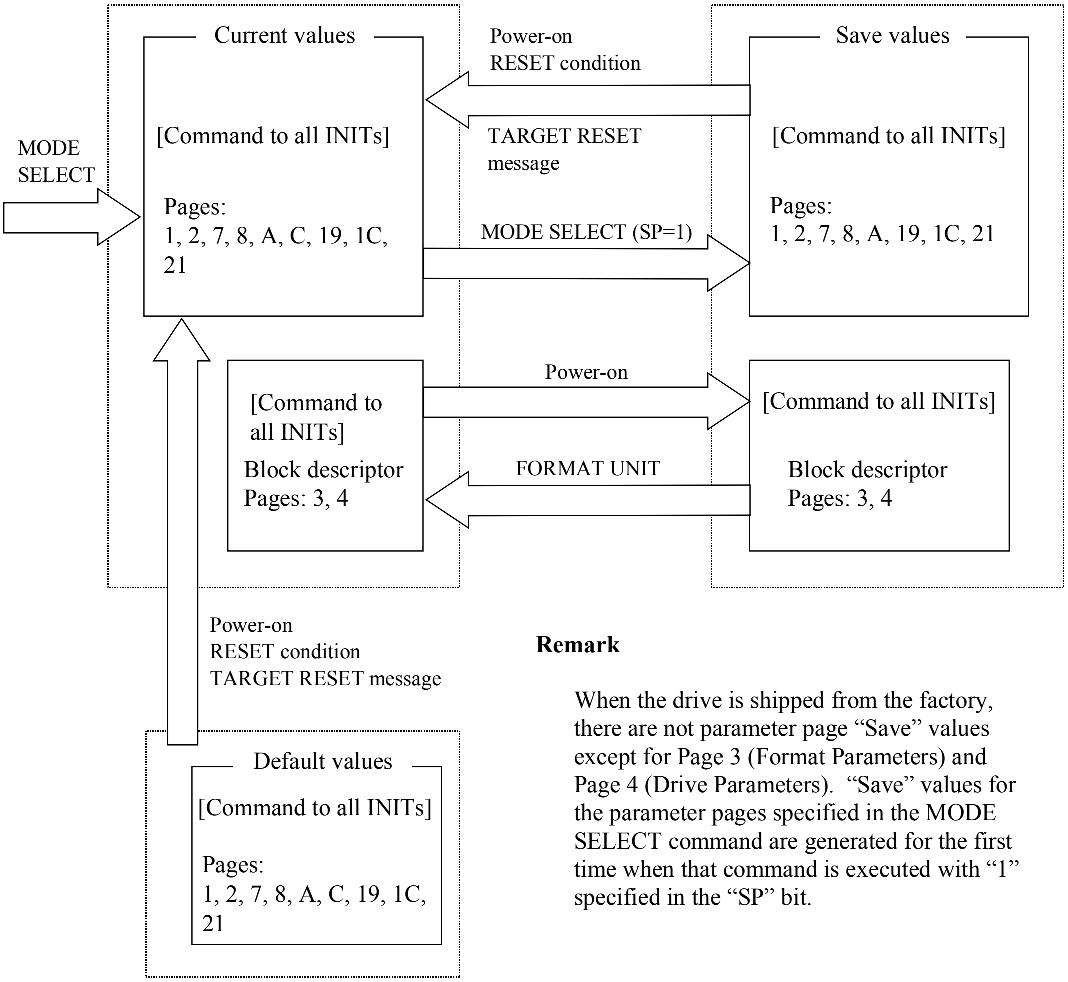
Three types of values exist in the MODE SELECT parameters, "Current," "Save" and "Default" values. "Current" values are parameters which actually control the IDD's operation, and the parameters specified by this command are converted to "Current" values. "Save" values are parameter values specified by this command which are preserved on the disk. And "Default" values are values which the IDD uses as "Current" values during the time until reading of "Save" values is completed after the IDD's power is switched on, or when no "Save" values exist and no MODE SELECT command is being issued.

The IDD has a common set of "Current", "Save" and "Default" values of all the MODE SELECT parameters for all the INITs.

When the IDD's power is switched on, when HARD RESET is received, LOGICAL UNIT RESET TASK is received, the "Current" MODE SELECT parameter values are changed to the "Save" parameter values, if they exist, and are changed to the "Default" parameter values if the "Save" values do not exist.

When any of the variable parameters of this command are changed, the unit attention condition is generated for (Mode parameters changed [= 2A-01]) for all the INITs except the one that has issued this command.

Figure 4.1 shows the relation between the three types of parameters, "Current," "Save" and "Default".



**Remark**

When the drive is shipped from the factory, there are not parameter page "Save" values except for Page 3 (Format Parameters) and Page 4 (Drive Parameters). "Save" values for the parameter pages specified in the MODE SELECT command are generated for the first time when that command is executed with "1" specified in the "SP" bit.

**Figure 4.1 MODE SELECT parameter structure**

The MODE SELECT parameters include parameters which can be changed by the INIT as desired, parameters which the INIT cannot change, which whose values are determined by the IDD unilaterally and parameters which can be changed by the INIT within certain appropriate limits. The IDD also contains parameter fields which are applicable for rounding processing ("rounding up" or "rounding down") of parameter values specified by the INIT to values which the IDD can use in actual operation.

When changing of parameters other than "variable parameters" is requested by the INIT in the MODE SELECT parameters which it transfers in this command, or when changes which are outside the permissible range are requested, even though they are "variable parameters," this command is terminated with a CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in parameter list [=26-00]) and all the parameters specified by the INIT are disabled. Furthermore, parameter fields exist which ignore the values specified by the INIT, even if the parameters are "variable parameters." Details are explained in the description of each page descriptor in this item.

If the IDD performs rounding processing ("rounding up" or "rounding down") of parameter values specified by the INIT, in some cases a "CHECK CONDITION" status (RECOVERED ERROR [=1] / Rounded parameter [37-00]) is reported, and in some cases it is not reported.

Whether or not the CHECK CONDITION status is reported depends on whether "rounding up" or "rounding down" is specified.

If the INIT would like to confirm that the IDD is implementing rounding processing, it issues a MODE SENSE or MODE SENSE EXTENDED command after issuing this command and reads the values for the "Current" parameters, then compares them with the parameter values sent in the MODE SELECT command.

Parameter fields which are the object of rounding processing are explained in the descriptions of each page descriptor in this item.

Table 4.13 lists the data configuration of the parameter list transferred by the INIT in this command. The parameter list is configured from header 4 bytes in length followed by a block descriptor with a length of 8 bytes. This is followed by one or more page descriptors, or, when there is no block descriptor the 4-byte header is followed by one or more page descriptors. The INIT may transfer a header only, or the header and block descriptor only without the page descriptor added.

### Table 4.13 MODE SELECT command (Group 0) parameter configuration

Header

| Bit / Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘00’ | | | | | | | |
| 1 | X‘00’ (Media Type) | | | | | | | |
| 2 | × | 0 | 0 | × | 0 | 0 | 0 | 0 |
| 3 | X‘00’ or X‘08’ (Product Descriptor Length) | | | | | | | |

Block Descriptor

| Bit / Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Data Block Count (MSB) | | | | | | | |
| 1 | Data Block Count | | | | | | | |
| 2 | Data Block Count | | | | | | | |
| 3 | Data Block Count (LSB) | | | | | | | |
| 4 | X‘00’ | | | | | | | |
| 5 | Data Block Length (MSB) | | | | | | | |
| 6 | Data Block Length | | | | | | | |
| 7 | Data Block Length (LSB) | | | | | | | |

Page Descriptor

| | Bit / Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Page Header | 0 | 0 | 0 | Page Code | | | | | |
| | 1 | Page Length | | | | | | | |
| | 2 | Parameter Field | | | | | | | |
| | ~ | ~ | | | | | | | ~ |
| | n | | | | | | | | |

a. Header

- Media type

  X '00' (default type) must be specified in this field.

- Byte 2

  Bits 7 and 4 of this field have meaning only in the header transferred to the INIT by the MODE SENSE and MODE SENSE EXTENDED commands. The values specified in these bits are disregarded in the MODE SELECT and MODE SELECT EXTENDED commands. "0" must always be specified by the INIT in the other bit positions.

- Block descriptor length

  This field indicates the length (block count) of the "Block descriptor" which follows the header (not including the length of the "Page descriptor"). It is possible to define only 1 "Block descriptor" to the IDD, and either X '00' or X '08' must be specified in this field. When X '00' is specified in this field, it indicates that the "Block descriptor" is not included in the parameter list transferred from the INIT and the "Page descriptor" follows immediately after the "Header."

b. Block descriptor

The logical attributes of the data format on the disk media are described in the 8-byte long "Block descriptor."

- Data block count

  This field specifies the total number of logical data blocks (the block length is specified in "Data block length") allocated in the user space on the disk media. The maximum logical block address is a value with 1 subtracted from the value in this field.

  If only the "Block descriptor" in this command is changed accessible data block count can be limited without formatting if "Data block count" value is within a "Cylinder count" value of page 4.

  If zero is specified for the "Data block count," or when the block descriptor is not specified, the IDD retains its current capacity, if the block size or alternate sector count has not changed. If the "Data block count" is set to zero and the Data block size or alternate sector count has changed, the IDD shall set to its maximum capacity when new block size or alternate sector count to be effect.

- Data block length

  This field specifies the byte length of a logical data block on the disk media.

  The logical data block length and physical data block length are the same in the IDD. The data block length can be specified at 512 to 528 bytes (4-byte boundary).

If less than 512 bytes is specified in this field, the IDD performs rounding processing (there is a rounding processing report), setting the data block length at 512 bytes. If more than 528 bytes is specified, rounding processing is performed (there is a rounding processing report), setting the data block length at 528 bytes. If the block length is not 4-byte boundary, rounding processing is performed to change 4-byte boundary.

If zero is specified in this field, the value specified in bytes 12 and 13 (Data byte length/sector) of Page 3 (Format Parameter) is set. At that time, if Page 3 is not specified at the same time, the current value in Page 3 is used.

If the value set in this field differs from the value specified in bytes 12 and 13 (Data byte length/sector) of Page 3 (Format Parameter), the data block length in the block descriptor is set.

c. Page descriptor

The "Page descriptor" is configured from a 2-byte page header followed by a parameter field and each parameter function attribute is classified in a unit called a "Page." The individual "Page descriptors" in the MODE SELECT and MODE SELECT EXTENDED commands may be specified independently by the INIT and multiple "Page descriptors" may be specified continuously in the desired sequence.

– Page code

This field specifies a code (Page No.) that indicates the type of "Page descriptor."

– SPF (Sub Page Format)

When this bit is set to "0," this indicates that the Page_0 Format (Short Page Format) is being used, and when this bit is set to "1," this indicates that the Sub_Page Format (Long Page Format) is being used.

If "1" is specified for a page that does not support the Sub_Page Format (pages other than Page 19), the MODE SELECT command is terminated with the CHECK CONDITION status (ILLEGAL REQUEST [= 5]/Invalid Field in Parameter List [= 26/00]) and all the parameters specified with the command are invalidated.

– Page length

This field indicates the length of the parameter field (number of bytes) after byte 2, excluding the page header, of the "Page descriptor" and is a fixed value for each page code. The INIT must specify the same value as the page length reported by the IDD in the MODE SENSE or MODE SENSE EXTENDED command, except in cases it is described in each of the page descriptor descriptions in this item.

d. MODE SELECT parameters of the IDD

The parameter list configuration and its length that can be transferred to the IDD by the INIT in the MODE SENSE or MODE SENSE EXTENDED command are as shown in Table 4.14. If a "Page descriptor" that is not supported by the IDD is specified, the command is terminated with a CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in parameter list [=26-00]), and all the MODE SELECT parameters transferred in the command are disabled.

**Table 4.14 MODE SELECT parameters**

| Parameter | | | Byte Length |
|---|---|---|---|
| Header | | | 4 |
| Block Descriptor | | | 8 or 0 |
| Page Descriptor | Page 1: | Read/Write Error Recovery Parameter | 12 |
| | Page 2 | Disconnect/Reconnect Parameter | 16 |
| | Page 3: | Format Parameter | 24 |
| | Page 4: | Drive Parameter | 24 |
| | Page 7: | Verify Error Recovery Parameter | 12 |
| | Page 8: | Caching Parameter | 20 |
| | Page A: | Control Mode Parameter | 12 |
| | Page C: | Notch Parameter | 24 |
| | Page 19: | Port Control Parameter | |
| | (Sub Page 00) | | 8 |
| | (Sub Page 01) | | 24 |
| | Page 1A: | Power Condition Parameter | 12 |
| | Page 1C: | Information Exception Control Parameter | 12 |
| | Page 21: | Additional Error Recovery Parameter | 4 |

### IMPORTANT

1) The MODE SELECT parameter is ordinarily different in its configuration depending on the input/output device and the type of controller. It is also possible that current definitions may be expanded in accordance with the expansion of the functions of the IDD in the future. In order to assure independence of software from the individual specifications of input/output devices, before the INIT issues this command, it should follow the procedure of using the MODE SENSE and MODE SENSE EXTENDED command to determine the types of parameters the TARG is actually equipped with and the attributes of those parameters, such as whether or not they can be changed.
2) After changing anything in the "Block descriptor," "Format parameters (Page 3)" or "Drive parameters (Page 4)," with the MODE SELECT or MODE SELECT EXTENDED command, it is impossible to execute a command to access the data on the disk media until execution of the FORMAT UNIT command is completed, and a CHECK CONDITION status (MEDIUM ERROR [=3] / Medium format corrupted [=31-00]) is reported for all such commands.

The configuration and functions of the "Page descriptors" supported by the IDD are described below.

### IMPORTANT

In the diagram that shows the configuration of each individual "Page Descriptor," the default column shows that parameter's "default" value and the "variable" column shows whether or not it is possible to vary that parameter ("1" indicates that it can be varied). The INIT can know those values and attributes by using the MODE SENSE or MODE SENSE EXTENDED command.

(1) Read/Write error recovery parameters (page code = 1)

Table 4.15 lists the format of the page descriptor of this MODE SELECT parameter.

**Table 4.15 MODE SELECT parameters: read/write error recovery parameters**

| Byte \ Bit | | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | |
| 1 | | X‘0A’ (Page Length) | | | | | | | | |
| 2 | | AWRE | ARRE | TB | RC | ERR | PER | DTE | DCR | |
| | Default | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | |
| | Variable | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| 3 | | Number of retries during READ | | | | | | | | |
| | Default | X‘3F’ | | | | | | | | (=63 times) |
| | Variable | X‘FF’ | | | | | | | | |
| 4 | | Correctable Bit Length | | | | | | | | |
| | Default | X‘FF’ | | | | | | | | |
| | Variable | X‘00’ | | | | | | | | |
| 5 | | X‘00’ (Head Offset Count) | | | | | | | | |
| 6 | | X‘00’ (Data Strobe Offset Count) | | | | | | | | |
| 7 | | X‘00’ (Reserved) | | | | | | | | |
| 8 | | Number of retries during WRITE | | | | | | | | (=63 times) |
| | Default | X‘3F’ | | | | | | | | |
| | Variable | X‘FF’ | | | | | | | | |
| 9 | | X‘00’ (Reserved) | | | | | | | | |
| 10-11 | | Recovery Time Limit | | | | | | | | |
| | Default | X‘7530’ | | | | | | | | (=30s) |
| | Variable | X‘FFFF’ | | | | | | | | |

Error recovery parameters defined in this page descriptor are applicable for the following commands, except in cases where it is specifically pointed out.

- READ
- READ EXTENDED
- READ LONG
- SEND DIAGNOSTIC (Write/read test)
- WRITE
- WRITE AND VERIFY (Write operation)
- WRITE EXTENDED
- WRITE LONG

a. AWRE (automatic write reallocation enabled)

"1": An "automatic alternate block allocation processing" operation is specified during execution of a write operation.

"0": An "automatic alternate block allocation processing" operation is prohibited during execution of a write operation.

Automatic alternate block allocation processing is explained in Section 5.3.2.

b. ARRE (automatic read reallocation enable)

"1": An "automatic alternate block allocation processing" operation is specified during execution of a read operation.

"0": An "automatic alternate block allocation processing" operation is prohibited during execution of a read operation.

Automatic alternate block allocation processing is explained in Section 5.3.2.

c. TB (transfer block)

"1": Data blocks which contain errors that are impossible to correct are transferred to the INIT during a read operation.

"0": Data blocks which contain errors that are impossible to correct are not transferred to the INIT during a read operation.

d. RC (read continuous)

This bit specifies continuous transfer of all the data requested by a command unaccompanied by a delay for executing error recovery processing.

The IDD disregards the specification in this bit and operates according to the default value (=0).

e. EER (enable early recovery)

"1": When a correctable data check has been detected, data correction according to the ECC is applied immediately without executing retry (rereading) up to the number of times specified in the "Number of retries during READ" parameter.

"0": When a correctable data check has been detected, retry (rereading) is executed up to the number of times specified in the "Number of retries during READ" parameter, then data correction according to the ECC is applied if possible.

The IDD disregards this bit and operates according to the default value (=1).

f. PER (post error)

"1": When several errors (errors related to the disk drive), which were recovered from normally through the IDD's error recovery processing, have been detected, a CHECK CONDITION status is reported when execution of that command is completed. In the sense data generated at this time, the sense key indicates "RECOVERED ERROR [=1]" and the content of the final error to be corrected successfully is reported.

"0": Even when several errors (errors related to the disk drive), which were recovered from normally through the IDD's error recovery processing, have been detected, that command is completed with a GOOD status and the contents of the recovered errors are not reported.

g. DTE (disable transfer on error)

"1": Even when several errors on the disk drive, which were recovered from normally through the IDD's error recovery processing, have been detected, execution of that command terminates at that point.

"0": When several errors on the disk drive, which were recovered from normally through the IDD's error recovery processing, have been detected, execution of that command is continued.

The IDD disregards this bit and operates according to the default value (=0).

h. DCR (disable correction)

"1": Even when a correctable data check has been detected, data correction according to the ECC is prohibited. However, On-the-fly correction processing is not prohibited.

"0": When a correctable data check has been detected, data correction according to the ECC is applied.

The IDD disregards this bit and operates according to the default value (=0).

i. Number of retries during read

This parameter specifies the number of retries that should be executed for "Data Check" type errors detected in read operations on the disk media. The number of retries specified in this parameter is the maximum number of times reading is retried for each individual portion of data in each logical data block. If the IDD cannot perform correction of the data On-the-fly for each portion of data in the data block, it retries the reading of those portions. The reread retry is executed the number of times specified by the drive parameter internally by the IDD before this retry is executed, so actually the retry is executed the number specified here plus the number of internal retries.

The value specified in this parameter is applicable to the READ/READ EXTENDED commands and the read test in the SEND DIAGNOSTIC command.

When the page length in Page 1 is specified as X '06,' the value specified in this field is copied to the "Number of retries during WRITE" on this page and "Number of retries during VERIFY" on Page 7.

j. Correctable bit length

This parameter indicates the burst error length (bit length) which it is possible to apply data correction according to the ECC to. It is impossible to change this parameter from the INIT. The IDD disregards the value specified in this parameter and operates according to the "Default" value.

k. Head offset count (not supported)

This field specifies in two's-complement notation an incremental offset position from the track center to the radial position the heads are moved. Any value specified in this field does not preclude the device server from using positive or negative head offset during error recovery. However, after any error recovery is completed the device server returns the head offset to the value specified in this field.

The IDD is not supported this field. Therefore, the IDD ignores the specified value in this field.

l. Data strobe offset count (not supported)

   This field specifies in two's-complement notation an incremental position to where the recovered data strobe is adjusted from its nominal setting. Any value specified in this field does not preclude the device server from using positive or negative data strobe offset during error recovery. However, after any error recovery is completed the device server returns the data strobe offset to the value specified in this field.

   The IDD is not supported this field. Therefore, the IDD ignores the specified value in this field.

m. Number of retries during write

   This field specifies the maximum number of times writing of data to the disk media is retried in the case that there has been an interruption in a write operation such as a shock. The number of retries specified in this field is applied to each logical block unit. When zero is specified in this field, retrying of writing to the disk is prohibited.

   The value specified in this field is applicable to the WRITE command, WRITE EXTENDED command, write operation in the WRITE AND VERIFY command and write test in the SEND DIAGNOSTIC command. When the page length in Page 1 is specified as X '06,' the value specified in this field is not transferred from the INIT, but in this case, the value specified in the "Number of retries during READ," on the same page, is also applied to this field by the IDD.

n. Recovery time limit (not supported)

   This parameter specifies the maximum time that can be used by the TARG for error recovery processing, as a 1ms constant. The value specified in this parameter is the maximum permissible time for error recovery processing for each individual command. When both this parameter and the "Number of retries" parameter are specified, the parameter which specifies the shortest time must be given priority in application.

   If less than 5000ms is specified, the IDD performs rounding processing and sets 5000ms.

### Table 4.16 Combination of error recovery flags (1/4)

| EER | PER | DTE | DCR | Error Recovery Procedure |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1. Rereading is tried repeatedly up to the number of times specified in the "Read Retry Count", "Write Retry Count" or "Verify Retry Count" parameter. If possible, data correction is executed afterward according to the ECC.<br>2. When error recovery has succeeded, processing of the command is continued.<br>3. The contents of recovered errors are not reported.<br>4. If unrecoverable errors have been detected, execution of that command is terminated at that point.<br>5. Transfer of data in blocks which include unrecoverable errors to the INIT is done in accordance with the specification in the TB bit (read commands). |
| 0 | 0 | 0 | 1 | 1. Rereading is tried repeatedly up to the number of times specified in the "Read Retry Count", "Write Retry Count" or "Verify Retry Count" parameter. Data correction is not executed according to the ECC.<br>2. When error recovery has succeeded, processing of the command is continued.<br>3. The contents of recovered errors are not reported.<br>4. If unrecoverable errors have been detected, execution of that command is terminated at that point.<br>5. Transfer of data in blocks which include unrecoverable errors to the INIT is done in accordance with the specification in the TB bit (read commands). |
| 0 | 0 | 1 | 0 | (Setting prohibited) (See *1 at the end of this table.) |
| 0 | 0 | 1 | 1 | (Setting prohibited) (See *1 at the end of this table.) |
| 0 | 1 | 0 | 0 | 1. Rereading is tried repeatedly up to the number of times specified in the "Read Retry Count", "Write Retry Count" or "Verify Retry Count" parameter. If possible, data correction is executed afterward according to the ECC.<br>2. When error recovery has succeeded, processing of the command is continued.<br>3. If unrecoverable errors have been detected, execution of that command is terminated at that point.<br>4. Transfer of data in blocks which include unrecoverable errors to the INIT is done in accordance with the specification in the TB bit (read commands).<br>5. When recovery from all detected errors has been successful, a CHECK CONDITION status (RECOVERED ERROR [=1]) is reported after all processing of the command is completed and the sense data indicate the content of the last error that was successfully recovered from and the address of the data block where that error occurred. |

### Table 4.16 Combinations of error recovery flags (2/4)

| EER | PER | DTE | DCR | Error Recovery Procedure |
|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 1. Rereading is tried repeatedly up to the number of times specified in the "Read Retry Count", "Write Retry Count" or "Verify Retry Count" parameter. Data correction is not executed according to the ECC.<br>2. When error recovery has succeeded, processing of the command is continued.<br>3. If unrecoverable errors have been detected, execution of that command is terminated at that point.<br>4. Transfer of data in blocks which include unrecoverable errors to the INIT is done in accordance with the specification in the TB bit (read commands).<br>5. When recovery from all detected errors has been successful, a CHECK CONDITION status (RECOVERED ERROR [=1]) is reported after all processing of the command is completed and the sense data indicate the content of the last error that was successfully recovered from and the address of the data block where that error occurred. |
| 0 | 1 | 1 | 0 | 1. Rereading is tried repeatedly up to the number of times specified in the "Read Retry Count", "Write Retry Count" or "Verify Retry Count" parameter. If possible, data correction is executed afterward according to the ECC.<br>2. When error recovery has succeeded, or even when recovery is impossible, execution of the command is terminated with a CHECK CONDITION status at the point when error recovery processing is completed, and the sense data indicate the data block address where that error occurred.<br>3. Transfer to the INIT of data in blocks with recovered errors is done, but transfer to the INIT of data blocks in which the errors were unrecoverable is done in accordance with the specification in the TB bit (read commands). |
| 0 | 1 | 1 | 1 | 1. Rereading is tried repeatedly up to the number of times specified in the "Read Retry Count", "Write Retry Count" or "Verify Retry Count" parameter. Data correction is not executed according to the ECC.<br>2. When error recovery has succeeded, or even when recovery is impossible, execution of the command is terminated with a CHECK CONDITION status at the point when error recovery processing is completed, and the sense data indicate the data block address where that error occurred.<br>3. Transfer to the INIT of data in blocks with recovered errors is done, but transfer to the INIT of data blocks in which the errors were unrecoverable is done in accordance with the specification in the TB bit (read commands). |

**Table 4.16 Combinations of error recovery flags (3/4)**

| EER | PER | DTE | DCR | Error Recovery Procedure |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 1. When a correctable data check is detected, immediately, correction is executed according to the ECC. For data checks which cannot be corrected, rereading is tried repeatedly up to the number of times specified in the "Read Retry Count", "Write Retry Count" or "Verify Retry Count" parameter. However, if a correctable error is detected during reading, data correction is executed at that point according to the ECC.<br>2. When error recovery has succeeded, processing of the command is continued.<br>3. The contents of recovered errors are not reported.<br>4. If unrecoverable errors have been detected, execution of that command is terminated at that point.<br>5. Transfer of data in blocks which include unrecoverable errors to the INIT is done in accordance with the specification in the TB bit (read commands). |
| 1 | 0 | 0 | 1 | (Setting prohibited) (See *1 at the end of this table.) |
| 1 | 0 | 1 | 0 | (Setting prohibited) (See *1 at the end of this table.) |
| 1 | 0 | 1 | 1 | (Setting prohibited) (See *1 at the end of this table.) |
| 1 | 1 | 0 | 0 | 1. When a correctable data check is detected, immediately, correction is executed according to the ECC. For data checks which cannot be corrected, rereading is tried repeatedly up to the number of times specified in the "Read Retry Count", "Write Retry Count" or "Verify Retry Count" parameter. However, if a correctable error is detected during reading, data correction is executed at that point according to the ECC.<br>2. When error recovery has succeeded, processing of the command is continued.<br>3. If unrecoverable errors have been detected, execution of that command is terminated at that point.<br>4. Transfer of data in blocks which include unrecoverable errors to the INIT is done in accordance with the specification in the TB bit (read commands).<br>5. When recovery from all detected errors has been successful, a CHECK CONDITION status (RECOVERED ERROR [=1]) is reported after all processing of the command is completed and the sense data indicate the content of the last error that was successfully recovered from and the address of the data block where that error occurred. However, if the error is corrected with ECC only, the CHECK CONDITION is not reported and no sense data is created. |
| 1 | 1 | 0 | 1 | (Setting prohibited) (See *1 at the end of this table.) |

### Table 4.16 Combinations of error recovery flags (4/4)

| EER | PER | DTE | DCR | Error Recovery Procedure |
|---|---|---|---|---|
| 1 | 1 | 1 | 0 | 1. When a correctable data check is detected, immediately, correction is executed according to the ECC. For data checks which cannot be corrected, rereading is tried repeatedly up to the number of times specified in the "Read Retry Count", "Write Retry Count" or "Verify Retry Count" parameter. However, if a correctable error is detected during reading, data correction is executed at that point according to the ECC.<br>2. When error recovery has succeeded, or even when recovery is impossible, execution of the command is terminated with a CHECK CONDITION status at the point when error recovery processing is completed, and the sense data indicate the data block address where that error occurred.<br>3. Transfer to the INIT of data in blocks with recovered errors is done, but transfer to the INIT of data blocks in which the errors were unrecoverable is done in accordance with the specification in the TB bit (read commands). |
| 1 | 1 | 1 | 1 | (Setting prohibited) (See *1 at the end of this table.) |

*1 If a setting-prohibited combination of error recovery flags is specified, the MODE SELECT or MODE SELECT EXTENDED command is terminated with a CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in parameter list [=26-00]) and all the parameters specified at that time are disabled.

Remark:

Just as explained for the EER, PER, DTE and DCR bits, the IDD can only make a valid specification for the PER bit. Therefore, among the error recovery flag combinations listed above, the only one which can actually operated is (EER, PER, DTE, DCR) = (1, 0, 0, 0) and (1, 1, 0, 0).

### (2) Disconnect/reconnect parameters (page code = 2)

The format of the page descriptor in this MODE SELECT parameter is shown in Table 4.17.

**Table 4.17 MODE SELECT parameters: disconnect/reconnect parameters**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | X ' 0E ' (Page Length) | | | | | | | |
| 2 | X ' 00 ' | | | | | | | |
| 3 | X ' 00 ' | | | | | | | |
| 4-5 | Bus Inactivity Ratio | | | | | | | |
| Default | X ' 0000 ' | | | | | | | |
| Variable | X ' 0000 ' | | | | | | | |
| 6-7 | X ' 0000 ' | | | | | | | |
| 8-9 | Connect Time Limit | | | | | | | |
| Default | X ' 0000 ' | | | | | | | |
| Variable | X ' 0000 ' | | | | | | | |
| 10-11 | Maximum Burst Size | | | | | | | |
| Default | X ' 0000 ' | | | | | | | |
| Variable | X ' 0000 ' | | | | | | | |
| 12 | X ' 00 ' | | | | | | | |
| 13 | X ' 00 ' | | | | | | | |
| 14-15 | (Burst Size During the Initialize Connection) | | | | | | | |
| Default | X ' 0000 ' | | | | | | | |
| Variable | X ' 0000 ' | | | | | | | |

a. Bus inactivity ratio

This parameter specifies the maximum period of time from the time of OPEN processing for the address frame during which the TARG executes no operations as a multiple of 100 µs.

The IDD ignores the value specified by this parameter and operates according to the default value of '000A.'

b Connect time limit

This parameter specifies the maximum period of time for which the open state of the connection can be maintained before the TARG starts the closing processing as a multiple of 100 μs.

This value of the IDD is infinite. This parameter cannot be changed by INITs.

The IDD ignores the value specified for this parameter.

c. Maximum burst size

This parameter specifies the maximum number of transfer bytes that the TARG transfers in the data frames between the OPEN processing for the address frame and the execution of the DONE-CLOSE primitive as a multiple of 512 bytes.

The IDD ignores the value specified for this parameter.

d. Burst size during the initial connection

When the ENABLE FIRST BURST bit of the command frame is set to "1," this parameter specifies the maximum number of write data bytes that an INIT can transfer without transferring XFER_RDY frames immediately after transfer of a command frame. The number of bytes is specified in this parameter as a multiple of 512 bytes.

Since the IDD does not support the ENABLE FIRST BURST function for command frames, this parameter is ignored if specified.

### (3) Format parameters (page code = 3)

The Page descriptor format of this MODE SELECT parameter is shown in Table 4.18.

**Table 4.18 MODE SELECT parameters: format parameters**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 1 | X‘16’ (Page Length) | | | | | | | |
| 2-3 | Track Count/Zone | | | | | | | |
| Default | X‘xxxx’ | | | | | | | |
| Variable | X‘0000’ | | | | | | | |
| 4-5 | Alternate Sector Count/Zone | | | | | | | |
| Default | X‘0066’ (MAUxxxx) or X’(T.B.D)’ (MAUxxxx) | | | | | | | |
| Variable | X‘FFFF’ | | | | | | | |
| 6-7 | Alternate Track Count/Zone | | | | | | | |
| Default | X‘0000’ | | | | | | | |
| Variable | X‘0000’ | | | | | | | |
| 8-9 | Alternate Track Count/Drive | | | | | | | |
| Default | X‘xxxx’ | | | | | | | |
| Variable | X‘0000’ | | | | | | | |
| 10-11 | Sector Count/Track | | | | | | | |
| Default | X‘xxxx’ | | | | | | | |
| Variable | X‘0000’ | | | | | | | |
| 12-13 | Data Byte Length/Physical Sector | | | | | | | |
| Default | X‘xxxx’ | | | | | | | |
| Variable | X‘FFFF’ | | | | | | | |
| 14-15 | Interleave Factor | | | | | | | |
| Default | X‘0001’ | | | | | | | |
| Variable | X‘0000’ | | | | | | | |
| 16-17 | Track Skew Factor | | | | | | | |
| Default | X‘xxxx’ | | | | | | | |
| Variable | X‘0000’ | | | | | | | |
| 18-19 | Cylinder Skew Factor | | | | | | | |
| Default | X‘xxxx’ | | | | | | | |
| Variable | X‘0000’ | | | | | | | |
| 20 | SSEC | HSEC | RMB | SURF | 0 | 0 | 0 | 0 |
| Default | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Variable | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21-23 | X‘000000’ (Reserved) | | | | | | | |

a. Parameters for specifying alternate processing areas for defective blocks (bytes 2 to 9)

The following 4 parameters specify the position and number of spare sectors for performing defective block alternate allocation processing on the disk media. See Chapter 3, "Data Format" of Product Manual for details of the IDD's alternate block processing.

– Track count/zone (bytes 2 to 9)

This parameter specifies the number of tracks a unit for alternating blocks. The INIT cannot clearly specify this value. The IDD ignores the specification for this bit. If the value of the Active Notch in Page C is 0, the “Number of Logic Heads a cell” is reported for the MODE SENSE and MODE SENSE EXTENDED commands.

If not, the total number of track of the zone which is specified as the Active Notch is reported.

– Alternate sector count/zone

This parameter specifies the number of sectors per one cell as the number of spare sectors secured for use as alternate blocks. In the IDD, this parameter indicates the number of spare sectors secured in each cell.
It is possible for the INIT to vary this parameter within a range of 0 to the maximum permissible value. When a value which exceeds the maximum permissible value is specified, the IDD performs rounding down of the parameter and sets a value equal to this parameter's maximum permissible value. If the above rounding processing is performed, a CHECK CONDITION status (RECOVERED ERROR [= 1] / Rounded parameter [37-00]) is reported for that command.

– Alternate track count/zone

This parameter specifies the area secured for alternate blocks as the number of tracks per one cell. It is impossible to change this parameter. When a value other than zero is specified in this field, the IDD performs rounding down processing of this parameter and always sets this parameter value at zero.

– Alternate track count/drive

This parameter specifies the area secured for alternate blocks as the number of tracks per disk drive. In the IDD, this parameter indicates the number of tracks in the spare area secured as alternate cells. This value is fixed at a value that equals the number of tracks per cylinder multiplied by the number of zones in the IDD. This parameter cannot be changed by the INIT.

b. Parameters specifying track format (bytes 10, 11)

– Sector count/track

This parameter specifies the number of physical sectors per 1 track. In the IDD, the number of physical sectors in a track is set unilaterally according to the data format specified by the "Data Block Length" parameter in the block descriptor or the "Data byte length/Physical sector" parameter in this page descriptor, so this parameter cannot be changed. The IDD disregards the value specified in this field. This parameter indicates the value of zone specified in Active Notch of Page C. If it is 0, this parameter indicates the value in zone 0.

c. Parameters specifying sector format (bytes 12 to 19)

– Data byte length/physical sectors

This parameter specifies the data length per 1 physical sector as the number of bytes. In the IDD, the data byte length per 1 physical sector is the same as the data byte length in 1 logical data block. The INIT can specify the value of this parameter at 0 or 512 to 528 bytes (4-byte boundary).

If a value less than 512 bytes, the IDD sets a byte length of 512. If more than 528 bytes is specified, the IDD performs rounding processing and sets a byte length of 528. If an odd number of bytes is specified within the specified range, the IDD performs rounding up processing. If the above rounding processing is performed, the IDD reports the CHECK CONDITION status (RECOVERED ERROR [=1] / Rounded parameter [37-00]) for that command.

If 0 is specified in this parameter, the value calculated based on the value of the "Data block length" in the block descriptor is used as this parameter value.

When both this page descriptor and the block descriptor are specified by the same MODE SELECT command, and a nonzero value is specified in this parameter which differs from the value in the "Data block length" parameter in the block descriptor, the value specified in the block descriptor has priority.

– Interleave factor

This parameter field has meaning only with the MODE SENSE and MODE SENSE EXTENDED commands. The interleave factor (in the IDD, this is always X '0001' :non interleave) of the disk drive's current data format. The value specified in this field is disregarded in the MODE SELECT and MODE SELECT EXTENDED commands.

– Track skew factor

This parameter indicates the number of physical sectors existing between the data block with the highest order logical block address on a track and the data block with the next logical block address on the next track of the same cylinder (track skew). This parameter cannot be changed.

The IDD disregards the value specified in this field and sets the optimum track skew value in the specified data block length. See Chapter 3, "Data Format" in the Product Manual for details about track skew. This parameter indicates the value of zone specified in active notch of Page C. If it is 0, this parameter indicates the value in zone 0.

– Cylinder skew factor

This parameter indicates the number of physical sectors existing between the data block with the highest order logical block address in a cylinder and the data block with the next logical block address in the next cylinder (cylinder skew). This parameter cannot be changed. The IDD disregards the value specified in this field and sets the optimum cylinder skew value in the specified data block length. See Chapter 3, "Data Format" in the Product Manual for details about cylinder skew. This parameter indicates the value of zone specified in active notch of Page C. If it is 0, this parameter indicates the value in zone 0.

d. Parameters related to device type (byte 20)

– SSEC (soft sectoring)

When this bit is "1," it indicates that the data formatting method on the disk media is "soft sectoring." However, since the IDD uses only the "hard sectoring" method (refer to previously shown item b), this bit is disregarded. Furthermore, it is impossible to change this parameter.

– HSEC (hard sectoring)

When this bit is "1," it indicates that the data formatting method on the disk media is "hard sectoring." However, since the IDD uses only the "hard sectoring" method, this bit is disregarded. Furthermore, it is impossible to change this parameter.

– RMB (removable medium)

When this bit is "1," it indicates that the storage media of the disk drive can be replaced. When this bit is "0," it indicates that the storage media is fixed. However, since the IDD has a fixed media, this bit is disregarded. Furthermore, it is impossible to change this parameter.

– SURF (surface addressing)

When this bit is "1," it indicates that after logical data block address allocation is performed over all the sectors in order on the same memory surface (same head), it is proceeding to the next memory surface (next head) after all the sectors have been done. When this bit is "0," it indicates that after logical data block address allocation is performed over all the sectors in order in the same cylinder (all heads), it is proceeding to the next cylinder. In the IDD, only the latter type of addressing is possible, so this bit is disregarded. It is also impossible to change this parameter.

### (4) Drive parameters (page code = 4)

The page descriptor format of this MODE SELECT parameter is shown in Table 4.19.

**Table 4.19 MODE SELECT parameters: drive parameters**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 1 | X‘16’ (Page Length) | | | | | | | |
| 2-4 | Cylinder Count | | | | | | | |
| Default | X‘xxxxxx’ | | | | | | | |
| Variable | X‘000000’ | | | | | | | |
| 5 | Number of Heads | | | | | | | |
| Default | X‘xx’ | | | | | | | |
| Variable | X‘00’ | | | | | | | |
| 6-8 | "Write Precompensation" Starting Cylinder | | | | | | | |
| Default | X‘000000’ | | | | | | | |
| Variable | X’000000’ | | | | | | | |
| 9-11 | "Reduced Write Current" Starting Cylinder | | | | | | | |
| Default | X‘000000’ | | | | | | | |
| Variable | X‘000000’ | | | | | | | |
| 12-13 | Drive Step Rate | | | | | | | |
| Default | X‘0000’ | | | | | | | |
| Variable | X‘0000’ | | | | | | | |
| 14-16 | Landing Zone Cylinder | | | | | | | |
| Default | X‘000000’ | | | | | | | |
| Variable | X‘000000’ | | | | | | | |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | RPL | |
| Default | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Variable | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | Rotational Synchronization Offset | | | | | | | |
| Default | X‘00’ | | | | | | | |
| Variable | X‘00’ | | | | | | | |
| 19 | X‘00’ (Reserved) | | | | | | | |
| 20-21 | Rotational Speed | | | | | | | |
| Default | X’2729’ (10,025 rpm)<br>or<br>X’3A98’ (15,000 rpm) | | | | | | | |
| Variable | X‘0000’ | | | | | | | |
| 22-23 | X‘0000’ (Reserved) | | | | | | | |

a. Cylinder count

This parameter specifies the total number of cylinders configured in the user space on the disk media. This value includes the number of cylinders for alternate blocks specified in the "Alternate Track Count/Drive" parameter of the format parameters (Page code = 3).

It is impossible to change this parameter.

b. Number of heads

This parameter indicates the number of data Read/Write heads in the disk drive. It is impossible to change this parameter. If zero or a value which differs from the "Default" value is specified in this parameter field, the IDD performs rounding processing of the parameter, setting a value which is the same as the default value in it.

c. Bytes 6 to 16

The parameter defined in bytes 6 to 16 of this page descriptor is a parameter that it is clearly not necessary for the INIT to specify. The IDD disregards the values specified in this field.

d. RPL (rotational position locking)

These bits are used for rotational synchronization of the disk and can be specified. The IDD disregards the value specified in this field.

e. Rotational synchronization offset

This is a field which specifies the offset value used for rotational synchronization of the disk, but it is not supported in the IDD. The IDD disregards the value specified in this field.

f. Rotational speed

This specifies the disk's rotational speed in rpm (rotations/minute). This parameter cannot be changed by the INIT. The IDD disregards the value specified in this field and operates according to the “Default” value.

### (5) Verify error recovery parameters (page code = 7)

The page descriptor format of this MODE SELECT parameter is shown in Table 4.20.

**Table 4.20 MODE SELECT parameters: verify error recovery parameters**

| Byte \ Bit | | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| 0 | | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 1 | | X'0A' (Page Length) | | | | | | | |
| 2 | | (Reserved) | | | | EER | PER | DTE | DCR |
| | Default | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | Variable | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 3 | | Number of retries during VERIFY. | | | | | | | |
| | Default | X'3F' | | | | | | | |
| | Variable | X'FF' | | | | | | | |
| 4 | | Correctable Bit Length | | | | | | | |
| | Default | X'FF' | | | | | | | |
| | Variable | X'00' | | | | | | | |
| 5-9 | | X'0000000000' (Reserved) | | | | | | | |
| 10-11 | | Recovery Time Limit | | | | | | | |
| | Default | X'7530' | | | | | | | |
| | Variable | X'FFFF' | | | | | | | |

The error recovery parameters divided in this page descriptor are applicable for the following commands.

- VERIFY
- WRITE AND VERIFY (verify operation)

a. Error recovery flags

- EER (enable early recovery)
- PER (post error)
- DTE (disable transfer on error)
- DCR (disable correction)

The definitions and functions of these control flags are the same as for the read/write error recovery parameters. See item (1) concerning the details.

b. Number of retries during VERIFY

This parameter specifies the number of times reading of the disk media should be retried when a "Data Check" type error is detected in a read operation. the number of retries specified by this parameter is the maximum number of times reading of each individual data area in each logical data block is retried. The IDD retries reading the data area in each data block the specified number of times. When zero is specified in this field, retrying to read data from the disk is prohibited.

c. Correctable bit length

This parameter indicates the burst error length (bit length) that can be applied for data corrections according to the ECC. This parameter cannot be changed by the INIT. However, the IDD disregards the value specified in this parameter and operations according to the "Default" value.

d. Recovery time limit

This parameter specifies the maximum time the TARG can be used for error recovery processing, as a 1ms constant. The value specified in this parameter is the maximum permissible error recovery processing time for an individual command. When both this parameter and the "Number of retries during VERIFY" parameter are specified, priority must be given to whichever parameter specifies the shortest time in its application.

The reported value in this field is a copy of the Recovery time limit in Page 1. The IDD disregards the value specified in this field.

(6) Caching parameters (page code = 8)

The page descriptor format of this MODE SELECT parameter is shown in Table 4.21.

**Table 4.21 MODE SELECT parameters: caching parameters**

| Bit<br>Byte | | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| 0 | | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 1 | | X'12' (Page Length) | | | | | | | |
| 2 | | IC | ABPF | CAP | DISC | SIZE | WCE | MS | RCD |
| | Default | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| | Variable | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 3 | | Demand Read Retention Priority | | | | Write Retention Priority | | | |
| | Default | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Variable | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4-5 | | Pre-fetch inhibit block count | | | | | | | |
| | Default | X'FFFF' | | | | | | | |
| | Variable | X'0000' | | | | | | | |
| 6-7 | | Minimum pre-fetch | | | | | | | |
| | Default | X'0000' | | | | | | | |
| | Variable | X'0000' | | | | | | | |
| 8-9 | | Maximum pre-fetch | | | | | | | |
| | Default | X'xxxx' | | | | | | | |
| | Variable | X'0000' | | | | | | | |
| 10-11 | | Maximum pre-fetch limit block count | | | | | | | |
| | Default | X'FFFF' | | | | | | | |
| | Variable | X'0000' | | | | | | | |
| 12 | | FSW | LBCSS | DRA | VS | VS | (Reserved) | | |
| | Default | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Variable | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | | Cache Segment Count | | | | | | | |
| | Default | X'08' | | | | | | | |
| | Variable | X'3F' | | | | | | | |
| 14-15 | | Cache Segment Size | | | | | | | |
| | Default | X'0000' | | | | | | | |
| | Variable | X'0000' | | | | | | | |
| 16 | | X'00' (Reserved) | | | | | | | |
| 17-19 | | Non Cache Segment Size | | | | | | | |
| | Default | X'000000' | | | | | | | |
| | Variable | X'000000' | | | | | | | |

The parameters defined in this page descriptor control the range of look-ahead data in the Look-Ahead cache feature and enable or disable the caching operation. See Section 3.2, "Look-Ahead Cache Feature" and Section 3.3, "Write Cache" concerning details of the Look-Ahead cache feature and parameter setting methods.

a. RCD (read cache disable)

This bit can be specified, and its operation is as specified.

This bit specifies whether or not to activate the cache operation for a read command.

"1": Prohibits operation of the Look-Ahead cache function.

The IDD reads ahead all of the data requested by the READ command or READ EXTENDED command from the disk and transfers it to the INIT. Moreover, it does not read ahead data blocks after the requested data.

"0": Specifies operation of the Look-Ahead cache function.

If part or all of the data, including logical data blocks of headers, requested by a READ command or READ EXTENDED command exists in the data buffer, the IDD transfers that data without accessing the disk. Also, depending on the instructions for the bytes beyond byte 4 of the parameter page, it reads ahead the data blocks after the requested data in the data buffer.

b. MS (multiple selection)

This bit specifies how to specify the "minimum prefetch count" (bytes 6 and 7) and "maximum prefetch count" (bytes 8 and 9) parameters in this page descriptor.

1: The "minimum prefetch count" and "maximum prefetch count" parameters indicate a multiplier. The number of data blocks to be prefetch is calculated that the value in the "transfer byte count" in the CDB specified by the READ or READ EXTENDED command X multiplier.

0: The "minimum prefetch count" and "maximum prefetch count" parameters indicate the data block count to be prefetched with the logical data block count.

This bit cannot be changed, and the IDD ignores this bit specification and operates according to the default value ('0').

c. WCE (write cache enable)

This bit can be specified, and its operation is as specified.

This bit specifies whether or not to activate the cache operation for a write command.

"1": This enables the write cache.
Write data remains in the buffer memory, the cache is made the object even for a read command, and when all of the write data has been received, "GOOD" status is reported without waiting for writing data to the disk media.
Sequential writing is performed without waiting for rotation.

"0": This prohibits operation of the write cache function.
Write data remains in the buffer memory, the cache is not made the object even for a read command, and as soon as all the data has been written to the disk, "GOOD" status is reported.

d. SIZE (size enable) (not supported)

"1": Divides the data buffer in accordance with the value specified for the cache segment size (bytes 14, 15).

"0": Divides the data buffer in accordance with the value specified for the number of cache segments (byte 13).

This bit cannot be changed. The IDD disregards the specification in this bit and operates according to the "Default" value (= "0").

e. DISC (discontinuity)

"1": Even if a track switch occurs during Look-Ahead, the Look-Ahead operation continues without interruption.

"0": Look-Ahead is terminated at the point where track switch occurs during Look-Ahead.

This bit cannot be changed. The IDD disregards the specification in this bit and operates according to the "Default" value (= "1").

f. IC (initiator control enable)

"1": Dividing of cache segments is according to the SIZE bit specification.

"0": Dividing of the cache segments is performed by an algorithm that is inherent in the IDD.

This bit can be changed, and its operation is as specified.

g. Demand read retention priority (not supported)

This field advises the device server the retention priority to assign for data read into the cache that has also been transferred from the logical unit to the INIT.

The IDD are not supported this field. Thus, the IDD disregards the specification in this field.

"F": Data put into the cache via a READ command was not replaced if there is other data in the cache that was placed into the cache by other means and it may be replaced.

"1": Data put into the cache via a READ command was replaced sooner than data placed into the cache by other means.

"0": Indicates the device server was not distinguish between retaining the indicated data and data placed into the cache memory by other means.

h. Write retention priority (not supported)

This field advises the device server the retention priority to assign for data written into the cache that has also been transferred from the cache memory to the medium.

"F": Data put into the cache during a WRITE or WRITE and VERIFY command was not replaced if there is ohter data in the cache that was placed into the cache by other means and it may be replaced.

"1": Data put into the cache during a WRITE or WRITE and VERIFY command was replaced sooner than data placed into the cache by other means.

"0": Indicates the device server was not distinguish between retaining the indicated data and data placed into the cache memory by other means.

i. Pre-fetch inhibit block count (not supported)

This parameter is used to selectively prohibit data Look-Ahead operations in the READ command or the READ EXTENDED command. When the "Transfer block count" specified in the CDB of the READ command or the READ EXTENDED command is greater than the value in this parameter, data Look-Ahead operations are not executed in that command. This bit cannot be changed. The IDD disregards the specification in this bit and operates according to the "Default" value (= X 'FFFF').

j. Minimum pre-fetch (not supported)

This parameter specifies the minimum quantity of logical data blocks pre-fetched to the data buffer with the READ command or READ EXTENDED command.

This parameter cannot be changed. The IDD disregards the specification in this field.

k. Maximum pre-fetch (not supported)

This parameter specifies the maximum quantity of logical data blocks pre-fetched to the data buffer with the READ command or READ EXTENDED command.

The IDD varies the pre-fetch volume according to the volume of data requested by the READ command or READ EXTENDED command. The value reported to the MODE SENSE command always indicates the number of blocks corresponding to 1 cache segment – 1.

This parameter cannot be changed. The IDD disregards the specification in this field.

l. Maximum pre-fetch control block count (not supported)

This parameter specifies the maximum quantity of logical data blocks pre-fetched to the data buffer with the READ command or READ EXTENDED command. In the IDD the maximum pre-fetch quantity cannot be limited.

This parameter cannot be changed. The IDD disregards the specification in this field.

m. DRA (disable read-ahead) (not support)

This bit specifies whether or not activate the read-ahead operation.

This bit cannot be changed. The IDD disregards the specification in this bit.

"1": Requests that the device server not read into the buffer any logical blocks beyond the addressed logical blocks.

"0": The device server continues to read logical blocks into the buffer beyond the addressed logical blocks.

n. FSW (force sequential write) (not supported)

This bit specifies how to write multiple blocks.

"1": If the IDD writes multiple blocks, this indicates that data are recorded on the disk media in the order in which they are transferred from the INIT.

"0": If the IDD writes multiple blocks, this indicates that data are recorded on the disk media with their order changed in order to complete the command in the fastest time.

This bit cannot be changed. The IDD disregards the specification in this bit and operates according to the "Default" value (="1").

o. LBCSS (logical block cache segment size) (not supported)

"1": Indicates that the "Cache segment size" field units are interpreted as logical blocks.

"0": The "Cache segment size" field units are interpreted as bytes.

This bit is not supported for the IDD. The IDD disregards the specification in this bit.

p. Cache segment count

This parameter specifies the number of cache segments used by the IDD. This parameter is valid when the SIZE bit specification is "0."

When a value greater than max value is specified, the IDD performs rounding processing and sets max value. Also, when a value less than 3 is specified, the IDD performs rounding processing and set 4.

This parameter indicates the same value for all initiators and if it is changed by any initiator, a UNIT ATTENTION condition (UNIT ATTENTION [=6] / Mode select parameter changed [=2A-01]) is generated for all the initiators that did not change it.

This parameter can be changed though the IDD disregards the specification of this field. The IDD divided the Cache Segments according to the inherent algorithm. That is, the Cache Segment size is best tuned per the request data size of Host command. Within one Cache Segment, data for various commands are stored. The biggest Cache Segment size is approximately 476 KB.

IDD does not support this parameter. IDD disregards the specification of this field.

q. Non cache buffer size

If this field is greater than zero, this field advises the device server how many bytes the application client requests that the device server allocate for a buffer function when all other cache segments are occupied by data to be retained. If the number is at least one, caching functions in the other segments need not be impacted by cache misses to perform the buffer function. The impact of this field equals 0 or the sum of this field plus this field greater than the buffer size is vendor-specific.

This bit is not supported for the IDD. The IDD disregards the specification in this bit.

### (7) Control mode parameters (page code = 0A)

The page descriptor format of this MODE SELECT parameter is shown in Table 4.22.

**Table 4.22 MODE SELECT parameters: control mode parameters**

| Bit<br>Byte | | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| 0 | | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 1 | | X‘0A’ (Page Length) | | | | | | | |
| 2 | | TST | | | (Reserved) | | | GLTSD | RLEC |
| | Default | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Variable | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 3 | | Queue Algorithm Qualifier | | | | Reserved | Qerr | | DQue |
| | Default | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Variable | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 4 | | Reserved | RAC | Reserved | | SWP | RAERP | UAAERP | EAERP |
| | Default | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Variable | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | | X‘00’ (Reserved) | | | | | | | |
| 6-7 | | Ready Aer Holdoff Period | | | | | | | |
| | Default | X‘0000’ | | | | | | | |
| | Variable | X‘0000’ | | | | | | | |
| 8-9 | | Busy Timeout Period | | | | | | | |
| | Default | X‘0000’ | | | | | | | |
| | Variable | X‘0000’ | | | | | | | |
| 10-11 | | Extended Self-Test Completion Time | | | | | | | |
| | Default | X‘xxxx’ | | | | | | | |
| | Variable | X‘0000’ | | | | | | | |

The parameters defined on this page control the operations of the tagged queuing function and statistical information function.

a. TST (task set type)

This field specifies the type of task set defined below.

**Table 4.23 TST**

| Value | Description |
|---|---|
| 000b | Task set per logical unit for all initiators |
| 001b | Task set per initiator per logical unit |
| 010b-111b | Reserved |

The IDD operates according to "000b". If other value is specified in this field, the IDD reports a "CHECK CONDITION" status (ILLEGAL REQUEST [=5] / Invalid parameter in list [=26-00]).

b. Queue algorithm qualifier

This parameter controls the execution order algorithm of a command issued together with a SIMPLE QUEUE TAG message.

"0000": The IDD executes commands queued from each INIT in the order in which they were received. However, the command execution order for the READ, READ EXTENDED and PRE-FETCH commands may be changed.

"0001": The IDD executes queued commands by the method selected by the IDD. At this time, the INIT must verify the correctness of the data through appropriate commands and QUEUE TAG messages.

"1111": The IDD prohibits to order queued commands.

When other value is specified in this parameter, the IDD reports a CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid parameter in List [=26-00]).

c. GLTSD (global logging target save disable) (not supported)

This bit specifies whether or not to permit the saving treatment of peculiar logging parameter within the IDD.

Since the IDD performs the saving treatment with itself algorithm regardless of specified value in this bit, disregards the specification in this bit.

d. RLEC (report log exception condition) (not supported)

This bit controls operations in cases where the accumulated value log parameter reaches the maximum value.

"1": The IDD reports a CHECK CONDITION status (UNIT ATTENTION [=6] / Log counter at maximum [5B-02]).

"0": The IDD executes the command which is issued next normally.

Since the IDD does not support the reporting function of exception condition, the IDD disregards the specification in this bit.

e. DQue (disable queuing)

This bit specifies whether the IDD will execute processing of tagged commands or not.

"1": The IDD prohibits tagged queuing processing. The IDD clears queued commands and generates a UNIT ATTENTION condition (Command cleared by another initiator [=2F-00]) for each of the INITs that issued the commands which were cleared. After that, the when a QUEUE TAG message is received, it is rejected with a MESSAGE REJECT message and executed as an untagged command.

"0": The IDD permits tagged queuing processing.

f. QErr (queue error management)

This field controls processing of commands queued after a sense hold state is canceled when the IDD is in the sense hold state.

**Table 4.24 QErr**

| Value | Description |
|---|---|
| 00b | The IDD, when it has been in any one of various sense hold states, then that sense hold state is cleared, continues executing the commands which are queued by normal methods. |
| 01b | The IDD, when it has been in any one of various sense hold states, then that sense hold state is cleared, clears the commands which are queued. At this time, the IDD generates a UNIT ATTENTION condition (UNIT ATTENTION [=6] / Command Cleared by Another Initiator [=2F-00]) for each of the INITs that issued the commands which were cleared. |
| 10b | Reserved |
| 11b | The IDD, when it has been in any one of various sense hold states, then that sense hold state is cleared, clears the commands which are queued by abnormal terminated INIT. |

The IDD is not supported "11b" specified in this field. If "11b" or "10b" is specified in this field, the IDD reports a CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid parameter in list [=26-00]).

Specifying "01b" alone is possible, but the IDD would not function.

g. RAC (report check) (not supported)

The IDD is not supported in this bit. Therefore, the IDD always report "0", and ignore specified value.

h. SWP (soft write protect) (not supported)

This bit specifies whether or not to execute for the device server write operation to the medium.

The IDD is not supported this bit. Therefore, the IDD always report "0", and ignore specified value.

i. RAERP, UAAERP, EAERP, READY AER HOLDOFF PERIOD (not supported)

These field specify the action method of asynchronous event reporting protocol.

The IDD is not supported these field. Therefore, the IDD always report '0', and ignore specified value.

j. Extended self-test completion time

This field contains advisory data that an application client may use to determine the time in seconds that the device server requires to complete an extended self-test when the device server is not interrupted by subsequent commands and no errors occur during execution of the self-test.

This field only use to report the value by the MODE SENSE / MODE SENSE EXTENDED command.

Therefore, the IDD ignores specified value by the MODE SELECT / MODE SELECT EXTENDED command.

(8) Notch parameters (page code = 0C)

**Table 4.25 MODE SELECT parameters: notch parameters**

| Byte \ Bit | | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| 0 | | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 1 | | X‘16’ (Page Length) | | | | | | | |
| 2 | | ND | LPN | X‘00’ (Reserved) | | | | | |
| | Default | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Variable | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | | X‘00’ (Reserved) | | | | | | | |
| 4-5 | | Maximum number of notches | | | | | | | |
| | Default | X‘0012’ | | | | | | | |
| | Variable | X‘0000’ | | | | | | | |
| 6-7 | | Active Notch | | | | | | | |
| | Default | X‘0000’ | | | | | | | |
| | Variable | X‘FFFF’ | | | | | | | |
| 8-11 | | Starting Boundary | | | | | | | |
| | Default | X‘00000000’ | | | | | | | |
| | Variable | X‘00000000’ | | | | | | | |
| 12-15 | | Ending Boundary | | | | | | | |
| | Default | X‘xxxxxxxx’ | | | | | | | |
| | Variable | X‘00000000’ | | | | | | | |
| 16-23 | | Page Notch | | | | | | | |
| | Default | X‘0000000000000008’ | | | | | | | |
| | Variable | X‘0000000000000000’ | | | | | | | |

This page is used to report the top address and final address of each zone.

If the zone number + 1 of the notching zone is set in the "Active notch" field and this parameter is issued, the starting and ending address of the specified zone can be referred to by the MODE SENSE command.

Also, if Page 3 and Page 3F are specified by the MODE SENSE command, the parameters below the zone specified in the notch page can be referred to.

- Track/zone (Page 3, Byte 02, 03) (Note)
- Sector count/track (Page 3, Bytes 10, 11)
- Track Skew Factor (Page 3, Bytes 16, 17)
- Cylinder Skew Factor (Page 3, Bytes 18, 19)

Note:

> Normally, the number of tracks (logical heads) per cell is set in the track count/zone, but in the case of notching only, the total track count (number of cylinders in the zone x number of logical heads) of the affected zone is reported.

If this parameter is issued, only the format parameter of the zone specified by the MODE SENSE command can be referred to without changing the number of accessible blocks.

Also, if a MODE SENSE command with a SP = "1" that includes a notch page is issued, the current value is reported for this page and the zone value which is the object is reported if Page 3 is notched, then the command is terminated normally. However, in the case of the FORMAT CORRUPTED state, caution is necessary because the value following changing of the Format parameter is reported.

The contents of each parameter are explained below.

- ND (Notch Drive)

  "0": Since the device is not in the notched state, "0" is reported for LPN, active notch, starting boundary and ending boundary.

  "1": Since the device is in the notched state, the starting boundary and ending boundary for the zone number (+1) shown in the active notch is set in the format specified in the LPN Bit.

- LPN (Logical or Physical Notch)

  "0": This shows that the boundary address is based on the physical address format. At that time, the higher order 3 bytes show the logical cylinder number and the lowest order byte shows the logical head number.

  "1": This shows that the boundary address is based on the 4-byte logical block address format.

  This bit is a bit which must be set during MODE SELECT.

- Maximum Number of Notches

  This indicates the number of device zones. 18 (X'12') zones are set for all drives.

- Active Notch

  This specifies the zone number 1 to 18 of a notching zone. If "0" is specified, the page and parameter changed by the notch page, and the notch page itself, are changed to the initial value. If a value which exceeds the maximum number of notches has been specified, the test ends by "CHECK CONDITION" status (ILLEGAL REQUEST [=5]/Invalid parameter in List [=26-00]).

  This field is a field which must be set during MODE SELECT.

- Starting Boundary

  This field is enabled by the MODE SENSE command. This field indicates the beginning of the active notch or, if the active notch is zero, the beginning of the logical unit (IDD).

- Ending Boundary

  This field is valid in the MODE SENSE command. This field indicates the ending of the active notch or, if the active notch is zero, the ending of the logical unit (IDD) (see Table 4.18).

- Page Notch

  This is a bit map which shows whether or not other mode pages are being changed if the device is notched. The most significant bit of this field corresponds to page code 3Fh and the least significant bit corresponds to page code 00h. If it is specified, the IDD disregards this value.

### (9) Port control parameter (page code = 19)

This page is used to set parameters concerning data transfer of the drive and to refer to the current settings and maximum settings of these parameters.

**Table 4.26 Port control parameter: Page 0 Format (Short Page Format)**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | PS | SPF (0) | 0 | 1 | 1 | 0 | 0 | 1 |
| 1 | X ' 06 ' (Page Length) | | | | | | | |
| 2 | Reserved | | | Ready LED | PROTOCOL IDENTIFIER | | | |
| Default | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| Variable | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 3 | X‘00’ (Reserved) | | | | | | | |
| 4-5 | I_T NEXUS LOSS TIME | | | | | | | |
| Default | X ' 07D0 ' | | | | | | | |
| Variable | X ' FFFF ' | | | | | | | |
| 6-7 | INITIATOR RESPONSE TIMEOUT | | | | | | | |
| Default | X ' 0000 ' | | | | | | | |
| Variable | X ' 0000 ' | | | | | | | |

a. SPF

"0": Indicates that the transfer data is in Short Page Format.

"1": Indicates that the transfer data is in Long Page Format.

b. Ready LED Meaning

Specifies the LED display mode when the drive is not executing a command.

Depending on the power condition states, the items displayed by the LED are as follows:

| | | |
|---|---|---|
| 0: | Active state: | The LED is on. |
| | Active_Wait/Stopped: | The LED is off. |
| 1: | Active/Active_Wait/Stopped: | The LED is off. |

For details, refer to Section 2.7, "LED display."

c. Protocol Identifier

"6h": Indicates that this page conforms to the SAS SCSI device specifications.

d. I_T NEXUS LOSS TIME

Specifies the maximum time for which the IDD performs error recovery processing for I_T Nexus Loss as a multiple of 1 ms.

| CODE | DESCRIPTION |
|---|---|
| 0000h | Vender-specific |
| 0001h to FFFEh | Specifies the maximum time for error recovery processing as a multiple of 1 ms (recommended value: 2,000 ms). |
| FFFFh | The error recovery processing time is not limited. |

e. INITIATOR RESPONSE TIMEOUT

Specifies the maximum time for which the IDD waits for reception of a frame (e.g., a WRITE data frame) as a multiple of 1 ms.

When zero is specified, INITIATOR RESPONSE TIMEOUT is disabled.

**Table 4.27 Port control parameter: Sub Page Format (Long Format)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | PS | SPF (0) | 0 | 1 | 1 | 0 | 0 | 1 |
| 1 | SUBPAGE CODE (01h) | | | | | | | |
| 2 | (MSB) | Page Length (n-3) | | | | | | |
| 3 | | | | | | | | (LSB) |
| 4 | Reserved<br>x '0000' | | | | | | | |
| 5 | | | | | | | | |
| 6 | Page Length (n-3) | | | | | | | |
| 7 | NUMBER OF PHYS | | | | | | | |
| 8 | First SAS phy mode descriptor | | | | | | | |
| … | … | | | | | | | |
| n | Last SAS phy mode descriptor | | | | | | | |

a. SPF

"0": Indicates that the transfer data is in Short Page Format.

"1": Indicates that the transfer data is in Long Page Format.

b. NUMBER OF PHYS

Indicates the total number of phys the TARG maintains.

Single Port: 1

Dual Port: 2

The following shows the details of the SAS phy mode descriptor that is reported in Byte 8 and subsequent bytes:

### Table 4.28 SAS phy mode descriptor format

[This page cannot be modified]

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Reserved (x'00') | | | | | | | |
| 1 | PHY IDENTIFIER (0h or 1h) | | | | | | | |
| 2 | PHY OPERATION CODE | | | | | | | |
| 3 | Reserved (x'00') | | | | | | | |
| 4 | Reserved (0b) | ATTACHED DEVICE TYPE (0, 0, 1) | | | Reserved ('0000'b) | | | |
| 5 | Reserved ('0000'b) | | | | NEGOTIATED PHYSICAL LINK RATE (8h or 9h) | | | |
| 6 | Reserved ('0000'b) | | | | ATTACH SSP INIT PORT | ATTACH STP INIT PORT | ATTACH SMP INIT PORT | Reserved (0b) |
| 7 | Reserved ('0000'b) | | | | ATTACH SSP TARGET PORT | ATTACH STP TARGET PORT | ATTACH SMP TARGET PORT | Reserved (0b) |
| 8 | SAS ADDRESS | | | | | | | |
| 15 | | | | | | | | |
| 16 | ATTACHED SAS ADDRESS | | | | | | | |
| 23 | | | | | | | | |
| 24 | ATTACHED PHY IDENTIFIER | | | | | | | |
| 25 | Reserved | | | | | | | |
| 31 | | | | | | | | |
| 32 | PROGRAMMED MINIMUM PHYSICAL LINK RATE (8h) | | | | HARDWARE MINIMUM PHYSICAL LINK RATE (8h) | | | |
| 33 | PROGRAMMED MAXIMUM PHYSICAL LINK RATE (9h) | | | | HARDWARE MAXIMUM PHYSICAL LINK RATE (9h) | | | |
| 34 | Reserved | | | | | | | |
| 41 | | | | | | | | |
| 42 | Vender Specific | | | | | | | |
| 43 | | | | | | | | |
| 44 | Reserved | | | | | | | |
| 47 | | | | | | | | |

a. PHY IDENTIFIER

Indicates the reported number for a Primary/Secondary Port.

For a Primary Port, X'00' is set, and for a Secondary Port, X'01' is set.

b. PHY OPERATION CODE

The operation code specified by SMP PHY CONTROL is set.

c. ATTACHED DEVICE TYPE

"001": Indicates that the device type is End device.

d. NEGOTIATE PHYSICAL LINK RATE

Indicates the physical link rate value that has been established through a speed negotiation sequence.

"8": 1.5 Gbps

"9": 3.0 Gbps

e. ATTACHED SSP INITIATOR PORT

Indicates the SSP INIT value received from the INIT with an IDENTIFY address frame.

f. ATTACHED STP INITIATOR PORT

Indicates the STP INIT value received from the INIT with an IDENTIFY address frame.

g. ATTACHED SMP INITIATOR PORT

Indicates the SMP INIT value received from the INIT with an IDENTIFY address frame.

h. ATTACHED SSP TARGET PORT

Indicates the SSP TARGET value received from the INIT with an IDENTIFY address frame.

i. ATTACHED STP TARGET PORT

Indicates the STP TARGET value received from the INIT with an IDENTIFY address frame.

j. ATTACHED SMP TARGET PORT

Indicates the SMP TARGET value received from the INIT with an IDENTIFY address frame.

k. SAS ADDRESS

Indicates the Port SAS ADDRESS of the TARGET.

port SAS address (Port-A): 5CCC CCCX XXXX XXX 2

port SAS address (Port-B): 5CCC CCCX XXXX XXX 3
C: Company ID
X: Serial number for WWN

l. ATTACHED SAS ADDRESS

Indicates the SAS address received from the INIT with an IDENTIFY address frame.

m. ATTACHED PHY IDENTIFIER

Indicates the phy address received from the INIT with an IDENTIFY address frame.

n. PROGRAMMED MINIMUM/MAXIMUM PHYSICAL LINK RATE

Indicates the minimum and maximum values of the PHYSICAL LINK RATE supported by a program.

| Code | Description | |
|---|---|---|
| 0h | Unsupported | |
| 8h | 1.5Gbps | PROGRAMMED MINIMUM PHYSICAL LINK RATE |
| 9h | 3.0Gbps | PROGRAMMED MAXIMUM PHYSICAL LINK RATE |
| Others | Reserved | |

o. HARDWARE MINIMUM/MAXIMUM PHYSICAL LINK RATE

Indicates the minimum and maximum values of PHYSICAL LINK RATE supported by hardware.

| Code | Description | |
|---|---|---|
| 8h | 1.5Gbps | HARDWARE MINIMUM PHYSICAL LINK RATE |
| 9h | 3.0Gbps | HARDWARE MAXIMUM PHYSICAL LINK RATE |
| Others | Reserved | |

(10) Power condition parameter (page code = 1A)

**Table 4.29 Power condition parameter: Page 0 Format (Short Page Format)**

| Bit<br>Byte | | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| 0 | | (PS)* | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| 1 | | X ' 0A ' (Page Length) | | | | | | | |
| 2 | | X ' 00 ' (Reserved) | | | | | | | |
| 3 | | | | | | | | Idle | Stanby |
| | Default | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Variable | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 3 | | X ' 00 ' (Reserved) | | | | | | | |
| 4-7 | | Idle Condition Timer | | | | | | | |
| | Default | X ' FFFF ' | | | | | | | |
| | Variable | X ' FFFF ' | | | | | | | |
| 8-11 | | Standby Condition Timer | | | | | | | |
| | Default | X ' FFFF ' | | | | | | | |
| | Variable | X ' FFFF ' | | | | | | | |

This page descriptor is used to set the time over which the power condition state is transformed into the idle condition or standby condition state. However, because the IDD does not support the above states, the parameter cannot be set on this page.

a. Idle

Specifies whether to permit the IDD to enter the Idle condition when the IDD does not receive a command within the time specified in the "Idle Condition Timer" field.

The IDD disregards this setting and executes Power Save.

b. Idle Condition Timer

Specifies the time before the IDD enters the Idle condition. When the Idle bit is "1", the IDD disregards the specified value and enters Power Save mode in two seconds (x 14) fixed.

c. Standby (unsupported)

Specifies whether to permit the IDD to enter the Standby condition if the IDD does not receive a command within the time specified in the "Standby Condition Timer" field.

If "1" is specified, the IDD is permitted to enter the Standby condition after the elapse of the time specified in the "Standby Condition Timer" field.

If "0" is specified, the IDD is prohibited from entering the Standby condition.

d. Standby Condition Timer (unsupported)

Specifies the time before the IDD enters the Standby condition. When the Standby bit is "1," the IDD enters the Standby condition after the elapse of the time calculated by multiplying the value specified in this field by 100 ms.

## (11) Informational exceptions control page (page code = 1C)

### Table 4.30 MODE SELECT parameters: informational exception control page

| Bit<br>Byte | | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| 0 | | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 1 | | Page length (X’0A’) | | | | | | | |
| 2 | | Perf | 0 | EBF | EWASC | DExcpt | Test | 0 | LogErr |
| | Default | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | Variable | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 |
| 3 | | 0 | 0 | 0 | 0 | MRIE | | | |
| | Default | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Variable | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 4-7 | | Interval Timer | | | | | | | |
| | Default | X‘00000000’ | | | | | | | |
| | Variable | X‘FFFFFFFF’ | | | | | | | |
| 8-11 | | Report Count | | | | | | | |
| | Default | X‘00000001’ | | | | | | | |
| | Variable | X‘FFFFFFFF’ | | | | | | | |

This page specifies whether the drive failure prediction function is enabled or disabled and the reporting method when a drive failure is predicted.

a. LogErr (log error)

This bit (LogErr) of zero indicates that the logging of informational exception conditions within a target is vendor specific. A LogErr bit of one indicates the target logs informational exception conditions.

b. TEST

"1": If "0" is set for DExcpt, a failure prediction is reported with a failure prediction reporting condition that is generated when the time specified with Interval Timer has elapsed.

The method and number of times of this reporting are determined according to the specifications in the MRIE and Report Count fields. At this time, the sense key of 0x5D and additional sense code of 0xFF are reported.

"0": This specifies that the test of the failure prediction function and its reporting method be disabled.

The value of this bit cannot be saved, and the stored value is fixed at 0. The current value is initialized to 0 when power is turned on or when LIPyx or TARGET RESET is received.

c. DExcpt (disable exception control)

This bit of zero indicates information exception operations is enabled. The reporting of information exception conditions when the "DExcpt" bit is set to zero is determined from the method of reporting informational exceptions field. A "DExcpt" bit of one indicates the target disables all information exception operations. The method of reporting informational exceptions field is ignored when "DExcpt" is set to one.

d. EWASC (enable warning)

This bit of zero indicates the target disables reporting of the warning. The "MRIE" field is ignored when "DExcpt" is set to one and "EWASC" is set to zero. An "EWASC" bit of one indicates warning reporting is enabled. The method for reporting the warning when the "EWASC" bit is set to one is determined from the "MRIE" field.

e. EBF (enable background function)

If background functions are supported, this bit of one indicates the target enables background functions. An "EBF" bit of zero indicates the target disables the functions.

f. Perf (performance)

This bit of zero indicates that informational exception operations that are the cause of delays are acceptable. A Perf bit of one indicates the target is 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.

g. MRIE (method of reporting informational exceptions)

This field indicates the methods that is used by the target to report informational exception conditions. The priority of reporting multiple informational exceptions is vendor specific.

**Table 4.31  MRIE (1/2)**

| MRIE | Descriptor |
|---|---|
| X’00’ | No reporting of informational exception conditions:<br>This method instructs the target to not report informational exception conditions. |
| X’01’<br>(setting prohibited) | Asynchronous event reporting:<br>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.<br>The sense key shall be set to RECOVERED ERROR and the additional sense code shall indicate the cause of the informational exception condition. |
| X’02’ | Generate unit attention:<br>This method instructs the target to report informational exception conditions by returning a CHECK CONDITION status on any command.  The sense key shall be set to UNIT ATTENTION and the additional sense code shall indicate the cause of the informational exception condition.<br>The command that has the CHECK CONDITION shall not be executed before the informational exception condition is reported. |
| X’03’ | Conditionally generate recovered error:<br>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 shall be set to RECOVERED ERROR and the additional sense code shall indicate the cause of the informational exception condition.<br>The command that has the CHECK CONDITION shall complete without error before any informational exception condition may be reported. |
| X’04’ | Unconditionally generate recovered error:<br>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 shall be set to RECOVERED ERROR and the additional sense code shall indicate the cause of the informational exception condition.<br>The command that has the CHECK CONDITION shall complete without error before any informational exception condition may be reported. |

**Table 4.31 MRIE (2/2)**

| MRIE | Descriptor |
|---|---|
| X’05’<br>(setting prohibited) | Generate no sense:<br>This method instructs the target to report informational exception conditions by returning a CHECK CONDITION status on any command. The sense key shall be set to NO SENSE and the additional sense code shall indicate the cause of the informational exception condition.<br>The command that has the CHECK CONDITION shall complete without error before any informational exception condition may be reported. |
| X’06’ | Only report informational exception condition on request:<br>This method instructs the target to report informational exception(s) information. To find out about information exception conditions the Application Client polls the target by issuing an unsolicited REQUEST SENSE command. The sense key shall be set to NO SENSE and the additional sense code shall indicate the cause of the information exception condition. |
| X’07’- X’0B’ | Reserved |
| X’0C’- X’0F’ | Reserved (Vendor Specific) |

h. Interval timer

This field 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 frequency 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. A value of zero in the "Interval Timer" field indicates that the target shall only report the informational exception condition one time. A value of X’FFFFFFFF’ in the "Interval Timer" field indicates the timer interval is vendor specific.

In the implementation, actual period unit to be used in reporting information exception condition is minute. Therefore a value is rounded-up to minute as shown below. a value of zero and X’FFFFFFFF’ in the interval timer field indicates that drive report the information exception condition once.

**Table 4.32 Interval timer**

| A value of TIMER INTERVAL field | Actual time interval (minutes) |
|---|---|
| 0, 0xFFFFFFFFh | Drive reports the informational exception condition once |
| 1-600 | 1 |
| 601-1200 | 2 |
| 1201-1800 | 3 |
| 0xFFFFFE11-0xFFFFFFFE | 7158279 |

The "Report Count" field indicates the number of timer to report an informational exception conditions to the application client.

A value of zero in the Report Count field indicates there is no limit on the number of timers the target shall report an information exception condition.

### (12) Additional error recovery parameters (page code = 21)

The page descriptor format of this MODE SELECT parameter is shown in Table 4.33.

**Table 4.33 MODE SELECT parameters: additional error recovery parameters**

[Fujitsu unique parameter]

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 1 | X‘02’ (Page Length) | | | | | | | |
| 2 | 0 | 0 | 0 | 0 | Number of retries during a Seek Error | | | |
| Default | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| Variable | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 3 | RFJ | | | | | | | |
| Default | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Variable | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

a. Number of retries during a seek error

This parameter specifies the number of times repositioning is retried when a seek error is detected. When zero is specified in this field, repositioning retries are prohibited. The value specified in this field is applicable for all commands which are accompanied by a seek operation.

b. RFJ (reserved by Fujitsu)

All the bits in byte 3 are reserved by Fujitsu. The user should specify "0" in this bit.

### 4.1.5 MODE SELECT EXTENDED (55)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘55’ | | | | | | | |
| 1 | 0 | 0 | 0 | PF | 0 | 0 | 0 | SP |
| 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 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | Parameter List Length (MSB) | | | | | | | |
| 8 | Parameter List Length (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command performs setting and changing of each type of parameter related to disk drive physical attributes, data format, and error recovery procedures, etc.

This command's function is the same as that of the Group 0 MODE SELECT command (Section 4.1.4), except that the format of its data transferred by the INIT differs partially from that of the (MODE SELECT) data format.

Table 4.34 shows the configuration of the parameter list (MODE SELECT parameters) transferred by this command from the INIT. Compared to the 4-byte header in the Group 0 MODE SELECT command, it is necessary for an 8-byte header to be transferred in this command. The contents of each field in the header except that the byte positions differ, are the same as in the case of the Group 0 MODE SELECT command. The contents of the other parameters (Block descriptor, Page descriptor) are also the same as in the case of the Group 0 MODE SELECT command.

### Table 4.34 MODE SELECT EXTENDED command (group 2) parameter configuration

Header

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘00’ | | | | | | | |
| 1 | X‘00’ | | | | | | | |
| 2 | X‘00’ (Medium Type) | | | | | | | |
| 3 | × | 0 | 0 | × | 0 | 0 | 0 | 0 |
| 4 | X‘00’ | | | | | | | |
| 5 | X‘00’ | | | | | | | |
| 6 | X '00' (Block Descriptor Length: LSB) | | | | | | | |
| 7 | X‘00’ or X‘08’ (block descriptor length: MSB) | | | | | | | |

Block Descriptor

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Data Block Count (MSB) | | | | | | | |
| 1 | Data Block Count | | | | | | | |
| 2 | Data Block Count | | | | | | | |
| 3 | Data Block Count (LSB) | | | | | | | |
| 4 | X‘00’ | | | | | | | |
| 5 | Data Block Length (MSB) | | | | | | | |
| 6 | Data Block Length | | | | | | | |
| 7 | Data Block Length (LSB) | | | | | | | |

Page Descriptor

| | Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Page Header | 0 | 0 | 0 | Page Code | | | | | |
| | 1 | Page Length | | | | | | | |
| | 2 | Parameter Field | | | | | | | |
| | ~ | ~ | | | | | | | ~ |
| | n | | | | | | | | |

## 4.1.6 MODE SENSE (1A)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘1A’ | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | DBD | 0 | 0 | 0 |
| 2 | PC | | Page Code | | | | | |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | Transfer Byte Length | | | | | | | |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command reports the values for each type of parameter related to the disk drive's physical attributes, data format, timing for FC interface Loop OPEN/CLOSE processing, error recovery procedures, etc., as well as the attributes of those parameters, to the INIT.

The data (MODE SENSE data) transferred to the INIT from the IDD by this command are configured from a "Header," "Block Descriptor" and one or more "Page descriptors" which describe each type of parameter, each of which will be described later in this item.

When "1" is specified in the "DBD (disable block descriptors)" bit of CDB byte 1, it indicates that a "Block descriptor" is not included in the MODE SENSE data transferred to the INIT by this command and the IDD transfers MODE SENSE data composed from the "Header" and the specified "Page descriptor" only to INIT. When "0" is specified in this bit, the IDD transfers MODE SENSE DATA composed of the "Header, " a single "Block descriptor" and the specified "Page descriptor" to the INIT.

The "Page code" field in CDB byte 2 specifies the page code of the "Page descriptor" transferred to the INIT by this command. The types of "Page descriptor" supported by the IDD and their page codes and lengths are as shown in Table 4.35.

**Table 4.35 Mode page**

| Page Code | Page Descriptor Name | SCSI-3 |
|---|---|---|
| 1 | Read/Write Error Recovery Parameter | 12 bytes |
| 2 | Disconnect/Reconnect Parameter | 16 bytes |
| 3 | Format Parameter | 24 bytes |
| 4 | Drive Parameter | 24 bytes |
| 7 | Verify Error Recovery Parameter | 12 bytes |
| 8 | Read Caching Parameter | 20 bytes |
| A | Control Mode Parameter | 12 bytes |
| C | Notch Parameter | 24 bytes |
| 19 | Port Control Parameter | 16 bytes |
| 1C | Information Exception Control Parameter | 12 bytes |
| 21 | Additional Error Recovery Parameter | 4 bytes |
| 3F | All Page Descriptors Supported by the IDD | 176 bytes |

When the value specified in the "Page code" field is other than X '3F', the specified "Page descriptor" only is transferred to the INIT, and when X '3F' is specified, all the "Page descriptors" supported by the IDD are transferred to the INIT in the ascending order of the page code. Also, when X '00' is specified in the "Page code field," the "Page descriptor" is not transferred. If page codes other than the above mentioned ones ("Page descriptors" which are not supported by the IDD) are specified, the command is terminated with a CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in CDB [=24-00]).

Also the "PC (page control)" field in CDB byte 2 specifies the type of parameter value in the "Page descriptor" transferred to the INIT by this command, as shown in Table 4.36.

## IMPORTANT

Even in cases where the value specified in the MODE SELECT or MODE SELECT EXTENDED command is described in Table 4.35 as the value reported to the INIT by this command, if parameter rounding processing is applied by the IDD, or in cases of a parameter or bit with a specified value that is disregarded, different values than those specified by the INIT will be reported. For details, see the descriptions of each page descriptor (in Section 4.1.4). Also, "0" is reported in byte positions and bit positions which are reserved in each page descriptor.

## Table 4.36 MODE SENSE data type specifications

| PC | Type of Parameter Transferred to the INIT |
|---|---|
| 00 | Current Values:<br>Reports each "Current" parameter value. The "Current" values are either of the following values.<br>• Values specified by a MODE SELECT or MODE SELECT EXTENDED command which is finally normally terminated.<br>• When a MODE SELECT or MODE SELECT EXTENDED command is not executed after the power is switched on, after a LIP or after a TARGET RESET issued by any INIT is received, the same values as "Save" values. However, if "Save" values do not exist for parameters other than those on Page 3 and Page 4 (excluding byte 17), the same values as "Default" values. |
| 01 | Variable Values:<br>The INIT reports variable parameter fields and parameter bits through the MODE SELECT or MODE SELECT EXTENDED command. A "1" is reported in the variable fields and bit positions in each page descriptor and "0" is reported in the fields and bit positions which cannot be changed. See the description of each page descriptor for the MODE SELECT command (Section 4.1.4) concerning the variability of each parameter. |
| 10 | Default Values:<br>Reports the "Default" value of each parameter. See the description of each page descriptor for the MODE SELECT command (Section 4.1.4) concerning the actual default value of each parameter. |
| 11 | Save Values:<br>Reports the "Save" value of each parameter. The "Save" values are either of the following values.<br>• For parameters other than those on Page 3 and Page 4 (excluding byte 17), these are the values specified in a MODE SELECT or MODE SELECT EXTENDED command in which the "SP" bit after the final execution is completed is "1." When a MODE SELECT or MODE SELECT EXTENDED command in which the "SP" bit is "1" is not executed (when "Save" values do not exist), these are the same values as the "Default" values.<br>• The values in the parameters in Page 3 and Page 4 (excluding byte 17) are the values save to the disk media during execution of the FORMAT UNIT command. |

The "Transfer Byte Length" field in the CDB specifies the total number of bytes of MODE SENSE data which can be transferred to the INIT by this command. The IDD transfers the number of bytes of all the MODE SENSE data specified in the "Page code" field or the portion of MODE SENSE data with the length specified in the "Transfer Byte Length" field, whichever is smaller. When zero is specified in the "Transfer Byte Length" field, this command is terminated without anything being transferred.

Table 4.37 lists the data configuration in the parameter list (MODE SENSE data) transferred to the INIT by this command. The parameter list consists of a 4-byte header, an 8-byte block descriptor and one or more page descriptors, specified in the CDB, which are transferred in order. However, when "1" is specified in the DBD bit of the CDB, the block descriptor is not transferred. Also, when X'00' is specified in the "Page code" field of the CDB, the page descriptor is not transferred.

**Table 4.37 MODE SENSE command (group 0) parameter configuration**

Header

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Sense Data Length | | | | | | | |
| 1 | X‘00’ (Media Type) | | | | | | | |
| 2 | WP | 0 | 0 | DPOFUA | 0 | 0 | 0 | 0 |
| 3 | X‘00’ or X‘08’ (Block Descriptor Length) | | | | | | | |

Block Descriptor

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Data Block Count (MSB) | | | | | | | |
| 1 | Data Block Count | | | | | | | |
| 2 | Data Block Count | | | | | | | |
| 3 | Data Block Count (LSB) | | | | | | | |
| 4 | X‘00’ | | | | | | | |
| 5 | Data Block Length (MSB) | | | | | | | |
| 6 | Data Block Length | | | | | | | |
| 7 | Data Block Length (LSB) | | | | | | | |

Page Descriptor

| | Bi<br>t<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | PS | 0 | Page Code | | | | | |
| Page Header | 1 | Page Length | | | | | | | |
| | 2 | | | | | | | | |
| | ~ | Parameter Field | | | | | | | |
| | n | | | | | | | | |

### (1) Header

a. Sense data length

This field indicates the length (number of bytes) of the parameter list (MODE SENSE data) which it is possible to transfer to the INIT by this command. The length of the "Sense data length" field itself is not included in this value. Also, a value for a portion of data with a length that is supported by the IDD is reported in this field for a parameter list of the type specified in the CDB regardless of the specification of the "Transfer byte length" field in the CDB. In order for the INIT to confirm that all the parameter list requested in the command has been transferred, it should check whether the value which has the length of the "Sense data length" field itself added to the value indicated in this field is less than the value specified in the "Transfer byte length" field.

b. Media type

X '00' (default type) is always reported in this field.

c. WP bit

When this bit is "1," it indicates that a write operation to the disk media is prohibited and when "0" is specified, it indicates that a write operation is permitted.

d. DPOFUA bit

When this bit is "0," it indicates that the IDD does not supports the DPO and FUA bit. When this bit is "1," it indicates that the IDD supports the DPO and FUA bits.

e. Block descriptor length

This field indicates the "Block descriptor" length (byte length) which follows after the header. The "Page descriptor" length is not included in this value. The IDD always reports X '08' in this field if "0" is specified in the DBD bit of this command's CDB, and thus indicates that one "Block descriptor" set follows after the header. When "1" is specified in the DBD bit of the CDB, the value of this field is X '00'.

### (2) Block descriptor

The 8-byte "Block descriptor" indicates the logical attributes of the data format on the disk media.

a. Data block count

This field indicates the total number of logical data blocks (the block length is shown in the "Data block length" field) existing in the "User Space" on the disk media. This value does not include the number of spare sectors reserved for alternate block processing.

Furthermore, when this command specifies to transfer the "Default" value and "Variable" value, the value shown in this field is X '000000' (which means the maximum number of logical data blocks that it is possible to rank in the "User Space").

b. Data block length

This field indicates the length (byte length) of 1 logical data block on the disk media.

### (3) Page descriptor

The "Page descriptor" is configured from a parameter field which follows a 2-byte page header, and is divided into units called "Page" for each parameter's functional attributes. See the description of the MODE SELECT command (Section 4.1.4) concerning the configuration of each page descriptor and their contents.

a. PS bit

When this bit is "1," the parameter value defined in that "Page descriptor" can be saved on the disk media, and when it is "0", it indicates that this is a parameter which cannot be saved to the disk. It is possible to save all the "Page descriptors" supported by the IDD. However, "1" is always indicated in this bit for all "Page descriptors" transferred by this command.

b. Page length

This field indicates the length of the parameter field (number of bytes) from byte 2, excluding the page header of that "Page descriptor." The IDD always shows a value in this field which is the same as the length defined in that "Page descriptor" regardless of the type of parameter requested in the "PC (page control)" field of the CDB, and reports all the parameter fields that "Page descriptor" in byte 2 and subsequent bytes.

c. Parameter field

The parameter field in byte 2 and subsequent bytes, indicates parameter values of the type (current values, variable values, default values or save values) requested in the "PC (page control)" field of the CDB. See the description of the MODE SELECT command (Section 4.1.4) concerning the definition of each parameter, "Default" values and "Variable" values.

### 4.1.7 MODE SENSE EXTENDED (5A)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘5A’ | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | DBD | 0 | 0 | 0 |
| 2 | PC | | Page Code | | | | | |
| 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 | Transfer Byte Length (MSB) | | | | | | | |
| 8 | Transfer Byte Length (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command reports the values for each type of parameter related to the disk drive's physical attributes, data format, timing for FC interface Loop OPEN/CLOSE processing, error recovery procedures, etc., as well as the attributes of those parameters, to the INIT.

The functions of this command are the same as those of the Group 0 MODE SENSE command (Section 4.1.7) except that the format of data (MODE SENSE data) transferred to the INIT differs somewhat.

Table 4.38 lists the data configuration of the parameter list (MODE SENSE data) transferred to the INIT by this command. Compared to the 4-byte header in the case of a Group 0 MODE SENSE command, an 8-byte header is transferred in this command. The meanings of each field and bit in the header are the same as in the case of the Group 0 MODE SENSE command, except that the byte positions differ. Also, the contents of the other parameters (block descriptor and page descriptors) are the same as in the case of the Group 0 MODE SENSE command.

**Table 4.38 MODE SENSE EXTENDED command (group 2) parameter configuration**

Header

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Sense Data Length (MSB) | | | | | | | |
| 1 | Sense Data Length (LSB) | | | | | | | |
| 2 | X‘00’ (Media Type) | | | | | | | |
| 3 | WP | 0 | 0 | DPOFUA | 0 | 0 | 0 | 0 |
| 4 | X‘00’ | | | | | | | |
| 5 | X‘00’ | | | | | | | |
| 6 | X‘00’ (Block Descriptor Length: MSB) | | | | | | | |
| 7 | X‘00’ or X‘08’ (Block Descriptor Length: LSB) | | | | | | | |

Block Descriptor

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Data Block Count (MSB) | | | | | | | |
| 1 | Data Block Count | | | | | | | |
| 2 | Data Block Count | | | | | | | |
| 3 | Data Block Count (LSB) | | | | | | | |
| 4 | X‘00’ | | | | | | | |
| 5 | Data Block Length (MSB) | | | | | | | |
| 6 | Data Block Length | | | | | | | |
| 7 | Data Block Length (LSB) | | | | | | | |

Page Descriptor

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | PS | 0 | Page Code | | | | | |
| 1 | Page Length | | | | | | | |
| 2 | Parameter Field | | | | | | | |
| ~ | | | | | | | | |
| n | | | | | | | | |

### 4.1.8 REZERO UNIT (01)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘01’ | | | | | | | |
| 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 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command moves the read/write heads of the disk drive to the initial position (physical cylinder 0 / physical track 0). A data block with the physical block address of zero exists at the initial position. Initialization of the disk drive's positioning control system and automatic adjustment are also performed by this command.

### 4.1.9 START/STOP UNIT (1B)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘1B’ | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Immed |
| 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 | LoEj | Start |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command controls the power condition of the disk drive. For the power condition, see Chapter 2, "Power Condition."

The control of the power condition is performed with the Start bit in bit 0 of the CDB byte 4.

Issuing this command with the Start bit set to "0" transits from the power condition state to the Stopped state. Meanwhile, setting the Start bit to "1" transforms the power condition state from the Stopped state to the Active_Wait state. Setting the Start bit to "1" does not transform the power condition state when it is in a state other than the Stopped state.

Bit 1 (LoEj (load/eject) of byte 4 of the CDB is the exclusive bit which controls devices with replaceable recording media, and it has no meaning for the IDD. The IDD disregards the value specified in this bit and controls the Power Condition in accordance with the "Start" bit only.

Depending on the value specified in the "Immed (immediate)" bit, bit 0 of CDB byte 1, the timing of completion (status byte report) of this command differs as shown below.

a. In the case of the start specification ("Start" bit = "1")

   – When the Immed bit is "1," the power condition state becomes Active_Wait, the GOOD status is reported, and command execution is completed.

   – When the Immed bit is "0," the power condition state becomes Active_Wait, and the spindle motor is started after the NOTIFY (ENABLE SPINUP) primitive has been received. Then, when the disk drive enters the ready state, the status byte is reported and command execution is completed. In this case, the INIT has no means of detecting the timing when the power condition state becomes Active_Wait, and there are no limitations on the time period in which the system waits the NOTIFY (ENABLE SPINUP) primitive. Therefore, the INIT needs to issue the NOTIFY (ENABLE SPINUP) primitive after this command is issued and before the spindle motor becomes ready.

b. In the case of the stop specification ("Start" bit = "0")

   – When the Immed bit is "1," after the power condition state becomes Stopped, instructing the drive to stop the spindle motor is sufficient so that the GOOD status is reported and command execution is completed.

   – When the Immed bit is "0," after the power condition state becomes Stopped and the spindle motor enters the Stopped state, the status byte is reported and command execution is completed.

### 4.1.10 RESERVE (16)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘16’ | | | | | | | |
| 1 | 0 | 0 | 0 | 3rd Pty | 3rd Pty Dev ID | | | 0 |
| 2 | × | × | × | × | × | × | × | × |
| 3 | × | × | × | × | × | × | × | × |
| 4 | × | × | × | × | × | × | × | × |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Together with the RELEASE command, this command controls exclusive access to the logical unit (IDD) under a multi-initiator environment.

The IDD is reserved by this command for the INIT which issued this command.

The values specified in bytes 2 to 4 of the CDB have no meaning and are disregarded, but it is preferable that the INIT specify X'00' in these bytes.

(1) Logical unit reserve function

This command reserves the entire IDD (logical unit) for use as a special SAS device. The reserve state established by this command is maintained until any one of the following conditions occurs.

1) Reserve is released by a RELEASE command from the INIT that issued this command.

2) Receiving HARD RESET primitive from any INIT.

3) Switching the IDD's power off or on.

When an IDD is reserved for any SAS device, if this command is issued by an INIT that doesn't have the "Reserve Right" for that IDD, this command is terminated with a RESERVATION CONFLICT status.

After the Reserved status is established, a command issued by an INIT other than the device that reserved the IDD is rejected, except an INQUIRY, REQUEST SENSE or RELEASE command, and a RESERVATION CONFLICT status is reported to the INIT that issued that command. A RELEASE command is the release operation specified in a RELEASE command issued to the IDD by a SAS device which does not have the Reserve Right is disregarded.

(2) Reserve right and third party reserve function

**IMPORTANT**

The third party reserve function is not supported by the drive.

If the 3rd Pty bit of CDB byte 1 is "0," the IDD is reserved for the INIT that has issued this command. The INIT has the reserve right for the IDD.

If the 3rd Pty bit is "1," execution of this command is terminated with the CHECK CONDITION status (ILLEGAL REQUEST [= 5]/Invalid field in CDB [= 24-00]).

### 4.1.11 RESERVE EXTENDED (56)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X'56' | | | | | | | |
| 1 | 0 | 0 | 0 | 3rd Pty | 0 | 0 | 0 | 0 |
| 2 | × | × | × | × | × | × | × | × |
| 3 | Third Party Device ID | | | | | | | |
| 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 | × | × | × | × | × | × | × | × |
| 8 | × | × | × | × | × | × | × | × |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Together with the RELEASE command, this command controls exclusive access to the logical unit (IDD) under a multi-initiator environment.

### 4.1.12 RELEASE (17)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘17’ | | | | | | | |
| 1 | 0 | 0 | 0 | 3rd Pty | 3rd Pty Dev ID | | | 0 |
| 2 | × | × | × | × | × | × | × | × |
| 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 |

This command releases the reserve state of an IDD in relation to the INIT that issued this command.

When a reserve state in relation to the INIT that issues this command, or an IDD does not exist, this command is terminated normally with a GOOD status.

Also, the value specified in CDB byte 2 has no meaning and is disregarded, but it is desirable for X '00' to be specified by the INIT in this byte.

Also, the value specified in CDB byte 3 to 4 reports CHECK CONDITION status "05-24-00" except for X"00" is specified.

(1) Release function

This command releases a reserve state if a reserve state exists, and if the INIT which issued this command has a reserve right for the entire IDD (logical unit).

(2) Release object and third party release function

**IMPORTANT**

The third party reserve function is not supported by the drive.

If the 3rd Pty bit of CDB byte 1 is "0," the IDD is reserved for the INIT that has issued this command. The INIT has the reserve right for the IDD.

If the 3rd Pty bit is "1," execution of this command is terminated with the CHECK CONDITION status (ILLEGAL REQUEST [= 5]/Invalid field in CDB [= 24-00]).

### 4.1.13 RELEASE EXTENDED (57)

| Bit / Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘57’ | | | | | | | |
| 1 | 0 | 0 | 0 | 3rd Pty | 0 | 0 | 0 | 0 |
| 2 | × | × | × | × | × | × | × | × |
| 3 | Third Party Devices ID | | | | | | | |
| 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 | × | × | × | × | × | × | × | × |
| 8 | × | × | × | × | × | × | × | × |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Same as RELEASE command.

### 4.1.14 REQUEST SENSE (03)

| Bit / Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘03’ | | | | | | | |
| 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 | Transfer Byte Length | | | | | | | |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command transfers sense data to the INIT.

This command is executed in any state other than a CDB specification error.

The sense data of the IDD has a length of 48 bytes.  The IDD generates sense data in any of the following cases and holds the sense data for the INIT that has issued the relevant command:

If this command is executed when the IDD is holding the Unit Attention condition, at that point, if the IDD is not in the sense data hold state, sense data showing the Unit Attention condition are created by this command and are sent to the INIT, and the Unit Attention condition is cleared.

If this command is issued when no valid sense data are being held, the IDD sends sense data with a sense key which shows "NO SENSE".

The "Transfer Byte Length" field in the CDB show the number of bytes of sense data that can be received by the INIT. The IDD transfers sense data with a length that is specified in the "Transfer Byte Length" field or the IDD's own sense data length (48 bytes), whichever is smaller.

When the value specified in the "Transfer Byte Length" shows 48 bytes or more, 48 bytes of sense data are transferred and the command terminates with the "GOOD" status.

This command reports the "CHECK CONDITION" status and terminates abnormally only in the cases where the conditions shown below are detected. In this case, new sense data are generated and the sense data held up to that time are lost.

1) When sending of sense data is impossible due to an IDD hardware error.

2) When an irrecoverable error is detected on the SAS interface.

3) If an overlapped command occurs.

In cases other than the above, this command sends sense data to the INIT and terminates with the "GOOD" Status.

### 4.1.15 LOG SELECT (4C)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X'4C' | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | PCR | SP |
| 2 | PC | | 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 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | Parameter List Length (MSB) | | | | | | | |
| 8 | Parameter List Length (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command provides a means for an application client to manage statistical information maintained by the IDD about IDD. The INIT can know the types of statistical information and the current maintaining of each statistical information by using the LOG SENSE command.

A "Save Parameters (SP)" bit is one indicates that after performing the specified LOG SELECT operation the drive will save all parameters to the disc medium. A "SP" bit of zero specifies that parameters is not saved. 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.

The "Parameter Code Reset (PCR)" bit of one and a "Parameter list length" of zero cause all implemented parameters to be set to zero. It also clears the SMART Failure Warning and the Thermal Warning. If the "PCR" bit is one and the parameter list length is greater than zero, the command is terminated with CHECK CONDITION status (ILLEGAL REQUEST [=5] / INVALID FIELD IN CDB [=24-00]). In this case, the log parameters are not cleared. A PCR bit of zero specifies that the log parameters is not reset.

The "Page Control (PC)" bits specifies a kind and treatment content of parameters that changed by this command as shown in Table 4.39.

**Table 4.39  PC (page control)**

| Value | Description |
|---|---|
| 00b | Current threshold values |
| 01b | Current cumulative values |
| 10b | Default threshold values |
| 11b | Default cumulative values |

The "PC" bits are ignored by the drive. The drive assumes that current cumulative parameters are selected.

The "Parameter List Length" field specifies the length in bytes of the parameter list that is located in the Data-Out Buffer. If a parameter list length results in the truncation of any log parameter, the IDD terminates this command with CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in CDB [=24-00]).

A "Parameter List Length" of zero indicates that no pages shall be transferred. This condition shall not be considered an error.

## IMPORTANT

The IDD does not support that the application client should send pages in ascending order by page code value if the Data-Out Buffer contains multiple pages.

**Table 4.40  LOG SELECT command parameter configuration**

|  | Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Header | 0 | Page Code |  |  |  |  |  |  |  |
|  | 1 | Reserved |  |  |  |  |  |  |  |
|  | 2 | Page Length (MSB) |  |  |  |  |  |  |  |
|  | 3 | Page Length (LSB) |  |  |  |  |  |  |  |
| Log Paramete | 4 | Log Parameter (First)<br>(Length x) |  |  |  |  |  |  |  |
|  | ~ |  |  |  |  |  |  |  |  |
|  | x+3 |  |  |  |  |  |  |  |  |
|  | ~ |  |  |  |  |  |  |  |  |
|  | n-y+1 | Log Parameter (Last)<br>(Length y) |  |  |  |  |  |  |  |
|  | ~ |  |  |  |  |  |  |  |  |
|  | n |  |  |  |  |  |  |  |  |

a. Page code

This field identifies which log page is being transferred.

The log pages that can be transferred by this command are shown in Table 4.41.

**Table 4.41 Page code**

| Page Code | Description | Changeable Parameter |
|---|---|---|
| 01 | Buffer Overrun/Underrun Page | Disable |
| 02 | Write Error Counter Page | Enable |
| 03 | Read Error Counter Page | Enable |
| 05 | Verify Error Counter Page | Enable |
| 06 | Non-medium Error Page | Enable |
| 0D | Temperature Page | Disable |
| 0E | Start-stop Cycle Counter Page | Enable only 0002 |
| 0F | Application Client Log Page | Enable |
| 10 | Self-Test Result Log Page | Disable |

b. Page length

This field specifies the length in bytes of the following log parameters. If the application client sends a page length that results in the truncation of any parameter, the device server terminates the command with CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in parameter list [=26-00]).

The log pages contain one or more special data structures called log parameters as shown below. Each log parameter begins with a 4-byte parameter header followed by one or more bytes of "Parameter Value" data.

**Table 4.42 Page descriptor**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Parameter Code (MSB) | | | | | | | |
| 1 | Parameter Code (LSB) | | | | | | | |
| 2 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| 3 | Parameter Length | | | | | | | |
| 4 | Parameter Value | | | | | | | |
| ~ | | | | | | | | |
| n | | | | | | | | |

a. Parameter code

This field identifies the log parameter being transferred for that log page.

b. Byte 2

1) DU (Disable Update)

"1": The IDD does not update the log parameter value except in response to a LOG SELECT command that specifies a new value for the parameter.

"0": The IDD updates the log parameter value to reflect all events that are noted by that parameter.

2) DS (Disable Save)

"1": The IDD does not support saving that log parameter in response to LOG SELECT or LOG SENSE command with an "SP" bit of one.

"0": The IDD supports saving for that log parameter. The IDD saves the current parameter value in response to LOG SELECT or LOG SENSE command with a "SP" bit of one.

3) TSD (Target Save Disable)

The IDD does not support this bit. For LOG SENSE command (See 4.1.16), the IDD always report zero. Also, for this command, the IDD accepts this bit value of "1", but ignores its functionality.

4) ETC (Enable Threshold Comparison)

The IDD does not support this bit. For LOG SENSE command (See 4.1.16), the IDD always report zero. Also, for this command, the IDD accepts this bit value of "1", but ignores its functionality.

5) TMC (Threshold Met Criteria)

This field is ignored when "ETC" bit is 0. For LOG SELECT command (See 4.1.15), the IDD accepts this field value of other than "00b", but ignores its functionality.

6) LBIN

This bit is only valid if the "LP" bit is one. If the "LP" bit is one and this bit is zero then the list parameter is a string of ASCII graphic codes.

If the "LP" bit is one and this bit is one then the list parameter is a list of binary information.

7) LP (List Parameter)

"1": The parameter is a data counter.

"0": The parameter is a list parameter.

If these bits are specified by LOG SELECT command, the IDD terminates normally.

But the IDD's action is not changed.

For LOG SENSE command, these bits always report value defined in each log page (see 4.2).

### 4.1.16 LOG SENSE (4D)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X'4D' | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | PPC | SP |
| 2 | PC | | Page Code | | | | | |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | Parameter Pointer (MSB) | | | | | | | |
| 6 | Parameter Pointer (LSB) | | | | | | | |
| 7 | Parameter List Length (MSB) | | | | | | | |
| 8 | Parameter List Length (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command provides a means for the application client to retrieve statistical or other operational information maintained by the device about the device or its logical units.

It is a complementary command to the LOG SELECT command.

The "Parameter Pointer Control (PPC)" bit is not supported. It should be zero.

An "Save Parameters (SP)" bit of zero indicates the device server performs the specified this command and does not save any log parameters. If saving log parameters is implemented, an "SP" bit of one indicates that the device server performs the specified this command and saves all log parameters identified as savable by the "DS" bit to the disc medium.

The "Page Control (PC)" field defined the type of parameter values to be selected (see 4.1.15 for the definition of the page control field).

The "PC" bits are ignored by the drive. The drive assumes that current cumulative parameters are selected.

The "Page Code" field identifies which page of data is being requested. If the page code is reserved or not implemented, the device server terminates the command with CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in CDB [=24-00]).

The "Page Code" assignments for the log pages are listed in Table 4.43.

**Table 4.43 "Page Code" assignment for the log pages**

| Page Code | Description | Parameter Pointer |
|---|---|---|
| 00 | Supported Log Pages | Ignored |
| 01 | Buffer Overrun / Underrun Page | Supported |
| 02 | Write Error Counter Page | Supported |
| 03 | Read Error Counter Page | Supported |
| 05 | Verify Error Counter Page | Supported |
| 06 | Non-medium Error Page | Should be zero |
| 0D | Temperature Page | Supported |
| 0E | Start-stop Cycle Counter Page | Supported |
| 0F | Application Client Log Page | Supported |
| 10 | Self-Test Result Log Page | Supported |
| 18 | SAS Protocol Log Page | Ignored |
| 2F | SMART Status Page | Ignored |
| 38 | SMART Data Page | Ignored |

The "Parameter Pointer" field allows the application client to request parameter data beginning from s specific parameter code to the maximum allocation length or the maximum parameter code supported by the target, whichever is less. If the value of the "Parameter Pointer" field is larger than the largest available parameter code known to the device server for the specified page, the IDD terminates the command with CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in CDB [=24-00]).

The "Parameter List Length" field in the CDB specifies the total number of bytes of log parameter which can be transferred to the INIT by this command. The IDD transfers the number of bytes of all log parameters specified in the "Page Code" field or the portion of log parameters with the length specified in the "Parameter List Length" field, whichever is smaller. When zero is specified in the "Parameter List Length" field, this command is terminated without anything being transferred.

- **Log parameters**

This clause describes the log page structure and the log pages that are applicable to all devices. Pages specific to each device type are described in the command standard that applies to that device type. The LOG SENSE command returns a single log page specified in the page code field of the command descriptor block.

(1) Support log page (X'00')

The supported log page returns the list of log pages implemented by the drive.

**Table 4.44 Support log page (X'00')**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | X‘00’ (Reserved) | | | | | | | |
| 2 | X'00' (Parameter Length) | | | | | | | |
| 3 | X'0D' (Parameter Length) | | | | | | | |
| 4 | X'00' (Supported Page) | | | | | | | |
| 5 | X'01' (Supported Page) | | | | | | | |
| 6 | X'02' (Supported Page) | | | | | | | |
| 7 | X'03' (Supported Page) | | | | | | | |
| 8 | X'05' (Supported Page) | | | | | | | |
| 9 | X'06' (Supported Page) | | | | | | | |
| 10 | X'0D' (Supported Page) | | | | | | | |
| 11 | X'0E' (Supported Page) | | | | | | | |
| 12 | X'0F' (Supported Page) | | | | | | | |
| 13 | X'10' (Supported Page) | | | | | | | |
| 14 | X'18' (Supported Page) | | | | | | | |
| 15 | X'2F' (Supported Page) | | | | | | | |
| 16 | X'38' (Supported Page) | | | | | | | |

(2) Buffer overrun/underrun page (X'01')

**Table 4.45 Buffer overrun/underrun page (X'01')**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 1 | X‘00’ (Reserved) | | | | | | | |
| 2 | X'00' (Page Length) | | | | | | | |
| 3 | X'0C' (Page Length) | | | | | | | |
| 4 | X'00' (Reserved) | | | | | | | |
| 5 | Count Basis | | | Cause | | | | Type |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'02' (Parameter Length) | | | | | | | |
| 8-9 | X'0000' (Data Underrun) | | | | | | | |
| 10 | X'00' (Reserved) | | | | | | | |
| 11 | Count Basis | | | Cause | | | | Type |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | X'02' (Parameter Length) | | | | | | | |
| 14-15 | X'0000' (Data Overrun) | | | | | | | |

Cause

| | | |
|---|---|---|
| 0h | : | Undefined |
| 1h | : | SCSI bus busy, optional |
| 2h | : | Transfer rate too slow, optional |
| 3h-Fh | : | Reserved |

The drive dose not supports this field. Zero is always reported.

- Count Basis

  0h : Undefined

  1h : Per command, optional

  2h : Per failed reconnect, optional

  3h : Per unit of time, optional

  4h-7h : Reserved

  The drive does not support this field. Zero is always reported.

- Data Underrun

  Count of data underruns which occur during write operation when a buffer empty condition prevents continued transfer of data to the media from the buffer.

  The drive does not support this field due to a hardware limitation. Zero is always reported.

- Data Overrun

  Count of data overruns which occur during read operation when a buffer full condition prevents continued transfer of data from the media to the buffer.

  The drive does not support this field due to a hardware limitation. Zero is always reported.

(3) Write error count page (X'02')

**Table 4.46 Write error count page (X'02')**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | X‘00’ (Reserved) | | | | | | | |
| 2 | Page Length (MSB) | | | | | | | |
| 3 | Page Length (LSB) | | | | | | | |

All of the following parameters have this header.

Page Length will be defined based on the value of Parameter Pointer. (CDB 5-6)

- Write errors recovered without delays (page 02, code 0000)

**Table 4.47 Write errors recovered without delays (page 02, code 0000)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0000' (Parameter code)<br>(Errors Recovered Without Delays) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB)<br>Counter Value<br>(LSB) | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |

The Counter Value indicates the count of all recovered write errors that would not be reported to the initiator during write operations, because no delay is incurred.

The drive does not support this field due to a hardware limitation. Zero is always reported.

- Write errors recovered with possible delays (page 02, code 0001)

**Table 4.48 Write errors recovered with possible delays (page 02, code 0001)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0001' (Parameter code)<br>(Errors Recovered With Possible Delays) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB)<br>Counter Value<br>(LSB) | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |

The Counter Value indicates the count of all recovered write errors that would not be reported to the initiator during write operations, because possible delay is incurred.

- Total write errors posted (page 02, code 0002)

**Table 4.49 Total write errors posted (page 02, code 0002)**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB) | | | | | | | |
| 5 | X'0002' (Parameter code)<br>(Total Posted Errors) | | | | | | | (LSB) |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB) | | | | | | | |
| 9 | Counter Value | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | (LSB) |

The Counter Value indicates the count of all posted errors to the interface during write operations.

Implementation:

If a write error is posted, it will force a save of all error log pages information.

- Total recoverable write errors posted to INIT (page 02, code 0003)

**Table 4.50 Total recoverable write errors posted to INIT (page 02, code 0003)**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB) | | | | | | | |
| 5 | X'0003' (Parameter code)<br>(Total Posted Recoverable Errors) | | | | | | | (LSB) |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB) | | | | | | | |
| 9 | Counter Value | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | (LSB) |

The Counter Value indicates the count of all posted recovered (01/xx/xx) errors to the interface during write operations.

- Total write bytes processed (page 02, code 0005)

**Table 4.51 Total write bytes processed (page 02, code 0005)**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0005' (Parameter code) | | | | | | | |
| 5 | (Total Bytes Processed) | | | | | | | (LSB) |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'0A' (Parameter Length) | | | | | | | |
| 8 | (MSB) | | | | | | | |
| 9 | | | | | | | | |
| ~ | Total Write Bytes Processed (10 bytes) | | | | | | | |
| 16 | | | | | | | | |
| 17 | | | | | | | | (LSB) |

The Total Write Bytes Processed indicates the total processed bytes during write operations.

- Total unrecoverable write errors posted to INIT (page 02, code 0006)

**Table 4.52 Total unrecoverable write errors posted to INIT (page 02, code 0006)**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0006' (Parameter code) | | | | | | | |
| 5 | (Total Posted Unrecoverable Errors) | | | | | | | (LSB) |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB) | | | | | | | |
| 9 | Counter Value | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | (LSB) |

The Counter Value indicates the count of all posted unrecovered errors (03/xx/xx) to the interface during write operations.

(4) Read error count page (X'03')

**Table 4.53 Read error count page (X'03')**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 1 | X‘00’ (Reserved) | | | | | | | |
| 2 | Page Length (MSB) | | | | | | | |
| 3 | Page Length (LSB) | | | | | | | |

All of the following parameters have this header.

Page Length will be defined based on the value of Parameter Pointer. (CDB 5-6)

- Read errors recovered without delays (page 03, code 0000)

**Table 4.54 Read errors recovered without delays (page 03, code 0000)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0000' (Parameter code)<br>(Errors Recovered Without Delays) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB) | | | | | | | |
| 9 | Counter Value | | | | | | | |
| 10 | | | | | | | | |
| 11 | (LSB) | | | | | | | |

The Counter Value indicates the count of all recovered read errors that would not be reported to the initiator during read operations, because no delay is incurred.

- Read errors recovered with possible delays (page 03, code 0001)

**Table 4.55 Read errors recovered with possible delays (page 03, code 0001)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0001 (Parameter code) | | | | | | | |
| 5 | (Errors Recovered With Possible Delays) (LSB) | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB) | | | | | | | |
| 9 | Counter Value | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | (LSB) |

The Counter Value indicates the count of all recovered read errors that would not be reported to the initiator during read operations, because possible delay is incurred.

- Total read errors posted (page 03, code 0002)

**Table 4.56 Total read errors posted (page 03, code 0002)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0002' (Parameter code) | | | | | | | |
| 5 | (Total Posted Errors) (LSB) | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB) | | | | | | | |
| 9 | Counter Value | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | (LSB) |

The Counter Value indicates the count of all posted errors to the interface during read operations. The value includes the count of all posted verify errors to the interface (page X'05', Parameter code X'0002').

Implementation:

If a read error is posted, it will force a save of all error log pages information.

- Total recoverable read errors posted to INIT (page 03, code 0003)

**Table 4.57 Total recoverable read errors posted to INIT (page 03, code 0003)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0003 (Parameter code)<br>(Total Posted Recoverable Errors) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB)<br>Counter Value<br>(LSB) | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |

The Counter Value indicates the count of all posted recovered (01/xx/xx) errors to the interface during read operations. The value includes the count of all posted recovered verify errors (page X'05', Parameter code X'0003').

- Total read bytes processed (page 03, code 0005)

**Table 4.58 Total read bytes processed (page 03, code 0005)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0005' (Parameter code)<br>(Total Bytes Processed) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'0A' (Parameter Length) | | | | | | | |
| 8 | (MSB)<br>Total Write Bytes Processed (10 bytes)<br>(LSB) | | | | | | | |
| 9 | | | | | | | | |
| ≈ | | | | | | | | |
| 16 | | | | | | | | |
| 17 | | | | | | | | |

The Total Read Bytes Processed indicates the total processed bytes during read operation.

The bytes includes the total processed bytes during verify operation. (page X'05', Parameter code X'0005')

- Total unrecoverable read errors posted to INIT (page 03, code 0006)

**Table 4.59 Total unrecoverable read errors posted to INIT (page 03, code 0006)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0006' (Parameter code)<br>(Total Posted Unrecoverable Errors) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB)<br>Counter Value | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | (LSB) | | | | | | | |

The Counter Value indicates the count of all posted unrecovered errors (03/xx/xx) to the interface during read operations. The value includes the count of all posted unrecovered verify errors (page X'05', Parameter code X'0006').

(5) Verify error count page (X'05')

**Table 4.60 Verify error count page (X'05')**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 1 | X‘00’ (Reserved) | | | | | | | |
| 2 | Page Length (MSB) | | | | | | | |
| 3 | Page Length (LSB) | | | | | | | |

All of the following parameters have this header.

Page Length will be defined based on the value of Parameter Pointer. (CDB 5-6)

- Verify errors recovered without delays (page 05, code 0000)

**Table 4.61 Verify errors recovered without delays (page 05, code 0000)**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB) X'0000' (Parameter code) (Errors Recovered Without Delays) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB) Counter Value | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | (LSB) |

The Counter Value indicates the count of all recovered verify errors that would not be reported to the initiator during verify operations, because no delay is incurred.

- Vefiry errors recovered with possible delays (page 05, code 0001)

**Table 4.62 Vefiry errors recovered with possible delays (page 05, code 0001)**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB) X'0001' (Parameter code) (Errors Recovered With Possible Delays) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB) Counter Value | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | (LSB) |

The Counter Value indicates the count of all recovered verify errors that would not be reported to the initiator during verify operations, because possible delay is incurred.

- Total verify errors posted (page 05, code 0002)

**Table 4.63 Total verify errors posted (page 05, code 0002)**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0002' (Parameter code)<br>(Total Posted Errors) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB)<br>Counter Value<br>(LSB) | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |

The Counter Value indicates the count of all posted errors to the interface during verify operations.

Implementation:

If a verify error is posted, it will force a save of all error log page information.

- Total recoverable verify errors posted to INIT (page 05, code 0003)

**Table 4.64 Total recoverable verify errors posted to INIT (page 05, code 0003)**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0003' (Parameter code)<br>(Total Posted Recoverable Errors) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB)<br>Counter Value<br>(LSB) | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |

The Counter Value indicates the count of all posted recovered (01/xx/xx) errors to the interface during verify operations.

- Total verify bytes processed (page 05, code 0005)

**Table 4.65 Total verify bytes processed (page 05, code 0005)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB) | | | | | | | |
| 5 | | | X'0005' (Parameter code)<br>(Total Bytes Processed) | | | | | (LSB) |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | | | X'0A' (Parameter Length) | | | | | |
| 8 | (MSB) | | | | | | | |
| 9 | | | | | | | | |
| ~ | | | Total Verify Bytes Processed (10 bytes) | | | | | |
| 16 | | | | | | | | |
| 17 | | | | | | | | (LSB) |

The Total Verify Bytes Processed indicates the total processed bytes during verify operation.

- Total unrecoverable verify errors posted to INIT (page 05, code 0006)

**Table 4.66 Total unrecoverable verify errors posted to INIT (page 05, code 0006)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB) | | | | | | | |
| 5 | | | X'0006' (Parameter code)<br>(Total Posted Unrecoverable Errors) | | | | | (LSB) |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | | | X'04' (Parameter Length) | | | | | |
| 8 | (MSB) | | | | | | | |
| 9 | | | Counter Value | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | (LSB) |

The Counter Value indicates the count of all posted unrecovered errors (03/xx/xx) to the interface during verify operations.

(6) Non-medium error count page (X'06')

**Table 4.67 Non-medium error count page (X'06')**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 1 | X‘00’ (Reserved) | | | | | | | |
| 2 | X'00' (Page Length) | | | | | | | |
| 3 | X'08' (Page Length) | | | | | | | |
| 4 | (MSB)<br>X'0000' (Parameter code)<br>(Non-medium Error Count) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB)<br>Counter Value<br>(LSB) | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |

The Counter Value indicates the count of all non-medium errors (01/xx/xx, 02/xx/xx, 04/xx/xx, 05/xx/xx, 06/xx/xx, 07/xx/xx, 09/xx/xx and 0B/xx/xx) posted to the interface.

Implementation:

If a non-medium error is posted, it will force a save of all error log pages information.

(7) Temperature page (X'0D')

**Table 4.68 Temperature page (X'0D')**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| 1 | X‘00’ (Reserved) | | | | | | | |
| 2 | Page Length (MSB) | | | | | | | |
| 3 | Page Length (LSB) | | | | | | | |

All of the following parameters have this header.

Page Length will be defined based on the value of Parameter Pointer. (CDB 5-6)

- Temperature (page 0D, code 0000)

**Table 4.69 Temperature (page 0D, code 0000)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB) | | | X'0000' (Parameter code) | | | | |
| 5 | | | | (Temperature) | | | | (LSB) |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 7 | X'02' (Parameter Length) | | | | | | | |
| 8 | X'00' (Reserved) | | | | | | | |
| 11 | Temperature (degrees Celsius) | | | | | | | |

The Temperature sensed in the device at the time the LOG SENSE command is performed shall be returned in the parameter code 0000h. The one byte binary value specifies the temperature of the device in degrees Celsius. Temperatures equal to or less than zero degrees Celsius shall be indicated by a value of zero. If a valid temperature cannot be detected because of a sensor failure or other condition, the value returned shall be FFh. If EWASC (mode page 1C) is on, comparison is performed between the temperature value specified in parameter 0000h and the reference temperature specified in parameter 0001h.

- Reference temperature (page 0D, code 0001)

**Table 4.70 Reference temperature (page 0D, code 0001)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB) | | | X'0001' (Parameter code) | | | | |
| 5 | | | | (Temperature) | | | | (LSB) |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 7 | X'02' (Parameter Length) | | | | | | | |
| 8 | X'00' (Reserved) | | | | | | | |
| 11 | Reference Temperature (degrees Celsius) | | | | | | | |

The Reference Temperature reflect the maximum reported sensor temperature in degrees Celsius at which the device can operate continuously without degrading the device's operation or reliability outside the limits specified by the manufacturer of the device.

(8) Start-stop cycle counter page (X'0E')

**Table 4.71 Start-stop cycle counter page (X'0E')**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| 1 | X‘00’ (Reserved) | | | | | | | |
| 2 | Page Length (MSB) | | | | | | | |
| 3 | Page Length (LSB) | | | | | | | |

All of the following parameters have this header.

Page Length will be defined based on the value of Parameter Pointer. (CDB 5-6)

- Date of manufacture (page 0E, code 0001)

**Table 4.72 Date of manufacture (page 0E, code 0001)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0001' (Parameter code)<br>(Date of Manufacture) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 7 | X'06' (Parameter Length) | | | | | | | |
| 8 | (MSB)<br>Year of manufacture (4 ASCII characters)<br>(LSB) | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | (MSB)<br>Week of manufacture (2 ASCII characters)<br>(LSB) | | | | | | | |
| 13 | | | | | | | | |

The year and week in the year that the device was manufactured shall be set in the parameter field defined by parameter code 0001h. The date of manufacture shall not be savable by the INIT using the LOG SELECT command. The date is expressed in numeric ASCII characters (30h-39h) in the form YYYYWW, as shown above.

- Accounting date (page 0E, code 0002)

**Table 4.73 Accounting date (page 0E, code 0002)**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0002' (Parameter code)<br>(Accounting Date) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 7 | X'06' (Parameter Length) | | | | | | | |
| 8 | (MSB)<br>Accounting date Year (4 ASCII characters)<br>(LSB) | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | (MSB)<br>Accounting date week (2 ASCII characters)<br>(LSB) | | | | | | | |
| 13 | | | | | | | | |

The Accounting date specified by parameter code 0002h is a parameter that may be savable using a LOG SELECT command to indicate when the device was placed in service. If the parameter is not yet set or is not settable, the default value placed in the parameter field shall be 6 ASCII blank characters (20h). The field shall not be checked for validity by the device server.

- Specified cycle count over device lifetime (page 0E, code 0003)

**Table 4.74 Specified cycle count over device lifetime (page 0E, code 0003)**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0003' (Parameter code)<br>(Specified Cycle Count Over Device Lifetime) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB)<br>Specified Cycle Count Over Device Lifetime<br>(4-byte binary number)<br>(LSB) | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |

The Specified cycle count over device lifetime is a parameter provided by the device sever. The specified cycle count over device lifetime parameter shall not be savable by the INIT using the LOG SELECT command. The parameter value is a 4-byte binary number. The value indicates how operation or reliability outside the limits specified by the manufacture of the device.

- Start-stop cycle counter (page 0E, code 0004)

**Table 4.75 Start-stop cycle counter (page 0E, code 0004)**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB) | | | | | | | |
| 5 | X'0004' (Parameter code)<br>(Accumulated Start-Stop Cycles) | | | | | | | (LSB) |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 7 | X'04' (Parameter Length) | | | | | | | |
| 8 | (MSB) | | | | | | | |
| 9 | Accumulated Start-Stop Cycles (4-byte binary number) | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | (LSB) |

The Accumulated start-stop cycles is a parameter provided by the device sever. The accumulated start-stop cycles parameter shall not be savable by the application client using the LOG SELECT command. The parameter value is a 4-byte binary number. The value indicates how many start-stop cycles the device has detected since its date of manufacture. For rotating magnetic storage device, a single start-stop cycle is defined as an operational cycle that begins with the disk spindle at rest, continues while the disk accelerates to its normal operational rotational rate, continues during the entire period the disk is rotating, continues as the disk decelerates toward a resting state, and ends when the disk is no longer rotating. The count is incremented by one for each complete start-stop cycle. No comparison with the value of parameter 0003h shall be performed by the device server.

(9) Application client page (X'0F')

**Table 4.76 Application client page (X'0F')**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 1 | X‘00’ (Reserved) | | | | | | | |
| 2 | Page Length (MSB) | | | | | | | |
| 3 | Page Length (LSB) | | | | | | | |

All of the following parameters have this header.

Page Length will be defined based on the value of Parameter Pointer. (CDB 5-6)

- General usage application client parameter data (page 0F, code 0000-003F)

**Table 4.77 General usage application client parameter data (page 0F, code 0000-003F)**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0000'-X'003F' (Parameter code)<br>(Application Client Parameter) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 7 | X'FC' (Parameter Length) | | | | | | | |
| 8 | (MSB) | | | | | | | |
| 9 | | | | | | | | |
| ≈ | General Usage Parameter Bytes | | | | | | | |
| 258 | | | | | | | | |
| 259 | (LSB) | | | | | | | |

The values stored in the General usage parameter bytes represent data sent to the device server in a previous LOG SELECT command. If a previous LOG SELECT command has not occurred, the data is zero.

(10) Self-test result page (X'10')

**Table 4.78 Self-test result page (X'10')**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 1 | X‘00’ (Reserved) | | | | | | | |
| 2 | Page Length (MSB) | | | | | | | |
| 3 | Page Length (LSB) | | | | | | | |

All of the following parameters have this header.

Page Length will be defined based on the value of Parameter Pointer. (CDB 5-6)

- Self-test result parameter data (page 10, code 0001-0014)

**Table 4.79 Self-test result parameter data (page 10, code 0001-0014)**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 4 | (MSB)<br>X'0001'-X'0014' (Parameter code)<br>(Self-Test Result Parameter) (LSB) | | | | | | | |
| 5 | | | | | | | | |
| 6 | DU | DS | TSD | ETC | TMC | | LBIN | LP |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 7 | X'10' (Parameter Length) | | | | | | | |
| 8 | Self-Test Code | | | 0 | Self-Test Result Value | | | |
| 9 | Self-Test Segment Number | | | | | | | |
| 10 | (MSB)<br>Time Stamp<br>(LSB) | | | | | | | |
| 11 | | | | | | | | |
| 12 | (MSB)<br>Address of First Failure<br>(LSB) | | | | | | | |
| ~ | | | | | | | | |
| 19 | | | | | | | | |
| 20 | 0 | 0 | 0 | 0 | Sense Key | | | |
| 21 | Additional Sense Code | | | | | | | |
| 22 | Additional Sense Code Qualifier | | | | | | | |
| 23 | X'xx' (Vendor-specific) | | | | | | | |

When the self-test is initiated, the value specified in the SELF-TEST CODE field in the CDB is reported to the SELF-TEST CODE field by a SEND DIAGNOSTICS command.

The values reported to the “Self-Test Result Value” field are defined in Table 4.80.

**Table 4.80 Self-test results values**

| Value | Description |
|---|---|
| 0h | The self-test completed without error. |
| 1h | The background self-test was aborted by the application client using a SEND DIAGNOSTICS command with the SELF-TEST CODE field set to 100b (Abort background self-test). |
| 2h | The self-test routine was aborted by an application client using a method other than a SEND DIAGNOSTICS command with the SELF-TEST CODE field set to 100b (e.g., reception of the ABORT Task, RESET CONDITION. |
| 3h | An unknown error occurred while the device server was executing the self-test and the device server was unable to complete the self-test. |
| 4h | The self-test completed with a failure in a test segment, and the test segment that failed is not known. |
| 5h | The first segment of the self-test failed. |
| 6h | The second segment of the self-test failed. |
| 7h | Another segment of the self-test failed (see the SELF-TEST SEGMENT NUMBER field). |
| 8h – Eh | Reserved |
| Fh | The self-test is in grogress. |

The number of the segment that failed during the self-test is shown in the “Self-Test Segment Number” field. When the self-test is completed without an error, 0 is shown in the field.

The accumulated power-on time (unit: hour) in the event of an error occurring in the drive is shown in the “Time Stamp” field.

Address information of the data block where that error occurred is shown in the “Address of First Failure” field.

The error information in the same format as that used by sense data is reported to the “Sense Key,” “Additional Sense Code,” and “Additional Sense Code Qualifier” fields.

### (11) SAS protocol log page (page code = 18)

**Table 4.81 SAS protocol log page format**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Page Code (18h) | | | | | | | |
| 1 | Reserved (x'00) | | | | | | | |
| 2 | (MSB) | Parameter Length (n-3) | | | | | | |
| 3 | | | | | | | | (LSB) |
| 4 | First Protocol log parameter | | | | | | | |
| | | | | | | | | |
| | Nth Protocol log parameter | | | | | | | |
| m | | | | | | | | |

This log page is used to report the information on an error that occurs on the SAS bus.

As to the log parameters reported in byte 4 and the subsequent bytes, refer to Table 4.82, “Log parameter format.”

- Details of the log parameter

**Table 4.82 Log parameter format**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | (MSB) | Parameter Code | | | | | | |
| 1 | | | | | | | | (LSB) |
| 2 | DU<br>(0) | DS<br>(0) | TSD<br>(0) | ETC<br>(0) | TMC<br>(0, 0) | | LBIN<br>(1) | LP<br>(1) |
| 3 | Parameter Length (x'34') | | | | | | | |
| 4 | Reserved ('0000'b) | | | | PROTOCOL IDENTIFIER ('0110b') | | | |
| 5 | Reserved (x'0000') | | | | | | | |
| 6 | | | | | | | | |
| 7 | NUMBER OF PHYS (Number of ports) | | | | | | | |
| 8 | Reserved (x'00') | | | | | | | |
| 9 | PHY IDENTIFIER (0h or 1h) | | | | | | | |
| 10 | Reserved (x'0000') | | | | | | | |
| 11 | | | | | | | | |
| 12 | Reserved<br>(0b) | ATTACHED DEVICE TYPE<br>(0, 0, 1) | | | Reserved<br>('0000'b) | | | |
| 13 | Reserved<br>('0000'b) | | | | NEGOTIATED PHYSICAL LINK RATE<br>(8h or 9h) | | | |
| 14 | Reserved<br>('0000'b) | | | | ATTACH SSP INIT PORT | ATTACH STP INIT PORT | ATTACH SMP INIT PORT | Reserved<br>(0b) |
| 15 | Reserved<br>('0000'b) | | | | ATTACH SSP TARGET PORT | ATTACH STP TARGET PORT | ATTACH SMP TARGET PORT | Reserved<br>(0b) |
| 16-23 | SAS ADDRESS | | | | | | | |
| 24-31 | ATTACHED SAS ADDRESS | | | | | | | |
| 32 | ATTACHED PHY IDENTIFIER | | | | | | | |
| 33-39 | RESERVED | | | | | | | |
| 40-43 | INVALID DWORD COUNT | | | | | | | |
| 44-47 | RUNNING DISPARITY ERROR COUNT | | | | | | | |
| 48-51 | LOSS OF DWORD SYNCHRONIZATION | | | | | | | |
| 52-55 | PHY RESET PROBLEM | | | | | | | |

a. Parameter Code

Indicates the port number of a transferred log parameter.

For port A, "0001" is reported, and for port B, "0002" is reported.

b. PROTOCOL IDENTIFIER

"6h" is set.

c. NUMBER OF PHYS

Indicates the number of ports the drive has.

For a single port drive, X'01' is reported, while for a dual port drive, X'02' is reported.

d. PHY IDENTIFIER

Indicates the number of ports the TARG has minus one.

For a single port drive, X'00' is reported, and for a dual port drive, X'01' is reported.

e. ATTACHED DEVICE TYPE

Indicates the device type. 00b (End Device) is reported.

f. NEGOTIATE PHYSICAL LINK RATE

Indicates the physical link rate that has been established with a speed negotiation sequence.

For 1.5 Gbps, X"8" is reported, and for 3.0 Gbps, X"9" is reported.

g. ATTACHED SSP INITIATOR PORT

Reports the SSP INIT value received from the INIT with an IDENTIFY address frame.

h. ATTACHED STP INITIATOR PORT

Reports the STP INIT value received from the INIT with an IDENTIFY address frame.

i. ATTACHED SMP INITIATOR PORT

Reports the SMP INIT value received from the INIT with an IDENTIFY address frame.

j. ATTACHED SSP TARGET PORT

Reports the SSP TARGET value received from the INIT with an IDENTIFY address frame.

k. ATTACHED STP TARGET PORT

Reports the STP TARGET value received from the INIT with an IDENTIFY address frame.

l. ATTACHED SMP TARGET PORT

Reports the SMP TARGET value received from the INIT with an IDENTIFY address frame.

m. SAS ADDRESS

Reports the port SAS address of the IDD.

| | |
|---|---|
| - port SAS address (Port-A): | 5CCC CCCX XXXX XXX 2 |
| - port SAS address (Port-B): | 5CCC CCCX XXXX XXX 3 |
| | C: Company ID |
| | X: Serial number for WWN |

n. ATTACHED SAS ADDRESS

Reports the SAS address received from the INIT with an IDENTIFY address frame.

o. ATTACHED PHY IDENTIFIER

Reports the phy address received from the INIT with an IDENTIFY address frame.

p. INVALID DWORD COUNT

Reports the cumulative count of INVALID DWORD errors detected in a sequence of SP_WDS other than the PHY RESET sequence.

q. RUNNING DISPARITY ERROR COUNT

Reports the cumulative count of RUNNING DISPARITY errors received except in the PHY RESET sequence.

r. LOSS OF DWORD SYNCHRONIZATION COUNT

Reports the cumulative count of the LINK RESET sequences of a PHY RESET sequence and PHY LOST DWORD SYNCHRONIZATION.

s. PHY RESET PROBLEM COUNT

Reports the cumulative count of PHY RESET sequence failures.

### (12) SMART status page (X'2F')

**Table 4.83 SMART status page (X'2F')**

[Fujitsu unique page]

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| 1 | X‘00’ (Reserved) | | | | | | | |
| 2 | Page Length (MSB) | | | | | | | |
| 3 | Page Length (LSB) | | | | | | | |
| 4 | SMART Status Parameter | | | | | | | |
| ~ | | | | | | | | |
| n | | | | | | | | |

This page contains parameters which allow the application client to check the predictive drive failure condition of the IDD. The application client can check whether the IDD has predicted a drive failure by periodically reading out this page.

The "Page Length" field indicates the length (byte length) after byte 4.

The "SMART Status Parameter" field is Fujitsu unique parameters. The details of this field are outside the scope of this manual.

### (13) SMART data page (X'38')

**Table 4.84 SMART data page (X'38')**

[Fujitsu unique page]

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 1 | X‘00’ (Reserved) | | | | | | | |
| 2 | Page Length (MSB) | | | | | | | |
| 3 | Page Length (LSB) | | | | | | | |
| 4 | Log Parameters | | | | | | | |
| ~ | | | | | | | | |
| n | | | | | | | | |

This page reports data which the IDD collects for predicting drive failures.

The "Page Length" field indicates the length (byte length) after byte 4.

The "Log Parameters" field is Fujitsu unique parameters. The details of this field are outside the scope of this manual.

### 4.1.17 PERSISTENT RESERVE IN (5E)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X'5E' | | | | | | | |
| 1 | 0 | 0 | 0 | Service Action | | | | |
| 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 | 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 | 0 | 0 | 0 |

The PERSISTENT RESERVE IN command is used to obtain information on the reserve conditions that are valid within a target and information concerning a Reservation Key. This command is used in combination with the PERSISTENT RESERVE OUT command (see Section 4.1.18).

If the reserved state implemented with the RESERVE command is valid in a target when the target receives this command, the command is rejected with the report of the RESERVATION CONFLICT status.

When the reserved state implemented with the PERSISTENT RESERVATION command is valid, this command is always executed normally.

The length of the PERSISTENT RESERVE IN parameter data that can be reported with this command is indicated in the parameter data. When a byte count that is too small to transfer an entire parameter list is specified in the "Allocation Length" field of the CDB, the data bytes starting at byte 0 of the parameter data and numbering as many as the specified byte count are transferred (this is not considered to be an error). If it is necessary to read the rest of the parameter data, an INIT should reissue the PERSISTENT RESERVE IN command by specifying a byte count that is long enough to cover the entire list in the "Allocation Length" field.

### (1) PERSISTENT RESERVE IN service actions

In each Service Action, the drive needs to be in the ready state for accessing reserve conditions and registered information. When the drive is not in the ready state, the drive reports the CHECK CONDITION status. The sense key is set to NOT READY [= 2], and sense data similar to data reported with the TEST UNIT READY command is set.

The service action codes for the PERSISTENT RESERVE IN command are defined below.

**Table 4.85 PERSISTENT RESERVE IN service actions**

| Code | Name | Description |
|---|---|---|
| 00h | READ KEYS | Reads all registered Reservation Keys |
| 01h | READ RESERVATION | Reads the current persistent reservations |
| 02h-1Fh | Reserved | Reserved |

- READ KEYS

In the READ KEYS Service Action, a drive transfers the following information to the INIT as a parameter data list:

- The current Generation value (refer to (2)).
- All the Reservation keys currently registered (eight bytes for each key).

If multiple INITs have registered with the same key, the key appears in the list once for the registration of each INIT and as many times as there are registered INITs (keys appear in the list not in the order in which they have been registered in the drive, but in ascending order of IDs, starting with the last INITs that has registered a key (e.g., from ID#0)). These keys are those that have been registered with the REGISTER Service Action of the PERSISTENT RESERVE OUT command.

- READ RESERVATIONS

In the READ RESERVATIONS Service Action, a drive transfers the following information to the INIT as a parameter data list:

- The current Generation value (refer to (2)).
- The Reservation key that has been registered by the INIT having the Persistent Reservation.
- The Scope value and Type value
- Scope-specific address (only Element scope)

When this Service Action is executed, if the drive does not have Persistent Reservation, zero is set in the "Additional Length" field of the list to be transferred as a parameter.

### (2) PERSISTENT RESERVE IN parameter data for READ KEYS

The format for the parameter data provided in response to a PERSISTENT RESERVE IN command with the READ KEYS service action is shown in Table 4.86.

**Table 4.86 PERSISTENT RESERVE IN parameter data for READ KEYS**

| | Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Header | 0 | (MSB) | | | | | | | |
| | ~ | | | | Generation | | | | |
| | 3 | | | | | | | | (LSB) |
| | 4 | (MSB) | | | | | | | |
| | ~ | | | | Additional Length (n-7) | | | | |
| | 7 | | | | | | | | (LSB) |
| Reservation key list | 8 | (MSB) | | | | | | | |
| | ~ | | | | First reservation key | | | | |
| | 15 | | | | | | | | (LSB) |
| | ~ | | | | | | | | |
| | n-7 | (MSB) | | | | | | | |
| | ~ | | | | Last reservation key | | | | |
| | n | | | | | | | | (LSB) |

The "Generation" field shall contain a 32-bit counter maintained by the drive that shall be incremented every time a PERSISTENT RESERVE OUT command requests a REGISTER, a REGISTER AND IGNORE EXISTING KEY, a CLEAR, a PREEMPT, or a PREEMPT AND ABORT service action. When the PERSISTENT RESERVE IN command is executed, the RESERVE or RELEASE Service Action of the PERSISTENT RESERVE OUT command is executed, or the PERSISTENT RESERVE OUT command cannot be executed because of an error or RESERVATION CONFLICT, this counter is not updated. Regardless of the "APTPL" bit value the generation value shall be set to 0 in the power on reset process.

By referring to the value of the "Generation" field, an INIT can find out if the INIT configuration related to the logical unit has been changed by another INIT while the former INIT does not recognize such a change.

The "Additional Length" field contains a count of the number of bytes in the Reservation key list. If the Allocation Length value specified by the PERSISTENT RESERVE IN command is too small to transfer the entire valid parameter list, the bytes starting at byte 0 of the list and numbering as many as the specified byte count are transferred to the INIT. Even if the rest of the list is discarded without being transferred, the "Additional Length" field indicates the total number of bytes in the valid Reservation Key list (this is not considered to be an error).

The reservation key list contains the 8-byte reservation keys for all initiators that have registered through all ports with the device server.

### (3) PERSISTENT RESERVE IN parameter data for READ RESERVATIONS

The format of the parameter data provided in response to a PERSISTENT RESERVE IN command with the READ RESERVATIONS Service Action is shown in Table 4.87.

**Table 4.87 PERSISTENT RESERVE IN parameter data for READ RESERVATIONS**

| | Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Header | 0 | (MSB) | | | | | | | |
| | ~ | Generation | | | | | | | ~ |
| | 3 | | | | | | | | (LSB) |
| | 4 | (MSB) | | | | | | | |
| | ~ | Additional Length (n-7) | | | | | | | ~ |
| | 7 | | | | | | | | (LSB) |
| | 8 | (MSB) | | | | | | | |
| | ~ | Reservation descriptor(s)<br>(see below) | | | | | | | ~ |
| | n | | | | | | | | (LSB) |

The "Generation" field shall be as defined for the PERSISTENT RESERVE IN READ KEYS Service Action parameter data (see 4.1.17 (2) ).

The "Additional Length" field contains the count of bytes in the "Reservation Descriptors" field (after Byte 8). If the value specified in the "Additional Length" field by the PERSISTENT RESERVE IN command is not sufficient to contain the entire parameter list, then only the first portion of the list (byte 0 to the number specified) shall be sent to the application client. The remaining bytes shall be truncated, although the "Additional Length" field shall still contain the actual number of bytes in the "Reservation Descriptors" field without consideration of any truncation resulting from an insufficient value in the "Additional Length" field. This shall not be considered an error.

The format of the Reservation descriptors is defined in Table 4.88.

**Table 4.88 Format of reservation descriptors**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | (MSB) | | | | | | | |
| ~ | Reservation Key | | | | | | | |
| 7 | | | | | | | | (LSB) |
| 8 | (MSB) | | | | | | | |
| ~ | Scope-specific Address | | | | | | | |
| 11 | | | | | | | | (LSB) |
| 12 | X'00' (Reserved) | | | | | | | |
| 13 | Scope | | | | Type | | | |
| 14-15 | X'00' (Reserved) | | | | | | | |

The Reservation Descriptor in the parameter data contains the information on each reserve condition held in the logical unit. The Descriptor contains the Reservation key of the INIT that holds the reserve conditions. It also contains the "Type" and "Scope" reserve condition values specified by the PERSISTENT RESERVE OUT command.

The "Reservation key" field indicates the Reservation key registered with its reserve condition. If each INIT uses a key specific to itself, the application needs to know the association of the INIT that holds a reserve condition with a Reservation key.

If the "Scope" value is element reserve, the "Scope-specific Address" field indicates the element address (with the high byte filled with 0's). If the Scope value is logical unit reserve, the "Scope-specific Address" field is set to zero.

Remarks: Element reserve is not supported.

- Persistent reservations scope

The value in the "Scope" field shall indicate whether a persistent reservation applies to an entire logical unit or to an element. The values in the "Scope" field are defined in Table 4.89.

**Table 4.89 Persistent reservations scope**

| Code | Name | Description |
|---|---|---|
| 0h | Logical Unit | Persistent reservation applies to the full logical unit |
| 1h | Reserved | Reserved |
| 2h | Element (not supported) | Persistent reservation applies to the specified element |
| 3h-Fh | Reserved | Reserved |

a) Logical unit scope

A "Scope" field value of LU shall indicate that the persistent reservation applies to the entire logical unit. A drive that supports PERSISTENT RESERVE OUT must also support the Logical Unit scope.

b) Element scope (not supported)

This "Scope" field value indicates that reservation has been applied to the element specified in the "Scope-specific Address" field of the PERSISTENT RESERVE OUT parameter list. The support of Element Scope is optional.

- Persistent reservations type

The "Type" field value defines the reserve attribute applied to the data block in the logical unit. Table 4.90 shows the characteristics of each of the type codes. The codes for each of the types and the drives that support such codes are explained in the table. The requirements of the drives indicated in the table are divided into two separate categories. The first paragnaph defines the required handling for read operation. The second paragraph defines the required handling for write operations.

### Table 4.90 Persistent reservations type codes

| Code | Name | Description | |
|---|---|---|---|
| 0h | | Reserved | |
| 1h | Write Exclusive | Reads Shared: | Any INIT can execute a read-type command. |
| | | Writes Exclusive: | Any write-type command that is issued by an INIT other than the INIT holding this reservation state results in a Reservation Conflict. |
| 2h | | Reserved | |
| 3h | Exclusive Access | Reads Shared: | Any read-type command that is issued by an INIT other than the INIT holding this reservation state results in a Reservation Conflict. |
| | | Writes Exclusive: | Any write-type command that is issued by an INIT other than the INIT holding this reservation state results in a Reservation Conflict. |
| 4h | | Reserved | |
| 5h | Write Exclusive-Registrants Only | Reads Shared: | Any INIT can execute a read-type command. |
| | | Writes Exclusive: | Any write-type command issued by an INIT that has not registered the Reservation Conflict results in a Reservation Conflict. |
| 6h | Exclusive Access-Registrants Only | Reads Exclusive: | Any read-type command issued by an INIT that has not registered the Reservation Conflict results in a Reservation Conflict. |
| | | Writes Exclusive: | Any write-type command issued by an INIT that has not registered the Reservation Conflict results in a Reservation Conflict. |
| 7h-Fh | | Reserved | |

### 4.1.18 PERSISTENT RESERVE OUT (5F)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X'5F' | | | | | | | |
| 1 | 0 | 0 | 0 | Service Action | | | | |
| 2 | Scope | | | | Type | | | |
| 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 | Parameter List Length (MSB) | | | | | | | |
| 8 | Parameter List Length (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command is used for reserving so that the particular initiator can use the logical unit exclusively or share with others. The command shall be used in conjunction with the PERSISTENT RESERVE IN command and shall have no relevance to the RESERVE and RELEASE commands.

By using the reservation key defined by the INIT, PERSISTENT RESERVATION can be used to identify initiators that execute any of the Service Actions of the PERSITENT RESERVE OUT commands and that conflict with a reserve condition established by the RESERVE command. An INIT can check to see which INITs hold conflicting or illegal reserve conditions by using the PERSISTENT RESERVE IN command and, if necessary, an INIT can make new reserve conditions preempt these reserve conditions by using the PERSISTENT RESERVE OUT command.

Since set reserve conditions cannot be reset by processing such as TARGET RESET task, PERSISTENT RESERVATION can be used to have multiple INITs share a device. The PERSISTENT RESERVE OUT and PERSISTENT RESERVE IN commands provide a fundamental mechanism to analyze reserve conditions that change dynamically in a multi-initiator system using multi-port TARGs. It becomes possible to identify whether TARGs have particular reserve conditions, and to remove reserve conditions from INITs that have errors or are uncooperative.

If the reserve condition implemented with the RESERVE/RESERVE EXTENDED command is held when a drive receives this command, this command is rejected with the report of the RESERVATION CONFLICT status.

If illegal drive resources exist when this command is issued, the drive reports the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST

[= 5], and the sense data is set to INSUFFICIENT REGISTRATION [= 55-04]. (However, this sense data is not reported for a SCSI device.)

For RESERVE, PREEMPT, and PREEMPT and ABORT Service Actions of this command, it is determined whether a reserve condition to be newly set by this command conflicts with the reserve conditions already held in the drive, regarding the setting of the Scope and Type. When any conflicting reserve condition exists, this command is rejected with the RESERVATION CONFLICT status, and no RESERVE, PREEMPT, or CLEAR processing is performed. However, the reserve conditions held by the INIT to be preempted by PREEMPT or PREEMPT and ABORT Service Action (the INIT specified in the "Service Action Reservation Key" field) are not subject to the judgment on whether a conflict exists.

The RELEASE and CLEAR Service Actions of this command do not conflict with any reserve conditions (however, the RESERVATION CONFLICT is reported if a Reservation key has not been registered or it is different from the registered one).

If an INIT that has not registered a Reservation key issues this command with the specification of a Service Action except REGISTER, or REGISTER and IGNORE EXISTING KEY Service Action, this command is rejected with a report indicating a RESERVATION CONFLICT status.

The PERSISTENT RESERVE OUT command contains the fields for specifying different restrictions imposed according to the Service Action type of PERSISTENT RESERVATION, the Scope to which PERSISTENT RESERVATION is applied, and PERSISTENT RESERVATION. For the definitions of the "Type" and "Scope" fields, refer to the PERSISTENT RESERVE IN command. If a Scope value that is not executed by the device is specified in the "Scope" field, the drive reports the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST [= 5], and the sense data is set to INVALID FIELD IN CDB [= 24-00].

In each field in the PERSISTENT RESERVE OUT parameter list, the Reservation key required to execute this PERSISTENT RESERVATION Service Action and the information regarding the Reservation key are specified.

The parameter list is a 24-byte long list, and the Parameter Length field should contain "24 (18h)." If the Parameter Length field contains a value other than "24 (18h)," the drive reports the CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST [= 5], and the sense data is set to PARAMETER LIST LENGTH ERROR [= 1A-00].

A logical unit uses the SA space to maintain PERSISTENT RESERVATION and registered keys (across a power shutdown). If the drive is not in the Ready state when the Activate Persist Through Power Loss mechanism (this mechanism maintains reserve conditions during a power shutdown) is enabled by the PERSISTENT RESERVE OUT command, the drive reports the CHECK CONDITION status. The sense key is set to NOT READY [= 2], and the sense data is set according to the same definition that is used to report to the TEST UNIT READY command.

### (1) PERSISTENT RESERVE OUT service actions

When processing the PERSISTENT RESERVE OUT service actions, the device server shall update the generation value as specified in 4.1.17 (2).

The PERSISTENT RESERVE OUT command service actions are defined in table 4.91.

**Table 4.91 PERSISTENT RESERVE OUT service action codes**

| Code | Name | Description |
|---|---|---|
| 00h | REGISTER | Register a reservation key with the device server. |
| 01h | RESERVE | Gnerates a persistent reservation having a specified SCOPE and TYPE. |
| 02h | RELEASE | Releases persistent reservations. |
| 03h | CLEAR | Clears all reservation keys and all persistent reservations. |
| 04h | PREEMPT | Preempts persistent reservations from another initiator. |
| 05h | PREEMPT & ABORT | Preempts persistent reservations from another initiator and aborts the task set for the preempted initiator. |
| 06h | REGISTER AND IGNORE EXISTING KEY | Register a reservation key with the drive. |
| 07h-1Fh | Reserved | |

The parameter list values for each service action are specified in 4.1.18 (2).

(2) PERSISTENT RESERVE OUT parameter list

The parameter list of the PERSISTENT RESERVE OUT command are shown in Table 4.92.

Some fields of the parameter list of a particular Service Action and scope values may be invalid, but all the fields must always be transferred.

**Table 4.92 PERSISTENT RESERVE OUT parameter list**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | (MSB) | | | | | | | |
| ~ | Reservation Key | | | | | | | |
| 7 | | | | | | | | (LSB) |
| 8 | (MSB) | | | | | | | |
| ~ | Service Action Reservation Key | | | | | | | |
| 15 | | | | | | | | (LSB) |
| 16 | (MSB) | | | | | | | |
| ~ | Scope-specific Address | | | | | | | |
| 19 | | | | | | | | (LSB) |
| 20 | Reserved | | | | | | | APTPL |
| 21-23 | X'000000' (Reserved) | | | | | | | |

The "Reservation Key" field contains an 8-byte key code provided by the application client to identify the initiator that is the source of the PERSISTENT RESERVE OUT command. The drive checks whether the contents of the "Reservation Key" field received with the PERSISTENT RESERVE OUT command matches the Reservation Key registered by the INIT that has issued the command. However, if all the registered Reservation Keys are zero (not registered), the value specified in this field is ignored. If a key that is different from the Reservation Key for the relevant INIT is specified by the PERSISTENT RESERVE OUT command, the drive reports a RESERVATION CONFLICT status. All the Reservation Keys of this INIT are valid for Service Actions and scopes.

The specification of the "Service Action Reservation Key" field is necessary for the REGISTER, PREEMPT, and PREEMPT and ABORT Service Actions. For the REGISTER Service Action, a Reservation Key to be newly registered is set in this field. For the PREEMPT and, PREEMPT and ABORT Service Actions, the Reservation Key of the INIT that holds a reserve condition to be cleared (preempted) is set in this field. For the PREEMPT and, PREEMPT and ABORT Service Actions, if the value specified in this field does not match any of the Reservation Keys registered, the drive reports the RESERVATION CONFLICT status. For the Service Actions listed below, the value specified in this field is ignored.

When the Scope value indicates Element Reservation, an element address (with the high byte filled with zeroes) is set in the Scope-specific Address field. If the Service Action is REGISTER, REGISTER and IGNORE EXISTING KEY, or CLEAR, or if the Scope indicates LU Reservation, set zero in the Scope-specific Address field. The Activate Persist Through Power Loss (APTPL) bit is valid only for the REGISTER Service Action. For the other Service Actions, this bit is ignored. The support of the APTPL bit is optional, and if this bit is set for a drive that does not support this bit, the drive terminates this command with the CHECK CONDITION status. At this time, the sense key is set to ILLEGAL REQUEST [= 5], and the sense data is set to INVALID FIELD IN PARAMETER LIST [= 26-00].

If the value of the APTPL bit that is last received by the drive is '0,' the power shutdown of the TARG releases all the PERSISTENT RESERVATIONs and clears all the Reservation Keys. If the value of the APTPL bit that is last received by the drive is '1,' the logical unit maintains all the PERSISTENT RESERVATIONs and Reservation Keys for all the INITs throughout power shutdown and re-power-on sequences (the SA space is used to save the registration information). The APTPL value, which controls the logical unit behavior while the power is turned off, is valid regardless of which INIT the bit value has been received from.

Table 4.93 explains which fields are set by an application client and how such fields are recognized by a drive as regards each Service Action and Scope value. As for Reservation Keys and APTPL, they are as explained above.

**Table 4.93 PERSISTENT RESERVE OUT service action and valid parameters**

| Service Action | Allowed Scope | type | Parameters | | |
|---|---|---|---|---|---|
| | | | Reservation Key | Reservation Key | Service Action Scope-Specific Address |
| Register | ignored | ignored | valid | valid | ignored |
| Register And Ignore Existing Key | ignored | ignored | ignored | valid | ignored |
| Reserve | Logical Unit<br>Element | valid<br>valid | valid | ignored<br>ignored | ignored<br>valid(Element) |
| Release | Logical Unit<br>Element | valid<br>valid | valid | ignored<br>ignored | ignored<br>valid (Element) |
| Clear | ignored | ignored | valid | ignored | ignored |
| Preempt | Logical Unit<br>Element | valid<br>valid | valid | valid<br>valid | ignored<br>valid (Element) |
| Preempt & Abort | Logical Unit<br>Element | valid<br>valid | valid | valid<br>valid | ignored<br>valid (Element) |

Note: MATxxx and MAUxxx series does not support Element Scope.

### 4.1.19 REPORT LUNS (A0)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X'A0' | | | | | | | |
| 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 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | Allocation Length (MSB) | | | | | | | |
| 7 | Allocation Length | | | | | | | |
| 8 | Allocation Length | | | | | | | |
| 9 | Allocation Length (LSB) | | | | | | | |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command requests that the peripheral device logical unit inventory be sent to the application client.

This command normally operate under the reserve condition (RESERVE or PERSISTENT RESERVE).

The "Allocation Length" should be at least 16 bytes. If the "Allocation Length" is less than 16 bytes, the IDD reports the CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid Field in CDB [=24-00]). If the "Allocation Length" is not sufficient to contain the entire logical unit inventory, the device server shall report as many logical unit number values as fit in the specified allocation length. This shall not be considered an error.

The device server shall report those devices in the logical unit inventory using the format shown in Table 4.94.

**Table 4.94 REPORT LUNS parameter list**

|  | Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Header | 0 | (MSB) |  |  |  |  |  |  |  |
|  | ~ | LUN List Length (N-7) |  |  |  |  |  |  |  |
|  | 3 |  |  |  |  |  |  |  | (LSB) |
|  | 4 | (MSB) |  |  |  |  |  |  |  |
|  | ~ | Reserved |  |  |  |  |  |  |  |
|  | 7 |  |  |  |  |  |  |  | (LSB) |
| LUN List | 8 | (MSB) |  |  |  |  |  |  |  |
|  | ~ | First LUN |  |  |  |  |  |  |  |
|  | 15 |  |  |  |  |  |  |  | (LSB) |
|  | ~ ~ |  |  |  |  |  |  |  |  |
|  | n-7 | (MSB) |  |  |  |  |  |  |  |
|  | ~ | Last LUN |  |  |  |  |  |  |  |
|  | n |  |  |  |  |  |  |  | (LSB) |

The "LUN List Length" field shall contain the length in bytes of the LUN list that is available to be transferred. The "LUN list length" is the number of logical unit numbers in the logical unit inventory multiplied by eight. If the allocation length in the command descriptor block is too small to transfer information about the entire logical unit inventory, the LUN list length value shall not be adjusted to reflect the truncation.

### 4.1.20 REPORT DEVICE IDENTIFIER (A3)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X'A3' | | | | | | | |
| 1 | 0 | 0 | 0 | Service Action (X’ 05’) | | | | |
| 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 | 0 | 0 | 0 |
| 6 | Allocation Length (MSB) | | | | | | | |
| 7 | Allocation Length | | | | | | | |
| 8 | Allocation Length | | | | | | | |
| 9 | Allocation Length (LSB) | | | | | | | |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command requests that the device server send device identification information to the application client.

The "Service Action" field can be specified only X'05'.

The "Allocation Length" field indicates how much space has been reserved for the returned parameter data. If the length is not sufficient to contain all the parameter data, the first portion of the data shall be returned. This shall not be considered an error. The actual length of the parameter data is available in the "Identifier Length" field in the parameter data. If the remainder of the parameter data is required, the application client should send a new REPORT DEVICE IDENTIFIER command with an "Allocation Length" field large enough to contain all the data.

The REPORT DEVICE IDENTIFIER parameter list are shown in Table 4.95.

**Table 4.95 REPORT DEVICE IDENTIFIER parameter list**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | (MSB) | | | | | | | |
| ~ ~ | Identifier Length (n-4) | | | | | | | ~ |
| 3 | | | | | | | | (LSB) |
| 4 | (MSB) | | | | | | | |
| ~ ~ | Identifier | | | | | | | ~ |
| n | | | | | | | | (LSB) |

The "Identifier Length" field specifies the length in bytes of the "Identifier" field.

If the "Allocation Length" field in the CDB is too small to transfer all of the identifier, the length shall not be adjusted to reflect the truncation. The identifier length shall initially equal zero, and shall be changed only by a successful SET DEVICE IDENTIFIER command.

The "Identifier" field shall contain a vendor specific value. The value reported shall be the last value written by a successful SET DEVICE IDENTIFIER command. The value of the identifier shall be changed only by a SET DEVICE IDENTIFIER command. The identifier value shall persist through resets, power cycles, media format operations, and media replacement.

The target shall return the same Identifier to all initiators on all ports.

When this command is executed, the IDD must be in the Ready state. If this command is issued when the IDD is not in the Ready state, the IDD reports the CHECK CONDITION status (NOT READY [= 2]/Additional Sense Code indicating the NOT READY state).

### 4.1.21 SET DEVICE IDENTIFIER (A4)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X'A4' | | | | | | | |
| 1 | 0 | 0 | 0 | Service Action (X’ 06’) | | | | |
| 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 | 0 | 0 | 0 |
| 6 | Allocation Length (MSB) | | | | | | | |
| 7 | Allocation Length | | | | | | | |
| 8 | Allocation Length | | | | | | | |
| 9 | Allocation Length (LSB) | | | | | | | |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command requests that the device identifier information in the logical unit be set to the value received in the SET DEVICE IDENTIFIER parameter list.

On successful completion of this command a unit attention shall be generated for all initiators except the one that issued the service action. When reporting the unit attention condition the additional sense code shall be set to DEVICE IDENTIFIER CHANGED.

The "Service Action" field can be specified only X'06'.

The "Allocation Length" field specifies the length in bytes of the Identifier that shall be transferred from the application client to the device server. The maximum value for this field shall be 512 bytes. A parameter list length of zero indicates that no data shall be transferred, and that subsequent REPORT DEVICE IDENTIFIER commands shall return an Identifier length of zero. Logical units that implement this command shall be capable of accepting a parameter list length of 512 bytes or less. If the parameter list length exceeds 512 bytes and the logical unit is not capable of storing the requested number of bytes, then the device server shall return CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in CDB [=24-00]).

The SET DEVICE IDENTIFIER parameter lists are shown in Table 4.96.

**Table 4.96 SET DEVICE IDENTIFIER parameter list**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | (MSB) | | | | | | | |
| ~ ~ | Identifier | | | | | | | |
| n | | | | | | | | (LSB) |

The "Identifier" field shall be a vendor specific value, to be returned in subsequent REPORT DEVICE IDENTIFIER commands.

## 4.2 Data Access Commands

### 4.2.1 READ (08)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘08’ | | | | | | | |
| 1 | 0 | 0 | 0 | Logical Block Address (MSB) | | | | |
| 2 | Logical Block Address | | | | | | | |
| 3 | Logical Block Address (LSB) | | | | | | | |
| 4 | Transfer Block Count | | | | | | | |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command reads the number of blocks of data in continuous logical data blocks specified in the "Transfer block count" field with the logical data block on the disk media specified in the "Logical block address" field in the CDB as the top.

The transfer block count can be specified up to a maximum of 256 logical data blocks. When zero is specified in the "Transfer block count" field in byte 4 of the CDB, it specifies transfer of 256 logical data blocks and when a value other than zero is specified, it specifies the number of logical data blocks that should be transferred.

When transfer of multiple data blocks is instructed by this command, when the data blocks which are to be processed come to a track boundary, cylinder boundary or zone boundary, a head switch or cylinder switch is executed automatically and reading of the specified number of blocks is performed.

When the specifications in the "Logical block address" field and "Transfer block count" field in the CDB exceed the maximum logical block address in the IDD, that command is terminated with a CHECK CONDITION status (ILLEGAL REQUEST [=5] / Logical block address out of range [=21-00]) and the reading of data from the disk media is not executed.

Error recovery processing during execution of this command can be specified by the MODE SELECT parameter. If retry processing and data correction processing are not prohibited, when this command is completed normally, or when it is completed with a "RECOVERED ERROR [=1]" sense key report, the data transferred to the INIT by this command are error free. When a correctable error check is detected, the IDD first corrects the data errors in the data buffer, then transfers those data to the INIT.

If the Look-Ahead cache feature is permitted, a caching operation is performed using the IDD's data buffer by this command. See Chapter 3, "Data Buffer Management," concerning details of data buffer operation and the Look-Ahead cache feature.

### 4.2.2 READ EXTENDED (28)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘28’ | | | | | | | |
| 1 | 0 | 0 | 0 | × | FUA | 0 | 0 | 0 |
| 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 Block Count (MSB) | | | | | | | |
| 8 | Transfer Block Count (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command reads the number of blocks of data in continuous logical data blocks specified in the "Transfer block count" field with the logical data block on the disk media specified in the "Logical block address" field in the CDB as the top.

The functions of this command are the same as those of the Group 0 READ command (Section 4.2.1) with the exception that it is possible to specify 4-byte logical block addresses and 2-byte transfer block counts. However, when zero is specified for the "Transfer block count," the command is terminated normally without seek and pre-fetch being performed.

- FUA (force unit access)

  When this bit is "0", it indicates that the IDD satisfy the command by accessing the cache memory. Any logical blocks that are contained in the cache memory may be transferred to the INIT directly from the cache memory.

  When this bit is "1", it indicated that the IDD shall access the media in performing the command prior to returning GOOD status. READ commands shall access the specified logical blocks from the media (i.e., the data is not directly retrieved from the cache).

### 4.2.3 WRITE (0A)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘0A’ | | | | | | | |
| 1 | 0 | 0 | 0 | Logical Block Address (MSB) | | | | |
| 2 | Logical Block Address | | | | | | | |
| 3 | Logical Block Address (LSB) | | | | | | | |
| 4 | Transfer Block Count | | | | | | | |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command transfers the number of blocks of data specified in the "Transfer block count" field from the INIT and writes them in continuous logical data blocks with the logical data block on the disk media specified in the "Logical block address" field in the CDB as the top.

The transfer block count can be specified up to a maximum of 256 logical data blocks. When zero is specified in the "Transfer block count" field in byte 4 of the CDB, it specifies transfer of 256 logical data blocks and when a value other than zero is specified, it specifies the number of logical data blocks that should be transferred.

When transfer of multiple data blocks is instructed by this command, when the data blocks which are to be processed come to a track boundary, cylinder boundary or zone boundary, a head switch or cylinder switch is executed automatically and writing of the specified number of blocks is performed.

When the specifications in the "Logical block address" field and "Transfer block count" field in the CDB exceed the maximum logical block address in the IDD, that command is terminated with a CHECK CONDITION status (ILLEGAL REQUEST [=5] / Logical block address out of range [=21-00]) and writing of data to the disk media is not executed.

If the write cache function is enabled, the IDD reports a status byte at the point when reception of all the data transferred from the INIT is completed. If an error occurs while data are being written to the disk media, a CHECK CONDITION status is reported for the command to be executed next. If the write cache function is disabled, a status byte is reported after writing to the disk media of all the data transferred from the INIT is completed, then execution of the command is terminated.

**IMPORTANT**

Even when there is an error in the specification in the CDB, or when a write operation to the disk media cannot be executed normally due to various other causes, the transfer of data (data is pre-fetched to the data buffer) from the INIT to the IDD may be executed. In this case, the length of data transferred from the INIT to the IDD is undefined. Also, all the data transferred to the IDD will not necessarily be actually written to the disk media. However, if the command is terminated with a CHECK CONDITION status and the sense key of the sense data indicates "ILLEGAL REQUEST [=5]," the data from that command is not written to the disk media by a write operation.

## 4.2.4 WRITE EXTENDED (2A)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘2A’ | | | | | | | |
| 1 | 0 | 0 | 0 | × | FUA | 0 | 0 | 0 |
| 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 Block Count (MSB) | | | | | | | |
| 8 | Transfer Block Count (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command transfers the number of blocks of data specified in the "Transfer block count" field from the INIT and writes them in continuous logical data blocks with the logical data block on the disk media specified in the "Logical block address" field in the CDB as the top.

The functions of this command are the same as those of the Group 0 WRITE command (Section 4.2.3) with the exception that it is possible to specify 4-byte logical block addresses and 2-byte transfer block counts. However, when zero is specified for the "Transfer block count," the command is terminated normally without pre-fetch being performed.

In this device, specifications to the "FUA" bit in CDB byte 1 are invalid and operation is as if zero is specified.

The specification of bit 4 of CDB byte 1 is invalid and the specified value is disregarded.

### 4.2.5 WRITE AND VERIFY (2E)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘2E’ | | | | | | | |
| 1 | 0 | 0 | 0 | × | 0 | 0 | BytChk | 0 |
| 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 Block Count (MSB) | | | | | | | |
| 8 | Transfer Block Count (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command transfers the number of blocks of data specified in the "Transfer block count" field from the INIT and writes them in continuous logical data blocks with the logical data block on the disk media specified in the "Logical block address" field in the CDB as the top, then reads those data and performs a Verify check.

The functions of this command related to write operations are the same as those of the WRITE EXTENDED command (Section 4.2.4), with the exception that the write cache function and automatic alternate block allocation function cannot be applied. When zero is specified in the "Transfer block count," this command is terminated normally without performing seek or pre-fetch.

The specification in bit 4 of CDB byte 1 is disabled in the IDD and the specified value is disregarded.

The VERIFY check executed by this command is the only the ECC (data portion) normalcy check. Error recovery processing during execution of the VERIFY check conforms to the mode specified by the MODE SELECT parameter (Verify error recovery parameter). For example, when data correction processing is not prohibited, if a correctable data check is detected during the VERIFY check, the VERIFY check is regarded as having terminated successfully.

When “1” is set in bit 1 (BytChk bit) of CDB byte 1, the IDD reads data blocks from the disk and compares the data with the write data transferred from the INIT after terminating the write operation. This IDD does not support that function, however, so it performs the operation executed when “0” is set in bit 1 (BytChk bit) of CDB byte 1.

### 4.2.6 VERIFY (2F)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘2F’ | | | | | | | |
| 1 | 0 | 0 | 0 | × | 0 | 0 | BytChk | 0 |
| 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 Block Count (MSB) | | | | | | | |
| 8 | Transfer Block Count (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command reads the number of continuous logical data blocks specified in the "Block count" field with the logical data block on the disk media which is specified in the "Logical block address" field in the CDB as the top, then executes a VERIFY check on those data.

The "Block count" field in the CDB specifies the number of data blocks which is the object of the VERIFY check. When zero is specified in the "Transfer block count," the command is terminated normally without performing seek and pre-fetch.

Bit 4 of CDB byte 1 is disabled in the IDD and the specified value is disregarded.

If "1" is specified in bit 1 of CDB byte 1, the BytChk bit, the IDD performs a comparison check of the data read from the disk media and the data transferred from the INIT. If the data do not match during this mode, the command is terminated with a CHECK CONDITION status (MISCOMPARE [=E] / Miscompare during verify operation [=1D-00]).

If "0" is specified in bit 1 of CDB byte 1, the BytChk bit, an ECC (data portion) normalcy check is executed. Also, error recovery processing during execution of the verify check is according to the mode specified by the MODE SELECT parameter (verify error recovery parameter). For example, if data correction processing is not prohibited, even if a correctable data check is detected, it is regarded as if the verify check succeeded.

### 4.2.7 SEEK (0B)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘0B’ | | | | | | | |
| 1 | 0 | 0 | 0 | Logical Block Address (MSB) | | | | |
| 2 | Logical Block Address | | | | | | | |
| 3 | Logical Block Address (LSB) | | | | | | | |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command executes a seek operation of the cylinder/track where the logical data block specified in the "Logical block address" field in the CDB exists.

When disconnect processing is permitted, the IDD performs disconnect processing after receiving the CDB.  After that, the IDD executes reconnect processing at the point when the seek operation is completed and reports the status.

When disconnect processing is not permitted, the IDD executes the seek operation while still connected to the FC interface and when it is completed, reports the status of this command.

### 4.2.8 SEEK EXTENDED (2B)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘2B’ | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 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 | 0 | 0 | 0 |

This command executes a seek operation of the cylinder/track where the logical data block specified in the "Logical block address" field in the CDB exists.

The functions and operation of this command are the same as those of the Group 0 SEEK command (Section 4.2.7), except that it is possible to specify 4-byte logical block addresses.

## 4.2.9 SYNCHRONIZE CACHE (35)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘35’ | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | Immed | 0 |
| 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 | Block Count (MSB) | | | | | | | |
| 8 | Block Count (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command matches the logical block data in the data buffer with the same logical block data recorded on the disk media. If the data in the logical block in the data buffer is newer than the data on the disk media, those data are written to the disk media.

When the write cache is used, unwritten data held in the data buffer which are written to the disk media are written using this command.

The values specified in the "Logical block address" field and "Block count" field in the CDB are disregarded and if any unwritten data exist in the data buffer, writing of all those data to the disk media is performed.

If bit 1 of CDB byte 1, the "Immed (immediate) bit, is "1," a GOOD status is reported immediately at the point when the legality of the CDB is confirmed and the command is terminated. If this bit is "0," a GOOD status is reported at the point when writing of the unwritten data in the data buffer is completed and the command is terminated.

## 4.3 Format Commands

### 4.3.1 FORMAT UNIT (04)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘04’ | | | | | | | |
| 1 | 0 | 0 | 0 | FmtData | CmpLst | Defect List Format | | |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | Interleave factor (MSB) | | | | | | | |
| 4 | Interleave factor (LSB) | | | | | | | |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command initializes (formats) the entire area of the disk media that can be accessed from the INIT (User Space). At the same time, the IDD also implements defect management processing, allocating alternate blocks for defective portions of the disk media in accordance with the specifications in this command.

Furthermore, when the disk media is initialized with any of the following format attributes changed, the INIT must issue the MODE SELECT or MODE SELECT EXTENDED command before issuing this command and specify those format attributes in advance.

- Logical data block length
- Logical data block count
- User space cylinder count
- Spare sector count for alternate blocks

### (1) Defect list

In order to register or specify the positions of defects on the disk media in connection with defect management processing that can be specified from the INIT, the following types of “Defect List” are defined.

a. P List: primary defect list

Defect position information (permanent defects) is registered in this list at the time the disk drive is shipped from the factory. The P List registers areas on the disk media which clearly cannot be accessed from the INIT. The INIT can refer to the contents of this list by the READ DEFECT DATA command only, but cannot change or erase it.

b. D List: data defect list

The defect information in this list is defect position information transferred from the INIT when this command is executed. The IDD registers this defect information on the disk media as the G List.

c. C List: target certification list

This defect list contains position information on defective data blocks detected in the data block verify operation (Certification) after initialization when the FORMAT UNIT command is executed. The IDD generates this list internally when the FORMAT UNIT command is executed and adds it to the G List.

d. G List: grown defect list

The defect information in this list contains defect position information specified by the NIT and position information on defective data blocks detected by the IDD itself. The P List is not included in this defect list. The IDD stores the G List in an area on the disk media which clearly cannot be accessed from the INIT. The INIT can refer to the contents of this list by the READ DEFECT DATA command. the following defect position information is included in the G List.

- Defect information transferred from the INIT as the D List.
- Defect information detected in the Verify operation when this command was executed (C List)
- Defect information specified from the INIT by the REASSIGN BLOCKS command.
- Defect information on data blocks where alternate block allocation was performed among defective data blocks detected by the IDD when automatic allocation processing of alternate blocks is permitted.

### (2) Specifying the initialization method

The INIT can specify the method of defect processing executed by this command in the “FmtData (format data)” bit and “CmpLst (complete list)” bit of CDB byte 1 and the “Defect List Format” field.

When “1” is specified in the “FmtData (format data) bit, it indicates that the format parameters (header and defect list), described later, are transferred from the INIT when this command is executed. When this bit’s specification is “0,” it indicates that the format parameters are not transferred.

When the “CmpLst (complete list)” bit is “1”, it indicates that the previously existing G List is replaced with the defect list (D List) transferred from the INIT when this command is executed. When this bit is “0,” the contents of the D List are added to those of the previously existing G List.

The “Defect List Format” field specifies the format of the defect list (D List) transferred from the INIT when the “FmtData (format data)” bit is “1.” Any one of the following formats can be specified for the defect list.

**Table 4.97 Defect list format**

| Defect List Format | | | D List Format |
|---|---|---|---|
| 0 | 0 | 0 | Block Address Format |
| 1 | 0 | 0 | Byte Distance from the Index Format |
| 1 | 0 | 1 | Physical Sector Address Format |

If (0,0,0) is specified in the Defect List Format field and a value other than 0 is specified in “Defect List Length” in the Format parameters, this command is terminated with a CHECK CONDITION status (ILLEGAL REQUEST / Invalid field in parameter list).

The “Interleave factor” field in the CDB specifies the method of positioning logical data blocks in physical sectors on the disk media. Whichever value is specified in this field, the IDD does not apply sector interleave, but physically positions logical data blocks continuously in continuous sectors.

(3) Format parameters

Table 4.98 lists the data format of the Format parameter transferred from the INIT when “1” is specified in the “FmtData (format data)” bit of the CDB.

**Table 4.98 FORMAT UNIT command parameter list configuration**

Header

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘00’ | | | | | | | |
| 1 | FOV | DPRV | DCRT | STPF | 0 | 0 | Immed | 0 |
| | 0 | 0 | 0 | 0 | | | | |
| | 1 | 0/1 | 0/1 | × | | | | |
| 2 | Defect List Length (MSB) | | | | | | | |
| 3 | Defect List Length (LSB) | | | | | | | |

Defect List (D List)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Defect Descriptor 0 | | | | | | | |
| 1 | | | | | | | | |
| ~ | | | | | | | | |
| x | | | | | | | | |
| ~ | | | | | | | | |
| xx | Defect Descriptor n | | | | | | | |
| xx+1 | | | | | | | | |
| ~ | | | | | | | | |
| xx+x | | | | | | | | |

a. Header

The top of the format parameter transferred from the INIT is a 4-byte header. The INIT can specify the method used for defect processing that is executed by this command by control flags within the header.

– FOV (format option valid)

0: Indicates that the INIT does not specially specify concerning the functions specified by the control flags in bits 6 to 4 of byte 1 (see following “DPRY” to “STPF”.). The IDD executes format processing in accordance with the default values of the various control flags. If the INIT specifies “0” in this bit, “0” must be specified in all the control flags in bits 6 to 4 of byte 1.

1: Indicates that the INIT is clearly specifying the functions specified by the control flags in bits 6 to 4 of byte 1 (see following “DPRY” to “STPF”.). The IDD executes format processing according to the values specified in the various control flags.

– DPRY (disable primary): Default value: “0”

0: Specifies execution of format processing using the P List. Alternate blocks are allocated as substitutes for sectors in which defects registered in the P List exist, and logical data blocks are not positioned there.

1: Specifies use of the P List in defect processing. Even if this value is specified, the P List itself is saved without being erased.

## IMPORTANT

When the disk media is being initialized for normal operation, the P List must by all means be used. Therefore, “0” should be specified in this bit.

– DCRT (disable certification): Default value: “0”

0: Specifies that data block verification be performed after initialization of the disk media. The IDD confirms that all logical data blocks can be read from normally after initialization is completed. Any defective data blocks detected in this verify operation are registered as a C List and alternate blocks are allocated for those data blocks.

1: Indicates that data block verify operations are prohibited after initialization of the disk media.

- STPF (stop format): Default value: “1”

  When the defect list (P List or G List) necessary for executing the defect processing specified in this command, cannot be read from the disk media, this bit indicates whether to continue (“0” is specified) or terminate (“1” is specified) command processing, but in the IDD, this bit’s specification is disabled, and the specified value is disregarded. When the necessary defect list cannot be read, this command is terminated with a CHECK CONDITION status. The sense data at this time indicate “MEDIUM ERROR [=3] / Primary defect list not found [=1C-01]” or “MEDIUM ERROR [=3] / Defect list error in primary list [=19-02],” if the P List cannot be read and “MEDIUM ERROR [=3] / Grown defect list not found [=1C-02]” or “MEDIUM ERROR [=3] / Defect list error in grown list [=19-03],” if the G List cannot be read.

- Immed (Immediate)

  “1”: If “1” is specified in the Immed (immediate) bit, at the point when the CDB’s legality is confirmed, or at the point when transfer of the defect list is completed, a “GOOD” status is reported.

  “0”: If “0” is specified in the Immed (immediate) bit, the specified operation is executed and the status byte is reported at the point when that operation is completed, then the command is terminated.

- Defect list length

  This field specifies the total number of bytes in the “Defect list” transferred from the INIT following the header. The byte length of the “Defect descriptor” which configures the defect list differs depending on its format and the value specified by this field must be a multiple of 8 when the defect descriptor is in the byte distance from the index format or the physical sector address format. When zero is specified in this field, it indicates that the defect list is not transferred.

### IMPORTANT

The disk media defect processing method implemented during FORMAT UNIT command execution is specified by the CDB and by header of the format parameters transferred from the INIT. By specifying zero in the “Defect list length” field in the Format parameter header, the INIT can specify the control flags related to formatting processing without transferring the defect list (D List).

b. Defect list (D List)

The defect list (D List) contains defect position information about the disk media specified by the INIT and is configured from one or more “Defect descriptors.” “Defect descriptors must be described in the format specified in the “Defect List Format” field of the CDB.

The configurations which it is possible to specify for the “Defect descriptors” in the defect list (D List), and their description formats, are shown below. Furthermore, it is possible only to specify User Space and CE Space address information on the disk media in the Defect list (D List).

– Byte distance from the index format defect descriptor

Table 4.99 lists this description format of the defect descriptor. Defect descriptor in this format specifies the cylinder number, head (track) number and byte distance to the top byte of those data (8 bytes), of the data which includes defective bits, on the disk media. One defect is treated as a defect with a length of 8 bytes (64 bits length). Therefore, for defects with a length which exceeds 8 bytes, 2 or more defect descriptors must be specified. When multiple defect descriptors are specified, the cylinder number must be specified in the top position, the byte distance from the index in the bottom position, and the defect positions listed in ascending order.

**Table 4.99 Defect descriptor: byte distance from index format**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Cylinder No. (MSB) | | | | | | | |
| 1 | Cylinder No. | | | | | | | |
| 2 | Cylinder No. (LSB) | | | | | | | |
| 3 | Head No. | | | | | | | |
| 4 | Byte distance from index to defect position (MSB) | | | | | | | |
| 5 | Byte distance from index to defect position | | | | | | | |
| 6 | Byte distance from index to defect position | | | | | | | |
| 7 | Byte distance from index to defect position (LSB) | | | | | | | |

– Physical sector address format defect descriptor

Table 4.100 lists this description format of the defect descriptor. A defect descriptor with this format specifies the physical sector number of the data block which includes the defect on the disk media together with the cylinder No. and the head (track) No. When specifying multiple defect descriptors, the cylinder No. must be specified in the top position and the physical sector No. in the bottom position, with the defect positions listed in ascending order.

## IMPORTANT

Sector numbers described in this format are physical sector numbers which to not apply the “Track skew factor” and the “Cylinder skew factor.”

**Table 4.100 Defect descriptor: physical sector address format**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Cylinder No. (MSB) | | | | | | | |
| 1 | Cylinder No. | | | | | | | |
| 2 | Cylinder No. (LSB) | | | | | | | |
| 3 | Head No. | | | | | | | |
| 4 | Physical sector No. of defective block (MSB) | | | | | | | |
| 5 | Physical sector No. of defective block | | | | | | | |
| 6 | Physical sector No. of defective block | | | | | | | |
| 7 | Physical sector No. of defective block (LSB) | | | | | | | |

– Cautions in specifying the D list

The P List, containing defect position information, is always recorded on the IDD when it is shipped from the factory. Also, information on defect positions for which alternate block processing has been implemented during operation are recorded as the G List. The function which specifies defect position information as the D List when the FORMAT UNIT command is executed, is prepared mainly to specify initial defect position information of the disk media which does not have the P List recorded on it. In the IDD, by specifying use of the P List and G List, advance notice of the defect positions can be specified during initialization, so ordinarily, it is not necessary to use the D List. When the D List is used for the IDD, caution should be exercised in the follow points.

1. The maximum number of defective sectors (total amount of 'sector slip' and 'alternate sectors') are calculated per :
   a) Current condition of reallocated sectors:
   (how many Slip Sectors have been allocated ? and so Alternate Sectors ? Since Defect table entry for Slip and Alternate are different size.)
   b) The maximum size of Defect Management Table (Fixed value)
   c) Current allocation condition of 'sector slip'
   (i.e. Up to 16 consecutive Slip Sector can be controlled by 1 Slip Defect entry. So the necessary table size are varied not only the number of Defects but also the number of consecutive Slips.)

   Consequently, the concrete Defect numbers cannot be described though the IDD guarantees 12,000 Slip Sectors and 3,000 Alternate Sectors at minimum. If defect processing which exceeds this limit is specified in the FORMAT UNIT command, that command is terminated with a CHECK CONDITION status (HARDWARE ERROR [=4] / No defect spare location available [=32-00]).

2. A defect descriptor specified as the D List are received normally if the specified defect position information is within a range which does not exceed the disk drive’s physical boundaries (User Space), and is recorded as the G List, but formatting processing is executed only for the User Space in the range specified in the “Block descriptor” and “Format parameters” (Page 3), and the “Drive parameters” (Page 4) of the MODE SELECT parameter.

3. If a defect descriptor in the “Byte distance from the Index format” is specified in the D List, depending on the byte position of the specified defective byte, 2 sectors may be processed as defective sectors with one defect descriptor, or 1 sector may be processed as a defective sector with 2 or more defect descriptors. Also, if the specified defective byte position has no influence on data block read/write operations, that defect position information is disregarded and is not the object of defective sector processing, and thus is not recorded in the G List. Therefore, the defect position information specified in this command may not necessarily coincide with the defect position information read with the READ DEFECT DATA command after this command is terminated.

### (4) Defect processing during initialization

Table 4.101 shows each combination of control flag specification values and the contents of processing executed by the IDD. Furthermore, see Chapter 3 “Data Format” of the “Product Manual” concerning alternate block allocation processing methods.

**Table 4.101 FORMAT UNIT command defect processing (1/2)**

| CDB Byte 1 | | | Header | | | Defect Processing Method |
|---|---|---|---|---|---|---|
| FmtData | CmpLst | Defect List Format | FOV | DPRY | Defect List Length | |
| 0 | –<br>(Note 4) | – – – | (Format parameters not transferred) | | | 1) Alternate block allocation is performed for defects registered in the P List.<br>2) The previously existing G List is erased. |
| 1 | 0<br>(Note 1, Note 2, Note 3) | d d d | 0<br>1 | 0<br>0 | Zero | 1) Alternate block allocation is performed for defects registered in the P List and the previously existing G List.<br>2) The previously existing G List is saved. |
| 1 | 0<br>(Note 1, Note 2, Note 3) | d d d | 1 | 1 | Zero | 1) Alternate block allocation is performed for defects registered in the previously existing G List.<br>2) The P List is saved, but it is not used in defect processing.<br>3) The previously existing G List is saved. |
| 1 | 1<br>(Note 1, Note 2) | d d d | 0<br>1 | 0<br>0 | Zero | 1) Alternate block allocation is performed for defects registered in the P List.<br>2) The previously existing G List is erased and it is not used in defect processing. |
| 1 | 1<br>(Note 1, Note 2) | d d d | 1 | 1 | Zero | 1) Neither the P List or the G List is used in defect processing (alternate block allocation processing is not performed.)<br>2) The P List is saved, but the previously existing G List is erased. |
| 1 | 0<br>(Note 3) | 1 0 0<br>1 0 1 | 0<br>1 | 0<br>0 | >0 | 1) Alternate block allocation is performed for defects registered in the P List, in the previously existing G List and the defects described in the D List transferred from the INIT.<br>2) The D List is added to the previously existing G List. |

### Table 4.101 FORMAT UNIT command defect processing (2/2)

| CDB Byte 1 | | | Header | | | Defect Processing Method |
|---|---|---|---|---|---|---|
| FmtData | CmpLst | Defect list format | FOV | DPRY | Defect List Length | |
| 1 | 0<br>(Note 1, Note 3) | 1 0 0<br>1 0 1 | 1 | 1 | >0 | 1) Alternate block allocation is performed for defects registered in the previously existing G List and the defects described in the D List transferred from the INIT.<br>2) The P List is saved, but it is not used in defect processing.<br>3) The D List is added to the previously existing G List |
| 1 | 1 | 1 0 0<br>1 0 1 | 0<br>1 | 0<br>0 | >0 | 1) Alternate block allocation is performed for defects described in the D List transferred from the INIT.<br>2) The previously existing G List is erased and it is not used in defect processing.<br>3) The D List is registered as the new G list. |
| 1 | 1 | 1 0 0<br>1 0 1 | 1 | 1 | >0 | 1) Alternate block allocation is performed for defects registered in the P List and the defects described in the D List transferred from the INIT.<br>2) The P List is saved, but it is not used in defect processing.<br>3) The previously existing G List is erased and it is not used in defect processing.<br>4) The D List is added to the previously existing G List. |

Note 1) ddd: 0,0,0= D List in the block address format.
1,0,0= D List in the byte distance from the index format.
1,0,1= D List in the physical sector address format.

Note 2) The D List is not transferred from the INIT.

Note 3) If the data block length is changed and the disk media is initialized, the INIT cannot specify a combination defect processing method.

Note 4) When this combination of defect processing methods is specified, the IDD performs verification of the data blocks after initialization and creates the C List. In other combination defect processing methods, the INIT can clearly specify whether the verification operation is prohibited or permitted by the DCRT flag of the Format parameter.

### 4.3.2 REASSIGN BLOCKS (07)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘07’ | | | | | | | |
| 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 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command allocates alternate data blocks for defective data blocks specified in the “Defect Data” list transferred form the INIT.

The INIT specifies the logical block address of one or more defective data blocks in the “Defect Data” list which it transfers to the IDD. The IDD searches for unused spare sectors for use as alternate blocks and allocates these alternate blocks for the specified logical data blocks. Also, in the case of data blocks for which alternate data blocks have already been specified, the IDD allocates other usable spare sectors as alternate blocks for those data blocks.

Using this command, copying of the contents of the data in the logical data blocks specified in the “Defect data” list to the allocated alternate data blocks is attempted. If the data in logical data blocks which are specified in the “Defect data” list are correctable by ECC correction, the corrected data are copied and those data which are not correctable by ECC are copied as is in the uncorrected state (including the errors) and in the case of other media errors, X ‘00’ is copied in all bytes. Furthermore, the contents of data in data blocks other than the logical data blocks specified in the “Defect Data” list are not influenced by the alternate allocation processing through this command.

**IMPORTANT**

Copying of the contents of data in the logical data blocks specified in the “Defect data” list to alternate blocks allocated by this command is attempted, but in some cases, copying cannot be done. Confirmation of the contents of the data in allocated alternate blocks, saving of data before issuing this command and restoring of data after this command is executed are the responsibility of the INIT.

The format of the “Defect Data” list transferred from the INIT by this command is shown in Table 4.102.

**Table 4.102 REASSIGN BLOCK command: defect data list configuration**

| | Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Header | 0 | X‘00’ | | | | | | | |
| | 1 | X‘00’ | | | | | | | |
| | 2 | Defect List Length (m) (MSB) | | | | | | | |
| | 3 | Defect List Length (m) (LSB) | | | | | | | |
| Defect Descriptor List | 4 | Defective Block Logical Block Address (MSB) | | | | | | | |
| | 5 | Defective Block Logical Block Address | | | | | | | |
| | 6 | Defective Block Logical Block Address | | | | | | | |
| | 7 | Defective Block Logical Block Address (LSB) | | | | | | | |
| | 8 | Defective Block Logical Block Address | | | | | | | |
| | ~ | | | | | | | | ~ |
| | n+3 | | | | | | | | |

The “Defect data” list is configured from a 4-byte header and one or more defect descriptors which follow it. One defect descriptor has a length of 4 bytes.

The “Defect list length” field in the header indicates the total number of bytes (m) of the defect descriptor list transferred after the header, and must be a multiple of 4. Also, when zero is specified in this field, this command is terminated without transfer of the defect descriptor list and allocation processing of alternate blocks.

## IMPORTANT

The Defect list length that can be specified for the IDD is 2,044 (X ‘7FC’) bytes or less. Therefore, a maximum of 511 defective blocks can be specified in the REASSIGN BLOCKS command.

The logical block address of defective data blocks is described in 4-byte format in the defect descriptor. When multiple defect descriptors are specified, it is best for the INIT to describe defect descriptors in the ascending order of the logical data block addresses.

Furthermore, if the addresses of logical data blocks specified in the defect descriptor list overlap each other, This command is terminated with a CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in parameter list [=26-00] and none of the alternate block allocation processing in that command is executed.

The IDD allocates alternate blocks to the specified data blocks in order from the top of the defect descriptor list. When all the usable spare sectors have been used up, and it is impossible to allocate alternate blocks, execution of this command is terminated at that point and a CHECK CONDITION status is reported. The sense data at this time indicate the following contents.

| | |
|---|---|
| • Sense key: | 4 = HARDWARE ERROR |
| • Additional sense code/: Additional sense code qualifier | 32-00 = No defect spare location available |
| • "VALID" bit: | "1" |
| • Information field | Logical block address specified in the defect descriptor at the point when alternate block allocation becomes impossible. |
| • Command inherent information field | |

Also, when this command is terminated abnormally with a CHECK CONDITION status due to any one of several other types of error besides the above error, the logical block address specified in the first defect descriptor which did not undergo alternate block allocation is reported in the "Command inherent information" field in the sense data. However, if alternate block allocation processing of the defect descriptors for which alternate block allocation has not been implemented cannot be specified, or if alternate block allocation of all the specified defect descriptors has been completed, the "Command inherent information" field indicates X 'FFFFFFFF.'

When alternate block allocation processing is successful, the defect position information on the disk media related to the data blocks specified in the defect descriptor list is recorded on the disk media as the defect list (G List). The INIT can read the contents of the G List using the READ DEFECT DATA command. Also, this command has no influence on the contents of the primary defect list (P List).

## IMPORTANT

> The defect position information in the G List is physical block addresses (logical data block addresses are allocated when no defect exists on the disk media). Therefore, the values specified in this command's defect descriptor list (logical block addresses) may not necessarily be the same as the contents of the G List read by the READ DEFECT DATA command after this command is terminated. For details, see the description of the READ DEFECT DATA command (Section 4.3.3).

## IMPORTANT

If this command is terminated with a CHECK CONDITION status, the additional sense code/additional sense code qualifier in the sense data is other than “No defect spare location available [=32-00], and a valid logical block address (other than X ‘FFFFFFFF’) is displayed in the “Command inherent information” field, it is necessary for the INIT to reissue this command by the following procedure after executing recovery processing (shown in Section 5.2) in accordance with the contents of the sense data.

1. Delete the defect descriptors which precede the defect descriptor that specifies the logical block address displayed in the “Command inherent information” field of the sense data from the defect descriptor list specified in this command, and leave that defect descriptor in the list.

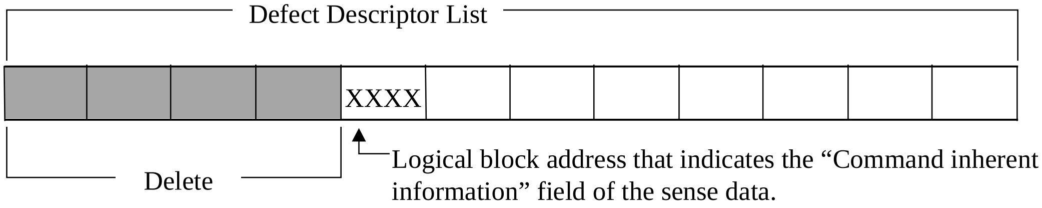

Defect Descriptor List
XXXX
Delete
Logical block address that indicates the “Command inherent information” field of the sense data.

**Figure 4.2 Correction of the defect descriptor**

2. Change the “Defect List Length” in the header and add the new ”Defect descriptor list” corrected in 1), then reissue the REASSIGN BLOCKS command.

### 4.3.3 READ DEFECT DATA (37)

| Bit / Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘37’ | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | PList | GList | Defect List Format | | |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | Transfer Byte Length (MSB) | | | | | | | |
| 8 | Transfer Byte Length (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command transfers the list described in the defect position information of the disk media (defect data) to the INIT.

There are two types of defect data, the P List (primary defect list) and the G list (grown defect list). The P List indicates the defect position information at the time the disk drive was shipped from the factory. On the other hand, the G List shows the defect position information specified from the INIT by the REASSIGN BLOCKS command or automatic alternate block allocation processing, or when executing the FORMAT UNIT command, or defective data block positional information from alternate block allocation from Verify operation after initialization.

The INIT can specify the defect data type transferred to the INIT by the “P List (primary list)” bit and “G List (grown list)” bit in the CDB and can specify the defect data format by the “Defect List Format” field.

**Table 4.103 Defect data type**

| PList | GList | Defect Data Type |
|---|---|---|
| 1 | 1 | P List and G List |
| 1 | 0 | P List only |
| 0 | 1 | G List only |
| 0 | 0 | 4-byte header information only (described in this section) |

**Table 4.104 Defect data format**

| Defect List Format | | | Defect Data Format |
|---|---|---|---|
| 0 | 0 | 0 | Block Address Format |
| 1 | 0 | 0 | Byte Distance from the Index Format |
| 1 | 0 | 1 | Physical Sector Address Format |

The "Transfer byte length" field in the CDB specifies the defect data length (number of bytes) that can be received by the INIT. The IDD terminates data transfer when transfer of the length of defect data specified in the "Transfer byte length" field is completed or when transfer of all the defect data of the specified type is completed. Also, when zero is specified in the "Transfer byte length" field, this command is terminated without execution of data transfer.

Table 4.105 lists the format of defect data transferred to the INIT by this command.

**Table 4.105 READ DEFECT DATA command: defect data configuration**

| | Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Header | 0 | X'00' | | | | | | | |
| | 1 | 0 | 0 | 0 | PList | GList | Defect List Format | | |
| | 2 | Defect List Length (MSB) | | | | | | | |
| | 3 | Defect List Length (LSB) | | | | | | | |
| Defect Descriptor List | 4 | Defect Data | | | | | | | |
| | ~ | | | | | | | | |
| | n | | | | | | | | |

(1) Header

a. P List (primary list) bit

When this bit is "1," it indicates that P List defect data are included in the defect descriptor list that is actually transferred to the INIT. When it is "0," it indicates that the P List defect data are not included. See 3) of item (2).)

b. G List (grown list) bit

When this bit is "1," it indicates that G List defect data are included in the defect descriptor list that is actually transferred to the INIT. When it is "0," it indicates that the G List defect data are not included. See 3) of item (2).)

c. Defect list format

This field indicates the description format of the defect descriptor list that is actually transferred to the INIT. It is possible for the IDD to transfer defect data in 3 different formats which it can specify in the CDB, and the values in this field are the same as the values specified in the "Defect List Format" field in the CDB.

d. Defect list length

This field follows the 4-byte header and indicates the total number of bytes of defect descriptor list that can be transferred. It has either 4 or 8 bytes, depending on the format of the defect descriptor. Also, the values shown in this field are the total number of bytes described in the "Defect List Format" which specifies the specified type (P List or G List) of defect data, regardless of the value specified in the "Transfer byte length" field in the CDB. The INIT should check whether the value shown in this field plus 4 is a smaller value than that specified in the "Transfer byte count" field in the CDB in order to confirm that all the defect data requested in this command have been transferred. Also, since the value shown in this field is divided by the number of bytes (4 or 8) per defect descriptor (quotient), the INIT can know the number of defects on the disk media.

### (2) Defect descriptor list

The data transferred after the 4-byte header is the "Defect descriptor" list (Defect data) in which the defect position information are described with the type and format specified in the CDB. One "Defect descriptor" has a length of 4 bytes when in the "Block address format," and a length of 8 bytes when in the "Byte distance from the index format" and "Physical sector address format." The "Defect descriptors" do not necessarily transfer defect position information in ascending order.

See the description of the FORMAT UNIT command (Section 4.3.1) concerning the configuration and contents of the "Defect descriptor" in each format.

1. When "1" is specified in both the "P List" bit and the "G List" bit in the CDB, and transfer of both the P List and G List is requested, the IDD first of all transfers the P List, then transfers the G List afterward (merging of the defect information in the two lists is not performed).
2. When "0" is specified in both the "PList" bit and the "GList" bit in the CDB, only the header is transferred by that command, but the following information is shown in the header at this time.

   – PList bit: "0"

   – GList bit: "0"

   – Defect List Length field: The total number of bytes described in the "Defect List Format" specifying defect data included in the P List and G List.

3. Even if defect data of the type specified in the CDB do not exist in the defect list (P List or G List) (if the defect list is empty), "1" is displayed in the "PList" bit and the "GList" bit in the header transferred to the INIT corresponding to the specification in the CDB.

4. By the INIT issuing this command specifying "4" in the "Transfer Byte Length" field in the CDB, and by investigating the information in the header transferred by the IDD, it can know the length (number) of data included in the P List and G List.

5. Depending on the combination of defect data type specifications and format specifications, the following conditions exist concerning the transferred defect data, so caution is necessary.

**Table 4.106 Defect data conditions**

| Defect List Format | PList | GList |
|---|---|---|
| Block Address Format | 2) | 2) |
| Byte Distance from the Index Format | 1) | 1), 3) |
| Physical Sector Address Format | 1) | 1) |

1) Regardless of the size of the User Space, all the defect position information for the disk media other than the system space is reported. Defect position information is also reported for areas which cannot be clearly accessed from the INIT, such as the spare sectors for alternate blocks.

2) Logical data blocks which have undergone slip processing due to defective sectors, and logical data blocks which have undergone alternate processing, are reported. Defect position information is not reported for areas which cannot be clearly accessed from the INIT (areas which do not have logical block addresses) such as cylinders and sectors, etc. which are not used as User Space or CE Space.

3) The byte position which indicates the first byte in defective sector data is reported.

6. The number of defects reported by this command differs depending on the defect data format.

   - When data are in the “Block Address Format,” defect position information is not reported for portions which cannot be clearly accessed from the INIT.

   - When data are in the “Block Address Format” or the “Physical Sector Address Format,” even if defects exist in multiple locations within that sector, that defect information is reported by one defect descriptor.

   - When data are in the “Byte Distance from the Index Format,” all the registered defect positions are reported when the P List is reported, but in the case of the “Block Address Format” and the “Physical Sector Address Format,” the defect position information is not reported for defects which do not have an influence on data block read/write operations.

   - When data are in the “Byte Distance from the Index Format,” when the P List is reported, multiple defect position information may be reported for a single sector, or 2 defective sectors may be reported as a single item of defect position information due to defects which extend across sector boundaries.

7. In defect data in the block address format, all the physical defect position information on the disk media cannot be described universally. For example, defect position information in areas without block addresses (spare sectors, or cylinders which are not being used as User Space or CE Space) cannot be described. The defect data in this format are provided in order to preserve continuity with previous specifications, but it is recommended that as much as possible, the INIT not use the “Block Address Format.”

## 4.3.4 READ DEFECT DATA (B7)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 00 | X ‘B7’ | | | | | | | |
| 01 | 0 | 0 | 0 | PList | GList | Defect List Format | | |
| 02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 05 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 06 | Transfer Byte Length (MSB) | | | | | | | |
| 07 | Transfer Byte Length | | | | | | | |
| 08 | Transfer Byte Length | | | | | | | |
| 09 | Transfer Byte Length (LSB) | | | | | | | |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command transfers the list containing the defect position information of disk media (defect data) to the INIT.

The command is the same as the READ DEFECT DATA command (37) described in Section 4.3.3 except for the following: the transfer byte length can be specified in four bytes and the defect list length can be specified in four bytes in this command.

Table 4.107 lists the format of defect data that is transferred to the INIT by this command.

**Table 4.107 READ DEFECT DATA command (B7): defect data configuration**

| | Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Header | 0 | X‘00’ | | | | | | | |
| | 1 | 0 | 0 | 0 | PList | GList | Defect List Format | | |
| | 2 | Reserved | | | | | | | |
| | 3 | Reserved | | | | | | | |
| | 4 | Defect List Length (MSB) | | | | | | | |
| | ~ | : | | | | | | | |
| | 7 | Defect List Length (LSB) | | | | | | | |
| Defect Descriptor List | 8 | Defect Data | | | | | | | |
| | ~ | | | | | | | | |
| | n | | | | | | | | |

## 4.4 Maintenance, Diagnostic Commands

### 4.4.1 SEND DIAGNOSTIC (1D)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘1D’ | | | | | | | |
| 1 | SELF-TEST CODE | | | PF | 0 | SelfTest | DevOfl | UnitOfl |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | Parameter List Length (MSB) | | | | | | | |
| 4 | Parameter List Length (LSB) | | | | | | | |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command executes self-diagnosis tests which the IDD is equipped to perform and operation specified in the parameter list transferred from the INIT.

### (1) Self-diagnosis test

When the “SelfTest (self test)” bit is “1,” and “Self-Test Code” field is “000” in the CDB, this command specifies execution of the self-diagnosis test which the IDD is equipped to perform. At this time, the “PF (page format)” bit and the “Parameter list length” field in the CDB have no meaning and the values specified there are disregarded. Also, the “DevOfl (device off-line)” bit specifies whether or not operations which have an influence on the status of logical units other than the logical unit specified in this command during the self-diagnosis test, but in the IDD, there is only 1 logical unit that exists. Therefore, the specification in this bit has no meaning and the specified value is disregarded.

The INIT can specify the type of self-diagnosis test to be executed through the “UnitOfl (unit off-line)” bit. When “1” is specified in the “SelfTest (self test)” bit, the IDD executes a series of self-diagnosis tests in accordance with the combination with the “UnitOfl (unit off-line)” bit, as shown in Table 4.108.

**Table 4.108 Self-diagnosis test**

| Type of Self-diagnosis Test | UnotOfl = “0” | UnitOfl = “1” |
|---|---|---|
| 1) Controller Function Test | × | × |
| 2) Disk Drive Seek Test | | × |
| 3) Disk Media (CE Space) Write/Read/Data Comparison Test | | × |

×: Execution Object

When the IDD completes all the specified self-diagnosis tests normally, it reports a GOOD status. On the other hand, when an error is detected in any of the specified self-diagnosis tests, a CHECK CONDITION status is reported and information related to the detected error is shown in the sense data. For example, when an error is detected in the controller function test, the type of error is shown by HARDWARE ERROR [=4] in the sense key, and the additional sense code/additional sense code qualifier show “Diagnostic failure on component ‘nn’ [=40-nn].” (nn is the code in the range X ‘80’ to X ‘FF,’ which shows the type of error. This code is a Fujitsu unique definition for the purpose of analysis when there is a failure, and its meaning is not released to the public. The user should present the value displayed in this sense data as repair information to the Fujitsu representative.)

Furthermore, error recovery processing when diagnostic tests (seek tests and write/read/data comparison tests) related to the disk drive are executed are in accordance with the mode set in the MODE SELECT command’s parameters (Page code 1: Read/Write Error Recovery parameter, Page code 21: Additional Error Recovery parameter), except in the following special cases.

Special cases of MODE SELECT parameters during a self-diagnosis test are as shown below

- The AWRE, ARRE and TB flags are not applied.
- The PER and DTE flags are as shown in Table 4.109.

**Table 4.109 Error recovery control flags during the self-diagnosis test**

| PER | DTE | Diagnostic test operation |
|---|---|---|
| 0 | 0 | The diagnostic test continues when error recovery is successful. The contents of recovered errors are not reported. When an error which cannot be recovered from is detected, the diagnostic test terminates at that point with an error. |
| 0 | 1 | – – – – – (Setting prohibited) – – – – |
| 1 | 0 | The diagnostic test continues when error recovery is successful. When an error which cannot be recovered from is detected, the diagnostic test terminates at that point with an error. Even when all the detected errors have been recovered, a CHECK CONDITION status (RECOVERED ERROR [=1]) is reported after the series of diagnostic tests is completed and the sense data show the contents of the last error to be successfully recovered from. |
| 1 | 1 | When error recovery is successful, or even when error recovery is impossible, the diagnostic test is terminated with an error at the point when the permitted error recovery processing is completed and a CHECK CONDITION status is reported. The sense data show the contents of the detected error. |

## IMPORTANT

When “1” is specified in the “SelfTest (self test)” bit in this command, the command execution results are reported by the status byte and the sense data. Therefore, even if the RECEIVE DIAGNOSTIC RESULTS command is executed after this command, the self-diagnosis test execution results are not reported as response data.

Remark:

The error recovery control flag is valid only for PER. Therefore, the only error recovery flag combination that is actually executed in the above self-diagnosis tests is the (PER, DTE) = (1, 0) combination.

### (2) Parameter specification

When “0” is specified in the “SelfTest (self test) bit in the CDB, the IDD executes the operations specified in the parameter list transferred from the INIT by this command. In this case, the IDD reports a GOOD status and terminates this command at the point when preparation of the “response data” is completed after completing the specified operations. The INIT can read the execution results (response data) by the RECEIVE DIAGNOSTIC RESULTS command.

When the “PF (page format)” bit in the CDB is “1,” the parameter list transferred from the INIT by this command shows the page format, explained later, but the IDD disregards the value specified in this bit and always handles the page format according to the specifications in the parameter list when the parameter list is transferred by this command. Also, when the “SelfTest (self test)” bit is “0,” the specifications in the “DefOfl (device off-line)” bit and the “UnitOfl (unit off-line)” bit have no meaning and their specified values are disregarded.

The “Parameter list length” field in the CDB shows the length (number of bytes) of the parameter list that is transferred from the INIT when the “SelfTest (self test)” bit’s specification is “0.” When zero is specified in the “Parameter list length” field, this command is terminated without anything being executed. Also, when the value specified in the “Parameter list length” field does not reach the specified length for the parameter list, explained later, and as a result, not all the bytes in the parameter list can be received, that command is terminated with a CHECK CONDITION status (ILLEGAL REQUEST) [=5] / Invalid field in CDB [=24-00]).

Table 4.110 lists the format of the parameter list (called the parameter page) transferred from the INIT to the IDD by this command. The parameter page is configured from the 4-byte “Page Header” and the “Page Parameters” which follow it. Furthermore, the INIT can specify only a single parameter page by this command. Even when multiple parameter pages have been specified by the INIT, the IDD executes only the operation specified by the top parameter page.

**IMPORTANT**

1. When “0” is specified in the “SelfTest (self test)” bit in this command, the INIT can specify only a single parameter page.
2. In order to avoid loss of security to the execution results (response data) of this command due to another command issued by another INIT, when “0” is specified in the “SelfTest (self test)” bit, the INIT should reserve the IDD before issuing this command, and should release the reserve status after executing the RECEIVE DIAGNOSTIC RESULTS command.

**Table 4.110 SEND DIAGNOSTIC command: parameter list configuration**

| | Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Header | 0 | Page Code | | | | | | | |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | Page Parameter Length (MSB) | | | | | | | |
| | 3 | Page Parameter Length (LSB) | | | | | | | |
| Page Parameter | 4 | Parameter | | | | | | | |
| | ~ | | | | | | | | |
| | n | | | | | | | | |

- Page code

  This field specifies the code which identifies the type of parameter page being transferred from the INIT and the operation that should be executed. The parameter pages which can be specified by the INIT and their functions are as shown Table 4.111.

**Table 4.111 Page code**

| Page Code (Hex) | Function |
|---|---|
| 00 | Reports a list of the supported page codes. |
| 40 | Logical/Physical Address Conversion |

- Page parameter length

  This field specifies the byte length of the page parameter after byte 4. The INIT must specify the same value as the length specified for each of the parameter pages, which will be explained later.

- Page parameter

  This field specifies each of the inherent parameters in each page code. Depending on the page code, this field may not be necessary (page parameter length = 0).

a. Page code list

This parameter page specifies transfer of the “Page code” list of the parameter page supported by the IDD in the SEND DIAGNOSTIC command and the RECEIVE DIAGNOSTIC RESULTS command to the INIT. Table 4.112 shows the format of this parameter page. The page code list supported by the IDD is transferred to the INIT by the RECEIVE DIAGNOSTIC RESULTS command which is issued following the SEND DIAGNOSTIC command that specifies this parameter page (shown in Section 4.4.2 (1) )

**Table 4.112 SEND DIAGNOSTIC parameters: page code list**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X ‘00’ (Page Code) | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | X ‘00’ (Page parameter length) | | | | | | | |
| 3 | X ‘00’ (Page parameter length) | | | | | | | |

b. Logical/physical address conversion

This parameter page specifies conversion of the address information expressed in either the “Logical Block Address,” “Physical Sector Address” or “Byte Distance from the Index” format to another expression format. Table 4.113 shows this parameter page format. The INIT can specify the address information that should be converted in this parameter page of the SEND DIAGNOSTIC command, and can read the conversion results by the RECEIVE DIAGNOSTIC RESULTS command (see Section 4.4.2 (2)).

**Table 4.113 SEND DIAGNOSTIC parameters: logical/physical address conversion**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X ‘40’ (Page Code) | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | X ‘00’ (Page Parameter Length) | | | | | | | |
| 3 | X ‘0A’ (Page Parameter Length) | | | | | | | |
| 4 | 0 | 0 | 0 | 0 | 0 | Address Format Before Conversion | | |
| 5 | 0 | 0 | 0 | 0 | 0 | Address Format After Conversion | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| | Logical or Physical Address | | | | | | | |
| 13 | | | | | | | | |

The “Address Format Before Conversion” field shows the format of the address information specified in bytes 6 to 13. The IDD converts that address information to the expression format specified in the “Address Format After Conversion” field. the following codes can be specified as Table 4.114.

**Table 4.114 Specifying address format**

| Code | Address Format |
|---|---|
| 0 0 0 | Logical Block Address Format |
| 1 0 0 | Byte Distance from the Index Format |
| 1 0 1 | Physical Sector Address Format |

The description format of the address information specified in bytes 6 to 13 is the same as the description specification of the D List transferred from the INIT by the FORMAT UNIT command. For details, see the description of the FORMAT UNIT command (Section 4.3.1). furthermore, when the logical block address format is specified, it must be described in bytes 6 to 9 and zero must be specified in the remaining byte positions.

When a logical data block address which does not exist (outside the range of the MODE SELECT parameter) is specified in the logical block address format, or when an area which cannot be allocated as User Space on the disk drive (cylinders which physically do not exist) is specified in the “Byte Distance from the Index” format or the “Physical Sector Address” format, that command is terminated with a CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in parameter list [=26-00]) and address conversion is not executed.

Details of the address conversion algorithm executed when this parameter page is specified and the data format, etc. of the conversion results reported to the INIT are explained in RECEIVE DIAGNOSTIC RESULTS command (Section 4.4.2).

### (3) Logical unit Self-Test

When "0" is specified in the "SelfTest" bit and the values other than zero is specified in the "SELF-TEST Code" field in CDB, the IDD executes the Self-Test specified in CDB. In this case, the INIT can read the executed results (page code= x10 : Self-Test Result Log Page) by the LOG SENSE command.

The specified values in "PF" bit, "DevOffL" bit and "UnitOffL" bit in CDB are ignored.

The "Parameter List length" field shall contain zero. If the value other than zero is specified in this field, this command is terminated with a CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in CDB [=24-00]).

The "SELF-TEST Code" field specifies the type of executing Self-Test by this command, as Table 4.115.

**Table 4.115 SELF-TEST**

| Page code (Hex) | Function |
|---|---|
| 0,0,0 | Refer to clause (2), Parameter Specification. |
| 0,0,1 | The device server shall start its short self-test routine in the background mode. |
| 0,1,0 | The device server shall start its extended self-test routine in the background mode. |
| 0,1,1 | Reserved |
| 1,0,0 | Abort the current self-test running in background mode. This value is only valid if a previous this command specified a Background self-test function and that function has not completed. If either of these conditions is not true, then the device server shall it respond by returning a CHECK CONDTION status. |
| 1,0,1 | The device server shall start its short self-test routine in the foreground mode. |
| 1,1,0 | The device server shall start its extended self-test routine in the foreground mode. |
| 1,1,1 | Reserved |

The Self-Test executes the following test segments in ascending order by number:

1. Buffer RAM test
2. Flash ROM test
3. Pre-SMART test
4. Low Level Format test
5. Random seek test
6. Sequential seek test
7. Data compare test
8. Random read test
9. Sequential read test
10. SMART test

### 4.4.2 RECEIVE DIAGNOSTIC RESULTS (1C)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘1C’ | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PCV |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | Transfer Byte Length (MSB) | | | | | | | |
| 4 | Transfer Byte Length (LSB) | | | | | | | |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command transfers data (response data) which show the results of executing the SEND DIAGNOSTIC command from the IDD to the INIT. The format and content of response data are determined by the parameter list (page code) specified by the INIT in the SEND DIAGNOSTIC command.

The “Transfer byte length” field in the CDB shows the maximum number of bytes of response data that can be received by the INIT by this command. The IDD transfers the number of bytes of data specified by this field or all the bytes of the effective response data, whichever is smaller in length. Also, when zero is specified in this field, this command is terminated without anything being transferred.

## IMPORTANT

Exercise caution in the following points when using this command.

1. In order to avoid damage to the results of SEND DIAGNOSTIC command execution (response data) from a command issued by another INIT during the interval until this command is issued, either this command should be executed after the IDD is reserved.
2. Response data are valid only when "0" is specified in the "SelfTest (self test)" bit and after a SEND DIAGNOSTIC command which specifies a specific operation in the parameter list is executed, with the IDD transferring response data showing the execution results of the latest SEND DIAGNOSTIC command. Also, even if this command is executed, the response data in not cleared, and remains valid until the next SEND DIAGNOSTIC command is executed.
3. If this command is issued when valid response data do not exist, the IDD transfers a maximum of 4 bytes of X '00' data to the INIT.

Table 4.116 lists the format of response data transferred to the INIT from the IDD by this command. The response data are configured from a 4-byte "Page header" and the "Page parameters" which follow it.

**Table 4.116 RECEIVE DIAGNOSTIC RESULTS command: response data configuration**

| | Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Header | 0 | Page Code | | | | | | | |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | Page Parameter Length (MSB) | | | | | | | |
| | 3 | Page Parameter Length (LSB) | | | | | | | |
| Page Parameters | 4 | Parameter | | | | | | | |
| | 5 | | | | | | | | |
| | ~ | | | | | | | | |
| | n | | | | | | | | |

- Page code

  This field is the same value as the page code specified in the parameter list transferred form the INIT by the SEND DIAGNOSTIC command executed last, and shows a code which identifies the type of response data reported in this command.

- Page parameter length

  This field shows the byte length of the page parameter after byte 4.

- Page parameter

  Data which show the execution results of the operation specified by the SEND DIAGNOSTIC command are reported in this field.

### (1) Page code list

This response data reports the “Page code” list of the parameter page supported by the IDD in the SEND DIAGNOSTIC command and the RECEIVE DIAGNOSTIC RESULTS command after byte 4. The format and contents of this response data are shown in Table 4.117.

**Table 4.117 RECEIVE DIAGNOSTIC RESULTS response data: page code list**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X ‘00’ (Page Code) | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | X ‘00’ (Page parameter length) | | | | | | | |
| 3 | X ‘02’ (Page parameter length) | | | | | | | |
| 4 | X ‘00’ [Page Code List] | | | | | | | |
| 5 | X ‘40’ [Logical/Physical Address Conversion] | | | | | | | |

### (2) Logical/physical address conversion

This response data reports the execution results of address conversion specified in the “Logical/Physical Address Conversion” parameter in the SEND DIAGNOSTIC command in bytes after byte 4. The format and contents of this response data are shown in Table 4.118.

**Table 4.118 RECEIVE DIAGNOSTIC RESULTS response data: logical/physical address conversion**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X ‘40’ (Page Code) | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | X ‘00’ (Page Parameter Length) | | | | | | | |
| 3 | X ‘0A’ (Page Parameter Length) | | | | | | | |
| 4 | 0 | 0 | 0 | 0 | 0 | Address Format Before Conversion | | |
| 5 | 0 | 0 | 0 | 0 | 0 | Address Format After Conversion | | |
| 6 | | | | | | | | |
| 7 | Logical or Physical Address | | | | | | | |
| ~ | | | | | | | | |
| 13 | | | | | | | | |

## IMPORTANT

The value of the “Page Parameter Length” field in this response data is a variable length within the range of [2 + 8n] in the FC specifications. For example, If multiple logical data blocks are located in 1 physical sector, or if 1 logical data block is located in multiple physical sectors, n address information items are reported as the address conversion results.

In the current IDD specifications, multiple address information items are not reported in this response data, but the “Page parameter length” always shows X ‘000A.’ However, considering expanded specifications in the future, the INIT should make it possible to correspond to variable lengths for the “Page parameter length.”

The “Address Format Before Conversion” field in byte 4 and the “Address Format After Conversion” field in byte 5 are the same values as the codes which show the expression format for address information specified by the SEND DIAGNOSTIC command parameters. The “Address Format After Conversion” field shows the expression format of the address information reported in bytes 6 to 13 of this response data. “Address format” codes are as shown in Table 4.119.

**Table 4.119 Address format**

| Code | Address Format |
|---|---|
| 0 0 0 | Logical Block Address Format |
| 1 0 0 | Byte Distance from the Index Format |
| 1 0 1 | Physical Sector Address Format |

The description of address information shown in bytes 6 to 13 is the same as the description specifications in the D List transferred from the INIT by the FORMAT UNIT command. For details, see the description of the FORMAT UNIT command (Section 4.3.1). Furthermore, When the logical block format is used, the address is shown in bytes 6 to 9 and zero is reported in the remaining byte positions. However, when the address information specified in the “SEND DIAGNOSTIC command points to a position on the disk media which is not used as physical data blocks, X ‘FFFFFFFF 00000000’ is reported as the logical block address after conversion.

### 4.4.3 WRITE BUFFER (3B)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘3B’ | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | Mode | | | |
| 2 | X ’00’ (Buffer ID) | | | | | | | |
| 3 | Buffer Address (MSB) | | | | | | | |
| 4 | Buffer Address | | | | | | | |
| 5 | Buffer Address (LSB) | | | | | | | |
| 6 | Transfer Byte Length (MSB) | | | | | | | |
| 7 | Transfer Byte Length | | | | | | | |
| 8 | Transfer Byte Length (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command is used in combination with the READ BUFFER command to diagnose the normality of the IDD’s data buffer memory or the SAS interface, or to download microcode to the IDD.

The IDD stores data transferred from the INIT in accordance with the specifications in this command's CDB to in the data buffer in the IDD. This command, using buffer addresses with a range of X'000000' to X'693660', must specify data storage positions in 1-byte units, and with 4-byte units addresses. The INIT can know the IDD's buffer configuration and the units which addresses can be specified in by issuing the READ BUFFER command.

The functions of this command and the format of data transferred from the INIT are specified in the “Mode” field in byte 1 of the CDB and any of the transfer modes shown in Table 4.120 can be selected.

**Table 4.120 WRITE BUFFER transfer mode**

| "Mode Bit" | 3 | 2 | 1 | 0 | Transfer Mode |
|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | Header + Data, without Address Specification |
| | 0 | 0 | 0 | 1 | Header + Data, with Address Specification |
| | 0 | 0 | 1 | 0 | Data Only, with Address Specification |
| | 0 | 1 | 0 | 0 | Microcode Download, without Saving |
| | 0 | 1 | 0 | 1 | Microcode Download, with Saving |
| | 0 | 1 | 1 | 0 | Microcode Download with offset, without Saving |
| | 0 | 1 | 1 | 1 | Microcode Download with offset, and Saving |
| | 1 | 0 | 1 | 0 | Echo buffer |

### (1) Mode = 0, 0, 0, 0: Header + data, without address specification

In this mode, a 4-byte header (with all zero's specified for the contents) must be added to the top of the data transferred from the INIT. Also, zero must be specified in the "Buffer address" field of the CDB.

The "Transfer byte length" field specifies the total number of bytes of data transferred form the INIT. The transfer byte count specification includes the 4 bytes of the header. The IDD stores the data transferred from the INIT with the header omitted ("Transfer byte length" – 4 bytes) in the data buffer beginning in order from the top of the data buffer (Address: X '000000').

Furthermore, a value which is less than the [IDD's buffer size + 4 bytes] must be specified in the "Transfer byte length" field in the CDB. When a value that is larger than this is specified, no data transfer with the INIT is executed. Also, when zero is specified in the "Transfer byte length" field, this command is terminated without data being transferred.

Table 4.121 lists the format of data transferred from the INIT when this mode is specified.

**Table 4.121 WRITE BUFFER command: buffer data (mode = 000, 001)**

|  | Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Header | 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 |
| Data | 4 | Buffer Data (Byte 0) |  |  |  |  |  |  |  |
|  | 5 | Buffer Data (Byte 1) |  |  |  |  |  |  |  |
|  | n | Buffer Data (Byte n–4) |  |  |  |  |  |  |  |

(2) Mode = 0, 0, 0, 1: Header + data, with address specification

The format of data transferred from the INIT in this mode must be the same as in the case of Mode = 0, 0, 0, 0, and the 4-byte header (with zero specified in all its contents) must be added to them.

In this mode, the top address of the data buffer where the data transferred from the INIT are stored can be specified in the “Buffer address” field in the CDB.

The “Transfer byte length” field in the CDB specifies the total number of bytes of data transferred by the INIT. The transfer byte count specification includes the 4 bytes of the header. The IDD stores data transferred from the INIT, in a length in which the number of bytes in the header has been deleted from the data (“Transfer byte length” – 4 bytes) in the data buffer beginning at the byte position specified in the “Buffer address” field in the CDB.

Furthermore, a value less than the [“IDD’s buffer size” – value specified in the “Buffer address” field – 4 bytes] must be specified in the “Transfer byte length” field in the CDB. When a value larger than that is specified, data transfer is not executed with the INIT. Also, when zero is specified in the “Transfer byte length” field, this command is terminated without data transfer being executed.

### (3) Mode = 0, 0, 1, 0: Data only, with address specification

In this mode, data transfer from the INIT includes buffer data only without the 4-byte header being added.

The top address of the data buffer where the data transferred from the INIT are to be stored can be specified in the “Buffer address” field.

The “Transfer byte length” field in the CDB specifies the total number of bytes of data transferred by the INIT. The IDD stores data transferred from the INIT in the data buffer beginning at the byte position specified in the “Buffer address” field in the CDB.

Furthermore, a value less than the [“IDD’s buffer size” – value specified in the “Buffer address” field] must be specified in the “Transfer byte length” field in the CDB. When a value larger than that is specified, data transfer is not executed with the INIT. Also, when zero is specified in the “Transfer byte length” field, this command is terminated without data transfer being executed.

### (4) Mode = 0, 1, 0, 0: Microcode download, without saving

In this mode, the controller’s microcode or control information is transferred to the IDD’s control memory area. “0” must be specified in the “Buffer ID” field and the “Buffer address” field.

The "Transfer byte length" field specifies the total number of transfer bytes of data transferred from the INIT.

When downloading of microcode is completed, the IDD generates a UNIT ATTENTION condition for all the INITs. At this time, the IDD performs microprogram reboot and generates sense data.

The IDD operates according to this microcode until its power is switched off. If the power is switched on again, the IDD’s operation returns to the existing microcode saved previously on the disk.

### (5) Mode = 0, 1, 0, 1 : Microcode download, with saving

In this mode, the controller’s microcode or control information is transferred to the IDD’s control memory area and written to the disk. “0” must be specified in the “Buffer ID” field and the “Buffer address” field.

The "Transfer byte length" field specifies the total number of transfer bytes of data transferred from the INIT.

When all the data have been received, the IDD writes the new microcode to the disk’s system area and operates in accordance with the old microcode until new microcode is downloaded.

## IMPORTANT

When abnormal termination for reasons other than ILLEGAL REQUEST [=5] / Invalid field in CDB [=24-00] or ILLEGAL REQUEST [=5] / Invalid field in parameter list [=26-00] occurs, the IDD indicates that downloading of the new microcode failed, and it is therefore necessary for the INIT to quickly download the new microcode.

When downloading of microcode is completed, the IDD generates a UNIT ATTENTION condition for all the INITs except the INIT that issued the WRITE BUFFER command. At this time, the additional sense code/additional sense code qualifier indicates “Microcode has been changed [=3F-01].”

When the IDD is checked and downloading of the microcode is judged to be possible, the IDD may be in the Not Ready state (the state in which the spindle motor is not rotating). In this event, the IDD starts the motor, then saves the microcode to flash ROM and the system area to disk media. Then, the IDD stops the motor and returns to the Not Ready state.

## IMPORTANT

During downloading of microcode, the supply of power to the drive must not be cut off (such as an instantaneous power failure). If a power failure occurs, for instance, while downloading the microcode to the FLASH-ROM, the IDD may be severely damaged. The worst-case scenario in this event would be an inoperable drive.

### (6) Mode = 0, 1, 1, 0 : Microcode Download with offsets, without saving

In this mode the INIT may split the transfer of the controller's microcode or control information over two or more WRITE BUFFER commands.

If the last WRITE BUFFER command of a set of one or more commands completes successfully, the microcode or control information shall be transferred to the control memory space of the IDD.

Since the download microcode or control information may be sent using several commands, when the IDD detects the last download microcode with offsets, the IDD shall perform the 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 IDD generates a unit attention condition for all INITs except the one that issued the set of WRITE BUFFER commands. When reporting the unit attention condition, the IDD sets the additional sense code to MICROCODE HAS BEEN CHANGED.

"0" must be specified in the "Buffer ID" field.

The microcode or control information is written to the logical unit buffer starting at the location specified by the BUFFER Address field. If the IDD is unable to accept the specified buffer address, it shall return CHECK CONDITION status and it shall set the sense key to ILLEGAL REQUEST [=5] with an additional sense code of INVALID FIELD IN CDB [=24-00].

The "Transfer Byte Length" field specifies the maximum number of bytes that shall be present in the Data-Out Buffer to be stored in the specified buffer beginning at the buffer offset. The INIT should attempt to ensure that the parameter list length plus the buffer offset does not exceed the capacity of the specified buffer. (The capacity of the buffer may be determined by the BUFFER CAPACITY field in the READ BUFFER descriptor.) If the BUFFER Address and Transfer Byte Length fields specify a transfer in excess of the buffer capacity, the IDD shall return CHECK CONDITION status and shall set the sense key to ILLEGAL REQUEST [=5] with an additional sense code of INVALID FIELD IN CDB [=24-00].

(7) Mode = 0, 1, 1, 1 : Microcode Download with offset, with saving

In this mode, the microcode of the controller, as a whole or after being divided into multiple parts, is transferred to the data buffer with one or multiple commands. When the entire microcode is transferred to the buffer by using the commands for this mode, the transferred microcode is saved in the FLASH-ROM of the media device, and the microcode restarts the device.

When the last part of the microcode data is transferred and the complete and correct microcode is received in the buffer, the IDD saves the microcode in the FLASH-ROM. If it has been saved correctly, the IDD restarts itself using this microcode. After the successful reboot of the IDD, this command is completed with the GOOD status. At this time, the IDD generates the UNIT ATTENTION condition (UNIT ATTENTION [6]/ Microcode has been changed [3F-01]) for all the INITs except the one that has issued this command.

If the IDD is in the Not Ready state (i.e., the spindle motor is not rotating) when the IDD determines that the microcode can be downloaded, this command terminates with the CHECK CONDITION status (NOT READY [02-04]/Additional Sense Code indicating the NOT READY state/Additional Sense Code Qualifier [= 04/xx]).

Other behavior is the same as when Mode = (0, 1, 1, 0).

### IMPORTANT

During downloading of microcode, the supply of power to the drive must not be cut off (such as an instantaneous power failure). If a power failure occurs, for instance, while downloading the microcode to the FLASH-ROM, the IDD may be severely damaged. The worst-case scenario in this event would be an inoperable drive.

(8) Mode = 1, 0, 1, 0 : Echo buffer

In this mode the IDD transfers data from the INIT and stores it in the echo buffer. The BUFFER ID and BUFFER OFFSET fields are ignored in this mode.

### 4.4.4 READ BUFFER (3C)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘3C’ | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | Mode | | | |
| 2 | X‘00’ (Buffer ID) | | | | | | | |
| 3 | Buffer Offset (MSB) | | | | | | | |
| 4 | Buffer Offset | | | | | | | |
| 5 | Buffer Offset (LSB) | | | | | | | |
| 6 | Transfer Byte Length (MSB) | | | | | | | |
| 7 | Transfer Byte Length | | | | | | | |
| 8 | Transfer Byte Length (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command is used in combination with the WRITE BUFFER command to diagnose the normalcy of the IDD’s data buffer memory and the FC interface.

In this command, each data byte position in the data buffer must be specified in 4-byte units using buffer addresses within the range X'000000' to X'693660'.

The functions of this command and the contents of the data transferred to the INIT are specified by the “Mode” field in the CDB and one of the transfer modes shown in Table 4.122 can be selected.

**Table 4.122 READ BUFFER transfer mode**

| “Mode” Bit | 3 | 2 | 1 | 0 | Transfer Mode |
|---|---|---|---|---|---|
| | 0 | 0 | 0 | 0 | Header + Data, without Address Specification |
| | 0 | 0 | 0 | 1 | Header + Data, with Address Specification |
| | 0 | 0 | 1 | 0 | Data Only, with Address Specification |
| | 0 | 0 | 1 | 1 | Buffer Descriptor |
| | 1 | 0 | 1 | 0 | Echo buffer |
| | 1 | 0 | 1 | 1 | Echo buffer descriptor |

### (1) Mode = 0, 0, 0, 0: Header + data, without address specification

When this mode is specified, the data stored in the IDD's data buffer are transferred to the INIT after the 4-byte header. Zero must be specified in the "Buffer offset" field in the CDB.

The "Transfer byte count" field in the CDB specifies the total number of bytes of the header and buffer data which can be received by the INIT. The IDD reads the data from the data buffer from the top (Address X '000000'), then adds the 4-byte header to it and transfers it to the INIT. Data transfer is completed at the point when the number of bytes of the header and data from the IDD's data buffer, specified in the "Transfer byte length" field, has been transferred, or at the point when transfer of the header and all the data in the IDD's data buffer, to the final byte position, has been completed. When zero is specified in the "Transfer byte length" field, this command is terminated without executing a data transfer.

The format of the data transferred to the INIT when this mode is specified is shown in Table 4.123

**Table 4.123 READ BUFFER command: buffer data (mode = 0000, 0001)**

| | Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Header | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | Effective Buffer Data Length (MSB) | | | | | | | |
| | 2 | Effective Buffer Data Length | | | | | | | |
| | 3 | Effective Buffer Data Length (LSB) | | | | | | | |
| Data | 4 | Buffer Data (Byte 0) | | | | | | | |
| | 5 | Buffer Data (Byte 1) | | | | | | | |
| | ~ | ~ | | | | | | | |
| | n | Buffer Data (Byte n–4) | | | | | | | |

The "Effective buffer data length" field in the header indicates the size of the data buffer (byte length). This value indicates the size of the IDD's data buffer that can be used by the WRITE BUFFER and READ BUFFER commands without relation to the length specified in the "Transfer byte length" field in the CDB or the length of the data actually stored in the data buffer by the WRITE BUFFER command. When this mode is specified, the "Effective buffer data length" shows the size (cache segment volume) of the IDD's entire data buffer area. Also, the length of the buffer data transferred to the INIT by this command is the value for the number of bytes in the ["Transfer byte length" field in the CDB – 4 bytes] or the value indicated in the "Effective buffer data length" field in the header, whichever is smaller.

### (2) Mode = 0, 0, 0, 1: Header + data, with address specification

The format of the data transferred to the INIT when this mode is specified is the same as the format of the data in the case of Mode = 0, 0, 0, 0, with the data stored in the IDD’s data buffer transferred to the INIT following the 4-byte header. In this mode, the address in the data buffer can be specified in the “Buffer offset” field in the CDB.

The “Transfer byte length” field in the CDB specifies the total number of bytes of header and buffer data that can be received by the INIT. The IDD reads the data from the data buffer beginning from the byte position in the data buffer specified in the “Buffer offset” field of the CDB and continuing in order, then adds the 4-byte header to it and transfers it to the INIT. Data transfer is completed at the point when the number of bytes of the header and data from the IDD’s data buffer, specified in the “Transfer byte length” field, has been transferred, or at the point when transfer of the header and all the data in the IDD’s data buffer, to the final byte position, has been completed. When zero is specified in the “Transfer byte length” field, this command is terminated without executing a data transfer.

The format and contents of the 4-byte header transferred in this mode are the same as in the case of Mode = 0, 0, 0, 0. However, the “Effective buffer data length” field in the header indicates the size (byte length) of the data from the byte position in the data buffer specified in the “Buffer offset” field in the CDB to the final byte position in the data buffer, including that byte. Also, the length of the buffer data transferred to the INIT by this command is the value for the number of bytes in the [“Transfer byte length” field in the CDB – 4 bytes] or the value indicated in the “Effective buffer data length” in the header, whichever is smaller.

### (3) Mode = 0, 0, 1, 0: Data only, with address specification

The data transferred to the INIT when this mode is specified is only the data which the IDD reads from the data buffer. The header is not transferred as it is in Mode = 0,0,0,0 and Mode = 0,0,0,1. In this mode, address in the data buffer can be specified in the “Buffer offset” field in the CDB.

The “Transfer byte length” field in the CDB specifies the total number of bytes of buffer data that can be received by the INIT. The IDD reads the data in order beginning from the byte position in the data buffer specified in the “Buffer address” field and transfers it to the INIT. Data transfer is completed at the point when the number of bytes of buffer data specified in the “Transfer byte length” field has been completed or transfer of the buffer data to the final byte position of the IDD’s data buffer is completed. When zero is specified in the “Transfer byte length” field, this command is terminated without executing a data transfer.

### (4) Mode = 0, 0, 1, 1: Buffer descriptor

When this mode is specified, the IDD transfers only the 4-byte buffer descriptor to the INIT. the IDD's data buffer attributes are indicated in the 4-byte buffer descriptor. Zero must be specified in the "Buffer offset" field in the CDB when this mode is specified. The IDD transfers the data length specified in the "Transfer byte length" field in the CDB or 4 bytes, whichever portion of data is smaller, to the INIT. When zero is specified in the "Transfer byte length" field, this command is terminated without executing a data transfer.

**Table 4.124 READ BUFFER command: buffer descriptor**

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X'02' Addressing Boundary | | | | | | | |
| 1 | X'69' Buffer Capacity (MSB) | | | | | | | |
| 2 | X'36' Buffer Capacity | | | | | | | |
| 3 | X'60' Buffer Capacity (LSB) | | | | | | | |

The "Addressing boundary" field in the buffer descriptor indicates the addressing boundary in the data buffer which can be specified in the WRITE BUFFER Command and the READ BUFFER Command as a "Power" when expressed as a "Power of 2." The IDDs report X'02' (=$2^2$), indicating that it is possible to specify the address in 4-byte units. Also, the "Buffer capacity" field indicates the byte length of the size of the data buffer which can be operated by the WRITE BUFFER and READ BUFFER commands.

## IMPORTANT

Exercise caution regarding the following points when using this command.

If the WRITE BUFFER command or READ BUFFER command is used under a multi-initiator or multitask environment, it is necessary to be careful of the contents of the data buffer being changed by another initiator or a command that issues another task during the interval between completion of WRITE BUFFER command execution and execution of the READ BUFFER command.

### (5) Mode = 1, 0, 1, 0 : Echo buffer

In this mode the IDD transfers data to the INIT from the echo buffer. The echo buffer shall transfer the same data as when the WRITE BUFFER command with the mode field set to echo buffer was issued. The BUFFER ID and BUFFER OFFSET fields are ignored in this mode.

(6) Mode = 1, 0, 1, 1 : Echo buffer descriptor

In this mode, a maximum of four bytes of READ BUFFER descriptor information is returned. The device server shall return the descriptor information for the echo buffer. The "Buffer Offset" field is reserved in this mode. The allocation length should be set to four or greater. The device server shall transfer the lesser of the allocation length or four bytes of READ BUFFER descriptor. The READ BUFFER descriptor is defined as shown in Table 4.125.

**Table 4.125 READ BUFFER command: echo buffer descriptor**

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | Reserved | | | | | | | EBOS |
| 1 | Reserved | | | | | | | |
| 2 | Reserved | | | | Echo Buffer Capacity (MSB) | | | |
| 3 | Echo Buffer Capacity (LSB) | | | | | | | |

The IDD return one in EBOS field, and the IDD verifies that echo buffer data from each initiator is the same as that previously written by the same initiator.

The "Buffer Capacity" field returns the size of the echo buffer X'01FC' in bytes aligned to a four-byte boundary.

### 4.4.5 READ LONG (3E)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X'3E' | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | CORRCT | 0 |
| 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 Byte Length (MSB) | | | | | | | |
| 8 | Transfer Byte Length (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command reads the logical data block data and its ECC byte, specified in the "Logical block address" field in the CDB, from the disk media and transfers it to the INIT. Normally, this command is used in combination with the WRITE LONG command to perform checks of the ECC function. The operation object in this command is 1 data block only.

Remark The Pad Byte and Sync Byte patterns are not included in the transfer data.

When "0" is specified in bit 1 of CDB byte 1, the "CORRCT (Corrected)" bit, the IDD does not implement ECC correction processing of data read from the disk media. When "1" is specified in the "CORRCT (Corrected)" bit, data errors that can be corrected by ECC are transferred to the INIT after being corrected in the IDD's data buffer.

When the "Transfer byte length" specifies zero, this command executes a seek operation of the cylinder/track existing in the logical data block which is specified in the "Logical block address" field in the CDB., then is terminated without data being transferred to the INIT.

When a length (other than zero) which does not match the data format on the disk media is specified in the "Transfer byte length" field in the CDB, this command is terminated with a CHECK CONDITION status without executing a data transfer to the INIT. At this time, the sense data indicate the following contents and the INIT can determine the correct "Transfer byte length" from their contents.

| | |
|---|---|
| • Sense Key | : 05 = ILLEGAL REQUEST |
| • Additional sense code/<br>Additional sense code qualifier | : 24-00 = Invalid field in CDB |
| • "VALID" Bit | : "1" |
| • "ILI" bit | : "1" |

- Information Field: ("Transfer byte length in the CDB) –
  (Original "Transfer byte length")

Remark: The calculation formula for the information field expresses 1 logical data block as n physical sectors, and when negative, as a complement of 2.

Error recovery processing during execution of this command is in accordance with the specifications in (Page code 1: Read/Write Error Recovery Parameter, Page code 21: Additional error recovery parameters).

- The ARRE flag and the DTE flag are not applied.
- The TB flag is treated as if "1" was specified.

## 4.4.6 WRITE LONG (3F)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘3F’ | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 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 Byte Length (MSB) | | | | | | | |
| 8 | Transfer Byte Length (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command writes the data block data transferred from the INIT, together with the ECC to form bytes, in the logical data blocks on the disk media specified in the “Logical block address” field in the CDB. Normally, this command is used for checking the ECC function in combination with the READ LONG command.

The object of this command’s operation is only 1 data block. Also, the data transferred from the INIT by this command must have the same order and the same length as the data transferred to the INIT from the IDD by the READ LONG command.

The “Transfer byte length” field in the CDB indicates the number of bytes of data transferred from the INIT by this command. When the “Transfer byte length” specification is zero, this command is terminated normally without performing anything.

If a value specifying a length (other than zero) that does not match the data format on the disk media is specified in the “Transfer byte length” field in the CDB, that command is terminated with a CHECK CONDITION status without data being transferred to the INIT. The sense data at this time indicate the following contents and the INIT can determine the correct “Transfer byte length” from their contents.

- Sense Key : 05 = ILLEGAL REQUEST
- Additional sense code/ Additional sense code qualifier : 24-00 = Invalid field in CDB
- “VALID” Bit : “1”
- “ILI” bit : “1”
- Information Field: (“Transfer byte length in the CDB) – (Original “Transfer byte length”)

Remark: The calculation formula for the information field expresses 1 logical data block as n physical sectors and n sub-sectors, and when negative, as a complement of 2.

Error recovery processing during execution of this command is performed in accordance with the specifications in the MODE SELECT parameters (Page code 1: Read/Write Error Recovery Parameter, Page Code 21: Additional Error Recovery Parameter, but the AWRE flag and DTE flag are not applied.

### 4.4.7 WRITE SAME (41)

| Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0 | X‘41’ | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | Pbdata | Lbdata | 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 | Number of Blocks (MSB) | | | | | | | |
| 8 | Number of Blocks (LSB) | | | | | | | |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

This command requests that the device server write the single block of data transferred by the application client to the medium multiple times to consecutive multiple logical blocks.

A "Logical Block data (Lbdata)" bit of zero and a "Physical Block data (Pbdata)" bit of zero indicates that the single block of data transferred by the application client shall be used without modification. A "Lbdata" bit of one requests that the IDD replace the first four bytes of the data to be written to the current logical block with the logical block address of the block currently being written.

A "Pbdata" bit of one requests that the IDD replace the first eight bytes of the data to be written to the current physical sector with the physical address of the sector currently being written using the physical sector format.

The IDD is not supported a "Pbdata" bit. Therefore, if "Pbdata" bit is one, this command is terminated with CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in CDB [=24-00]).

A "Relative Address (RelAdr)" bit of zero indicates that the "Logical Block Address" field specifies the first logical block of the range of logical blocks for this command.

A "RelAdr" bit of one indicates that the "Logical Block Address" field is a two's complement displacement. But the IDD is not supported this bit. Therefore, if this bit is one, this command is terminated with CHECK CONDITION status (ILLEGAL REQUEST [=5] / Invalid field in CDB [=24-00]).

The "Number of Blocks" field specifies the number of contiguous logical blocks to be written. A "Number of Blocks" field of zero requests that all the remaining logical blocks on the medium be written.

# CHAPTER 5 Sense Data and Error Recovery Methods

In this chapter, the configuration and contents of sense data reported to the INIT (initiator) when an error occurs, etc., key information for interpreting error states, recommended procedures for error recovery processing that should be executed by software in the INIT and error recovery processing executed internally by the IDD are described.

## 5.1 Sense Data

When the IDD reports a CHECK CONDITION status, or in cases when some fatal error is detected in connection with the SAS interface, and as a result, the command that is currently being executed, or the commands in the stack are cleared, it generates sense data for the INIT that issued that command. Sense data are returned to the INIT at the same time as the status is sent in response to the command.

### 5.1.1 Sense data format

The IDD's sense data is in the so-called "Expanded Sense Data" format. The expanded sense data format supported by the IDD is shown in Table 5.1.

**IMPORTANT**

1) In the specifications, each device is permitted to define whatever it chooses after byte 18 of the expanded sense data, and the length and format differ for each device. The length of expanded sense data is displayed in the sense data, so by analyzing the sense data which it receives, the INIT can know its effective length.

2) In the REQUEST SENSE command, even if a Transfer byte length that is shorter than the length of the sense data supported by the device which is the object of the command, the command will terminate normally, but in that case, some of the sense data only will be received and the remaining information will be lost. Sufficient caution should be exercised with regard to the devices connected to the INIT and all the sense data of those devices should be read.

**Table 5.1 Expanded sense data format**

| | Bit<br>Byte | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Basic Information | 0 | Valid | X ‘70’ or X ‘71’ (Error Code) | | | | | | |
| | 1 | X‘00’ | | | | | | | |
| | 2 | 0 | 0 | ILI | 0 | Sense Key | | | |
| | 3 | MSB | Information | | | | | | |
| | 4 | | | | | | | | |
| | 5 | | | | | | | | |
| | 6 | | | | | | | | LSB |
| | 7 | X ‘28’ (Additional Sense Data Length) | | | | | | | |
| | 8 | MSB | Command Inherent Information | | | | | | |
| | 9 | | | | | | | | |
| | 10 | | | | | | | | |
| | 11 | | | | | | | | LSB |
| | 12 | Additional Sense Code | | | | | | | |
| | 13 | Additional Sense Code Qualifier | | | | | | | |
| | 14 | X‘00’ | | | | | | | |
| | 15 | SKSV | Sense Key Inherent Information | | | | | | |
| | 16 | | | | | | | | |
| | 17 | | | | | | | | |
| Additional Information | 18 | 0 | 0 | 0 | Port | 0 | 0 | 0 | 0 |
| | 19 | CDB Operation Code | | | | | | | |
| | 20 | | Detailed Information | | | | | | |
| | 47 | | | | | | | | |

### 5.1.2 Sense data basic information

Bytes 0 to 17 of the sense data are basic information which show the contents of the error that has occurred. The INIT can know the contents of the error and the key information that is necessary for recovery processing by analyzing this basic information. Each field and the meanings of bits in the sense data basic information are explained below.

(1) Valid

When this bit is "1," it indicates that the values shown in the information field (bytes 3 to 6) are valid. On the other hand, when this bit is "0", it indicates that the information field does not contain valid information.

(2) Error code

This field shows the format and type of sense data. The IDD always displays X '70' (current error) or X '71' (deferred error), which has the meaning "expanded sense data format" in this field.

(3) ILI (incorrect length indicator)

When this bit is "1," it indicates that the transfer byte length requested in the command did not coincide with the data block length on the disk media. In the IDD, the only commands that it reports "1" in this bit for are the READ LONG command and the WRITE LONG command. For details, refer to the descriptions of these commands (Sections 4.4.5 and 4.4.6).

(4) Sense key

This field shows the cause of the sense data being generated. More details reasons are indicated in the additional sense code field (Byte 12) and the additional sense code qualifier field (Byte 13). Table 5.3 shows a list of the meanings of sense keys.

(5) Information

This field shows information related to the error that has been detected and is valid only when the Valid bit is "1." Depending on the command where the error occurred, additional information other than the information in this field may be indicated in the command inherent information field. The information shown in this field has the following meanings depending on the value of the "ILI" bit.

a) When the "ILI" bit is "0," the logical block address of the data block where the error occurred is indicated.

b) When the "ILI" bit is "1," the difference between the transfer byte length requested by the command and the actual data block length on the disk media is indicated. If the difference is a minus value, (if the request transfer byte count is smaller), it is expressed as a complement of 2. In the IDD, only the READ LONG command and the WRITE LONG command display this information. For details, see the descriptions of these commands (Sections 4.4.5 and 4.4.6).

### (6) Additional sense data length

This field indicates the length (number of bytes) after byte 8 of the sense data. The value shown in this field shows the length of sense data provided by the IDD without relation to the value specified in the “Transfer byte length” in the CDB of the REQUEST SENSE command. The length of the IDD’s sense data is fixed at 48 bytes and this field always indicates X ‘28’ (40 bytes).

### (7) Command inherent information

This field indicates information that is inherent to the command where the error occurred. The only command for which the value in this field is valid in the IDD is the REASSIGN BLOCKS command. See the description of the REASSIGN BLOCKS command (Section 4.3.2) concerning details of the information shown in this field.

### (8) Additional Sense code, Additional Sense code Qualifier

The codes which indicate the reason for the error displayed by the sense key in detail are reported in these fields. The INIT can decide procedures for error recovery according to the sense key and these fields. The sense code and sub-sense code are defined in Table 5.4.

### (9) SKSV (sense key specific valid) , sense key inherent information

When the sense key indicates one of “RECOVERED ERROR [=1],” “MEDIUM ERROR [=3]” or “HARDWARE ERROR [=4],” and the “SKSV” bit indicates “1,” indicates the number of times the IDD has attempted to recover from the detected error as shown in Table 5.2 (a).

When the sense key indicates “NOT READY [=2]” and the “SKSV” bit indicates “1”, indicates the progressing rate of the formatting operation by the FORMAT UNIT command with [n/65536] as shown in Table 5.2 (b), or the progressing rate of the drive self-test operation by the SEND DIAGNOSTICS Command (Self-Test = 0)

**Table 5.2 Sense key inherent information**

(a)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 15 | SKSV | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | X‘00’ | | | | | | | |
| 17 | Number of retries executed | | | | | | | |

(b)

| Byte \ Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 15 | SKSV | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | Progressing rate of formatting or Progressing rate of Self-Test operation [MSB] | | | | | | | |
| 17 | [LSB] | | | | | | | |

## Table 5.3 Sense key

| Sense Key | Name | Explanation |
|---|---|---|
| 0 | NO SENSE | The specific sense key does not exist. |
| 1 | RECOVERED ERROR | 1) Indicates that the command which was executed last was terminated normally with a recovery operation by the IDD. If multiple errors which were successfully recovered from during processing of a single command occurred, the last error to have occurred is reported.<br>2) Rounding processing of the MODE SELECT parameter was performed. |
| 2 | NOT READY | The disk drive is not in a state where it can be accessed. |
| 3 | MEDIUM ERROR | An irrecoverable error was detected due to a defect in the disk media or an error in the recorded data. |
| 4 | HARDWARE ERROR | The IDD detected an error in the hardware for which recovery processing is impossible during command execution or self-diagnosis. |
| 5 | ILLEGAL REQUEST | An illegal value was detected in the parameter transferred in the CDB or the specification in the command. Also, an error in the LUN specification. If the IDD detects an illegal parameter in the CDB, it terminates the command without changing the contents of the disk media. If an illegal parameter is detected in the parameters transferred from the INIT, the contents of the disk media may be changed by that command. |
| 6 | UNIT ATTENTION | A UNIT ATTENTION condition occurred. |
| 7 | DATA PROTECT | 1) An illegal operation was attempted in an area where a read or write operation is prohibited. In this case, that command is not executed.<br>2) A SET LIMITS command was issued 2 times in a group of commands linked in a series. |
| 8 | BLANK CHECK | Not Used |
| 9 | (Reserved) | Not Used |
| A | COPY ABORTED | Not Used |
| B | ABORTED COMMAND | The IDD terminated a command abnormally during execution. Normally, the INIT can attempt to recover by reissuing that command. |
| C | EQUAL | Not Used |
| D | VOLUME OVERFLOW | Not Used |
| E | MISCOMPARE | During execution of a Byte Check with the VERIFY command, the data transferred from the INIT were compared to the data read from the disk drive, but they did not match. |
| F | (Reserved) | Not Used |

### Table 5.4 Additional Sense Code and Additional Sense Code Qualifier (1/6)

| C* | Q* | Name | Explanation | Sense key |
|---|---|---|---|---|
| 00 | 00 | No additional sense information | No specific sense code exists. | 0 |
| 01 | 00 | No index/sector signal | The target sector was not detected by the sector counter within the specified time. | 4 |
| 03 | 00 | Peripheral device write fault | A write operation to the disk media was terminated abnormally.<br>• Off track during write. | 1, 3, B |
|  | 80 | Peripheral device write fault | A write operation to the disk media was terminated abnormally.<br>• Write current abnormality | 4, B |
|  | 82 | Peripheral device write fault | A write operation to the disk media was terminated abnormally.<br>• Servo mark not found during write. | 1, 3, B |
|  | 83 | Peripheral device write fault | A write operation to the disk media was terminated abnormally.<br>• Servo cell detected was detected during write.<br>• Write gate and sector pulse were activated at the same time during write. | 4, B |
|  | 87 | Peripheral device write fault | A write operation to the disk media was terminated abnormally.<br>• No write gate detected | 1, 4, B |
| 04 | 01 | Logical unit in process of becoming ready | Disk drive is getting ready.<br>(The spindle motor is not at its regular rotation speed or has reached its regular rotation speed but is still reading the information) | 2 |
|  | 02 | Logical unit not ready | Disk drive is in start command waiting state.<br>(initializing command required) | 2 |
|  | 04 | Logical unit not ready, format in progress | The drive cannot be accessed since it is being formatted. | 2 |
|  | 09 | Logical unit not ready, Self-Test in progress | The drive cannot be accessed since it is being Self-Test. | 2 |
|  | 11 | Logical unit not ready, Notify (ENABLE SPINUP) Required | The drive is in the Notify (ENABLE SPINUP) wait state. | 2 |
| 0B | 01 | Specified temperature exceeded | Temperature exceeded established value. | 0, 1, 6 |
| 0C | 01 | Write error recovered with auto reallocation | A write error was recovered with auto reallocation. | 1 |
|  | 02 | Write error – auto reallocation failed | Write auto reallocation or the write that was applied to auto reallocation was failed. | 3 |
|  | 03 | Write Error | Unrecovered Write Offtrack Error<br>• Write retries are exhausted in case of AWRE = 0 | 3 |
|  | 80 | Write Error (Unrecovered Write Offtrack Error Write offtrack retries are exhausted. | Reported if a write offtrack occurred during the Format unit command execution. | 3 |

* C: Additional Sense Code, Q: Additional Sense Code Qualifier

### Table 5.4 Additional Sense Code and Additional Sense Code Qualifier (2/6)

| C* | Q* | Name | Explanation | Sense key |
|---|---|---|---|---|
| 0E | 02 | Information Unit Too Long | The received write data is longer than the stipulated length. | B |
| 11 | 01 | Read retries exhausted | Unrecovered error was detected during data read (retry out). | 3, B |
|  | 02 | Error too long to correct | Unrecovered error was detected during data read (BCRC error detected by SAS/IF) | 3, B |
| 13 | 00 | Sync Mark not found for Data field | SM (Sync Mark) could not be detected in the Data area. | 1, 3, B |
| 14 | 00 | Record entity not found | Expected data from a sector was undetected. (LBA compare error detected by FMT) | 1, 3, B |
|  | 01 | Record not found | The target data block (sector) could not be detected. | 1, 3, B |
| 15 | 01 | Mechanical positioning Error | A seek error occurred in the drive. | 1, 3, B |
|  | 02 | Positioning Error detected by read of medium | LBA did not match due to Cylinder number's mismatch. | 1, 3, B |
| 17 | 01 | Recovered data with retries | A data error was recovered from by reading was retried. | 1 |
|  | 02 | Recovered data with positive head offset | A data error was recovered by read retry with offsetting head to positive direction. | 1 |
|  | 03 | Recovered data with negative head offset | A data error was recovered by read retry with offsetting head to negative direction. | 1 |
|  | 06 | Recovered data without ECC: data auto-reallocated | Automatic alternate allocation was applied without ECC correcting a data error. | 1 |
|  | 08 | Recovered data without ECC: recommended rewrite | Rewriting to the same sector was performed without ECC correcting a data error. | 1 |
| 18 | 00 | Recovered Data with Error Correction Applied | A data error was recovered by read retry with ECC corrercting. | 1 |
| 19 | 02 | Defect list error in primary list | An error was detected during reading of the defect list (P List). | 3 |
|  | 03 | Defect list error in grown list | An error was detected during reading of the defect list (G List). | 3 |
|  | 80 | Log information read error | An error was detected during reading of statistical information. | 3 |
|  | 81 | Log information write error | A write error was detected during writing of statistical information. | 3 |
|  | 84 | Mode Select SA write Error | An error was detected during writing of SA information (Mode Select Paramenter) | 3 |
|  | Ax | Drive Parameter SA write Error | An error was detected during writing of SA information (Device Information) | 3 |
|  | Bx | Drive Parameter SA write Error | An error was detected during writing of SA information (Device Information) | 3 |
| 1A | 00 | Parameter list length error | There is a mistake in the indication of the parameter list page length. | 5 |

* C: Additional Sense Code, Q: Additional Sense Code Qualifier

### Table 5.4 Additional Sense Code and Additional Sense Code Qualifier (3/6)

| C* | Q* | Name | Explanation | Sense key |
|---|---|---|---|---|
| 1C | 01 | Primary defect list not found | The defect list (P List) header is incorrect. | 3 |
| | 02 | Grown defect list not found | The defect list (G List) header is incorrect. | 3 |
| | 80 | SA information list not found | The SA information (MODE SELECT parameter) header is incorrect. | 3 |
| 1D | 00 | Miscompare during verify operation | Comparison of data transferred from the INIT by a VERIFY command (when the Byte Check mode was specified) with data read from the disk media was terminated unsuccessfully. | E |
| | 80 | Miscompare during self-configuration | There is an unmatch to compare read data with write data during self-configuration. | E |
| 1F | 00 | Partial Defect List Transfer | Read Defect Data command (37h) cannot transfer all the Defect data in the target because the numbers of defect exceeded the maximum. | 1 |
| 20 | 00 | Invalid command operation code | CDB byte 0 (operation code) is illegal. | 5 |
| 21 | 00 | Logical block address out of range | A logical block address which exceeds the drive's maximum value was specified. | 5 |
| 24 | 00 | Invalid field in CDB | There is an error in a specification in the CDB. | 5 |
| 25 | 00 | Logical unit not supported | An illegal LUN was specified. | 5 |
| 26 | 00 | Invalid field in parameter list | There is an error in the parameter list specifications transferred from the INIT during command execution. | 5 |
| 27 | 00 | Write protected | A write operation was attempted in a write protected area. Or a write operation is prohibited at the external operation panel. | 7 |
| 29 | 01 | Power on occurred | Microcode was downloaded immediately after power on. | 6 |
| | 03 | TARGET RESET function occurred | A Logical Unit RESET was received. | 6 |
| | 07 | I_T Nexus Loss occurred | I_T Nexus Loss Time (Mode Page 19) was expired. | 6 |
| 2A | 01 | Mode parameter changed | The MODE SELECT parameter values were changed by another INIT. | 6 |
| | 03 | Reservations preempted | A persistent reserve state was cleared by another INIT. | 6 |
| | 04 | Reservations released | A persistent reserve state was released | 6 |
| | 05 | Registrations preempted | A persistent reserve state was preempted by another INIT. | 6 |
| 2F | 00 | Command cleared by another INIT | A command was forcibly terminated by another INIT during execution or queuing.<br>• By a CLEAR TASK SET<br>• The sense hold state was entered when the QErr bit was set on "1." | 6 |

* C: Additional Sense Code, Q: Additional Sense Code Qualifier

### Table 5.4 Additional Sense Code and Additional Sense Code Qualifier (4/6)

| C* | Q* | Name | Explanation | Sense key |
|---|---|---|---|---|
| 31 | 00 | Medium format corrupted | The media format is different from the original format. (The media was not formatted after the data format specification was changed by the MODE SELECT command.) | 3 |
| | 01 | FORMAT command failed | For some reason, formatting cannot be completed and reformatting is necessary. | 3 |
| 32 | 00 | No defect spare location available | No usable alternate block area exists. Or alternate block processing cannot be performed due to control table overflow. | 4 |
| | 01 | Defect list update failure | Updating of the defect list (G List) failed. | 4 |
| 37 | 00 | Rounded parameter | Rounding processing of the MODE SELECT parameter specified by the command was performed. | 1 |
| 3E | 03 | Logical unit failed Self-Test | The test segment error occurred during the Self-Test | 4 |
| | 04 | Logical unit unable to update | The IDD failed to update the Self-Test result log | 4 |
| 3F | 01 | Microcode has been changed | Microcode was changed by another INIT. | 6 |
| | 02 | Changed operating definition | Operating definition was changed. | 6 |
| | 05 | Device identifier changed | Device identifier was changed. | 6 |
| 40 | nn | Diagnostic failure on component "nn" | An error was detected in self-diagnosis. ("nn" is a Fujitsu unique code)<br>• 81: Buffer RAM compare error/bus error<br>• 83: HDC register check error<br>• 84: Firmware header/check sum error<br>• 86: Parameter header/check sum error<br>• 88: Drive Serial No. unmatch<br>• 89: DE type unmatch<br>• 8F: Other MPU peripheral circuit diagnostic error<br>• 92: Spindle motor firmware initialize error | 4 |

* C: Additional Sense Code, Q: Additional Sense Code Qualifier

## Table 5.4 Additional Sense Code and Additional Sense Code Qualifier (5/6)

| C* | Q* | Name | Explanation | Sense key |
|---|---|---|---|---|
| 44 | nn | Internal target failure | An error was detected in self-diagnosis. ("nn" is a Fujitsu unique code)<br>• 90: Next sector IDD compare error<br>• 91: WCS RAM parity error<br>• 92: Unexpected FMT interrupt<br>• 94: NRZ parity error during Write (MAS3*** Series only)<br>• 99: Overflow error occurred at SPC FIFO<br>• 9A: Error interrupt in the HDC<br>• A0: Error interription from DBM<br>• A3: DBM buffer CRC error<br>• A4: DBM internal parity error<br>• A8: Data late error<br>• B0: Flash ROM erase operation failed.<br>• B1: Flash ROM write operation failed.<br>• C0: RDCLK error (FMT hang up)<br>• D1: DSP downloading failed<br>• D2: DSP overrun (watch dog time out, DRV hard error)<br>• D3: Servo Gate Window error<br>• D4: Illegal error was reported from DSP | 4, B<br>4, B<br>4<br>4<br>4<br>4<br>4<br>4<br>4 |
| 47 | 03 | Information Unit iuCRC Error Detected | An iuCRC error is detected on the SAS interface for a Data frame. | B |
| 4B | 01 | Invalid Target Port Transfer Tag Received | An illegal TPTT is received. | B |
|  | 02 | Too Much Write Data | The Write Data frame is longer than the stipulated frame length. | B |
|  | 03 | ACK/NAK Timeout | A response to a XFER_RDY frame or Data frame has not been detected for more than 1 ms. | B |
|  | 04 | NAK Received | A NAK primitive is received for a XFER_RDY frame or Data frame. | B |
|  | 05 | Data Offset Error | A Relative Offset error is detected in a Write Data frame. | B |
|  | 06 | Initiator Response Timeout | A response to a Data frame has not been detected for the “Initiator Response Timeout” in Mode Page 19. | B |
| 4C | nn | Logical unit failed self-configuration | The IDD's initial setup failed. ('nn' is a Fujitsu unique code)<br>• 91: Microcode Read error (any 3/11/** error during microcode read)<br>• 93: Microcode Read error (any 3/13/** NOSB error)<br>• 94: Microcode Read error (any 3/14/** NRF error)<br>• 95: Microcode Read error (any 3/15/** error during seek)<br>• 97: Microcode Read error (any 4/44/** or other errors during microcode read)<br>• 98: Invalid microcode (Header/Check Sum)<br>• A1: SA Read error (any 3/11/** error during SA read)<br>• A3: SA Read error (any 3/13/** error during SA read)<br>• A4: SA Read error (any 3/14/** error during SA read)<br>• A5: SA Read error (any 3/15/** error during SA read)<br>• A7: SA Read error (any 4/44/** error during SA read)<br>• A8: Invalid SA (Header/Check Sum)<br>• AA: SA Read error (DSP overrun/DRV hardware error)<br>• AB: SA Read error (abnormal rotation of spindle motor)<br>• AC: SA Read error (on-track failure)<br>• E0: Initial calibration failed | 4 |

* C: Additional Sense Code, Q: Additional Sense Code Qualifier

### Table 5.4 Additional Sense Code and Additional Sense Code Qualifier (6/6)

| C* | Q* | Name | Explanation | Sense key |
|---|---|---|---|---|
| 4D | nn | Tagged Over Lapped Commands<br>(nn=TAG number) | Before execution of the original command completed, a new command with the same tag number was issued to the same logical unit. | B |
| 4E | 00 | Overlapped commands attempted | Before execution of a tagged command was completed, the same INIT issued a command to the same LUN with the same tag. | B |
| 55 | 04 | Insufficient Registration Resource | PERSISTENT RESERVATION OUT command is issued from insufficient device server resource. | 5 |
| 5D | nn | SMART predictive failure | SMART related sense data<br>• 12: The read error rate attribute has reached the failure threshold.<br>• 14: The frequency of grown defect allocation attribute has reached the failure threshold.<br>• 41: The write error rate attribute has reached the failure threshold.<br>• 43: The seek error rate attribute has reached the failure threshold.<br>• 56: The spin up time attribute has reached the failure threshold.<br>• 64: The remaining alternate sector count attribute has reached the failure threshold.<br>• FF: The drive is in test mode. | 0, 1, 6 |
| C4 | nn | Drive Failure | A serious error was detected in the drive's control system.<br>('nn' is a Fujitsu unique code)<br>• 00: Abnormal Rotation of Spindle Motor<br>• 01: Any error at Spindle Motor Start<br>• 30: On track failure | 4 |

* C: Additional Sense Code, Q: Additional Sense Code Qualifier

### 5.1.3 Sense data additional information

Bytes 18 to 47 of sense data are defined as a Fujitsu unique field, and indicate the additional information which is explained below.

(1) PORT

The Port bit indicates the connected port. Port-A: '0'; Port-B: '1'

(2) CDB operation code

This field indicates the operation code (the value in the first byte of the CDB) of the command where the error occurred. When sense data are generated without relation to the INIT issuing a command, this field shows zero.

(3) Detailed information

The information displayed in bytes 20 to 47 of sense data is information defined by Fujitsu for the specific product for the purpose of analyzing trouble, and the contents of this information are not made public. However, the user should present this information to the persons in charge at Fujitsu as troubleshooting and repair information collected in error logging (shown in Section 5.3.3) of all the bytes in sense data, including this field.

## 5.2 INIT Error Recovery Methods (Recommended)

When a single command or a series of linked commands are not terminated with a status reported, the INIT should execute error recovery processing corresponding to the state in which the command was terminated. Here, the procedure for analyzing the command execution termination state and recommended procedures for error recovery processing executed by the INIT in accordance with the results are explained.

### 5.2.1 Termination status analysis and error recovery methods

Figure 5.1 shows a model of the INIT's general processing flow from issuing of the command until reception of the termination status.

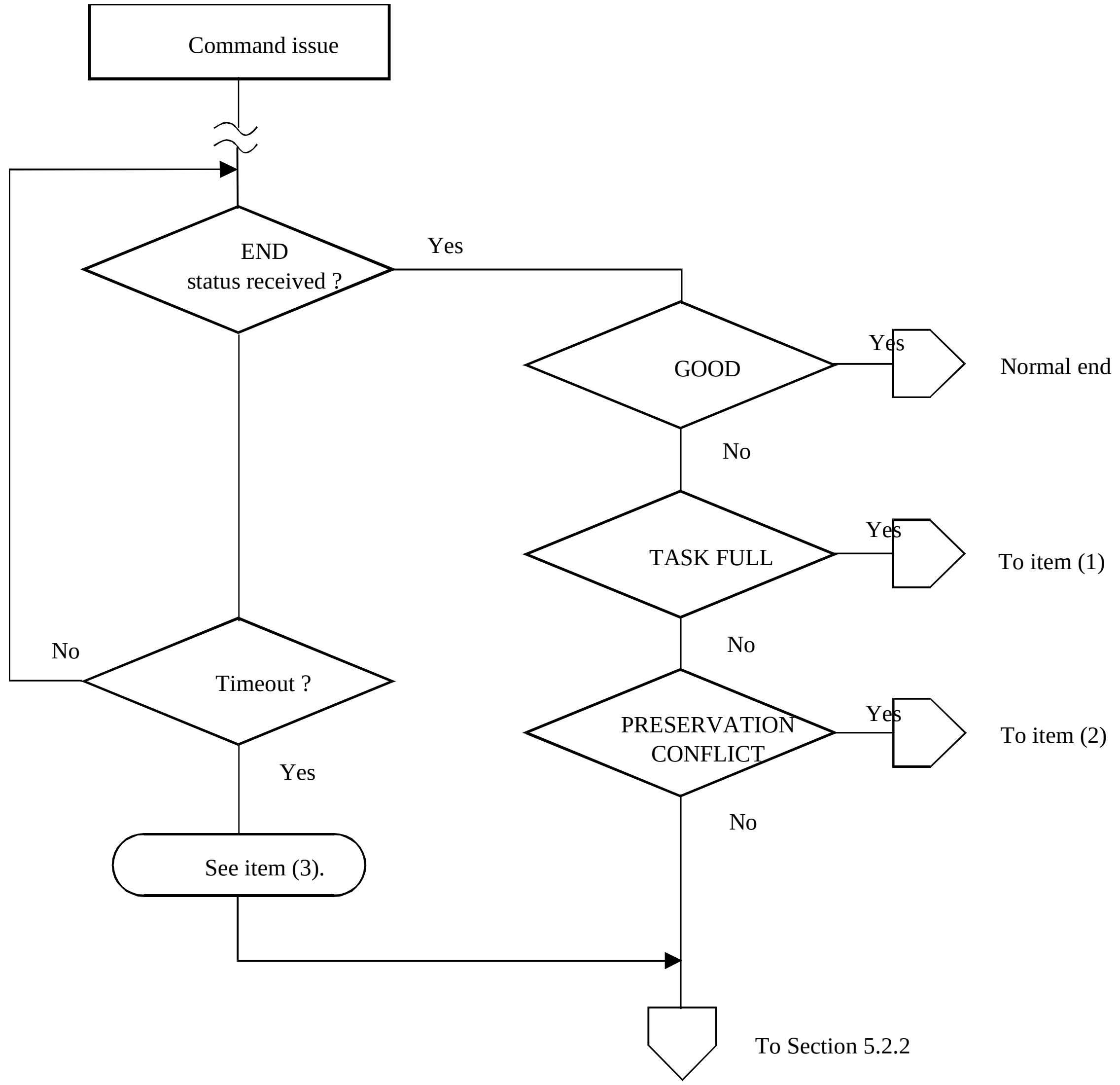


**Figure 5.1 Analysis of the termination status**

### (1) TASK SET FULL status

This status indicates that the IDD is currently executing processing of another command and that a new command cannot be received. The INIT that receives this status can reissue the original command.

Under a multi-initiator environment, when an INIT receives this status, the time until the IDD can receive the next command depends on the operating state with other INITs, so ordinarily, it cannot be predicted. In such a case, it is necessary for the INIT that issued the command for which this status was received to repeatedly issue the command until it is accepted.

### (2) RESERVATION CONFLICT status

This status shows, under a multi-initiator environment, that the IDD is currently reserved by another INIT, and cannot be used until that reserved status is released.

The period over which the reserved status continues should be managed by the system, but normally, an INIT that receives this status reissues the original command after waiting an appropriate length of time. The wait time until a command is reissued is generally an inherent value of the system and it is necessary that consideration be given to the operating states of the other INITs in the system when deciding it.

Of the INIT which reserved the IDD falls into a state which it cannot recover from for any reason before the reserved state is released, it will be impossible for other INITs to access the IDD because that reserved state will continue. In such a case, it is necessary for the INIT to take one of the following measures to forcibly release the reserved state and recover the access right.

- HARD RESET sequence

### (3) Command completion wait time-out

This error is a state where the completed status for a command is not reported within the time expected by the INIT that issued the command.

One cause of this error occurring, besides a malfunction of the IDD, is that the command was cleared by some method which the INIT that issued the command cannot clearly detect, such as a HARD RESET sequence, or the command was cleared when an unrecoverable error was detected in arbitration processing executed by the IDD, etc. When this error occurs, then judge which recovery method to use based on the contents of the sense data (see Section 5.2.2).

Not only does command execution time differ widely depending on the type and specified contents of the command, but since it has an influence on the following factors, it is necessary to give adequate consideration to these points when setting the monitoring time value at the INIT.

- Since the command stack feature exists (see Section 1.4), even if the IDD accepts a command normally, if a command issued by another INIT is being executed, or if there are other commands in the stack, execution of the command is caused to wait until all the other commands have been processed. The execution wait time is dependent upon the type of command issued by the other INITs and the contents of its specifications.
- If the IDD has executed error recovery processing (retried) for an error that occurred on the SAS I/F or in the disk drive, command completion time will be longer than normal.

### 5.2.2 Sense data analysis and error recovery methods

The INIT can judge the procedure for error recovery by analyzing the contents of the sense data. Table 5.5 the classifications of error information displayed in the sense data are shown and in Table 5.6, the procedures for error recovery recommended for the INIT to execute are shown. The error recovery procedure which can be executed by the INIT will differ depending on the system's condition, so the optimum processing procedure should be selected for the user system with reference to the following descriptions.

## Table 5.5 Sense data error classification (1/3)

| K* | C* | Q* | Outline of Error | L* | Recovery Method (See Table 5.6.) |
|---|---|---|---|---|---|
| 0 | x | x | No sense data showing the error contents are held. | None | 4 |
| 1 | 13<br>15<br>17<br>18 | 00<br>xx<br>xx<br>xx | Sync Mark not found for data field<br>Positioning error<br>Recovered data without ECC<br>Recovered data with error correction applied.<br>These errors are errors detected during accessing of the disk media, but they are recovered from through the IDD's retry processing. However, when "1" is specified in the DTE flag in the MODE SELECT parameters, the command may not necessarily be executed until it is completed. | Need | 8 |
| 1 | 37 | 00 | Rounded parameter<br>The IDD's rounding processing was applied to the MODE SELECT parameters specified by the INIT. | None | 9 |
| 2 | 04 | 01<br>02 | Logical unit not ready<br>The logical unit specified by the command is in a state where it cannot be accessed.<br>Logical unit not ready | Need** | 10** |
| 2 | 04 | 04 | Logical unit not ready, format in progress<br>The logical unit specified by the command is currently being formatted, so access is impossible. | None | 11 |
| 3 | 03<br>0C | xx<br>03 | Peripheral device write fault<br>Write error recommend reassignament<br>Unrecoverred write error | Need | 7 |
| 3 | 11<br>13<br>14<br>15 | xx<br>00<br>01<br>xx | Unrecovered read error<br>Sync Mark not found for data field<br>No record found<br>These errors were detected during accessing of the disk media, but they were errors which could not be recovered from through the IDD's retry processing.<br>Positioning error<br>This is an error of the disk drive’s seek system | Need | 12 |
| 3 | 19<br>1C | xx<br>xx | SA information error<br>SA information error not found<br>The information recorded in (SA) on the disk media cannot be read correctly. | Need | 7 |

* K: Sense Key C: Additional Sense Code
Q: Additional Sense Code Qualifier L: Logging Necessary? (shown in Section 5.2.3)

** Except within the time required for the disk drive to reach the ready state (approx. 20 seconds) after the power has been switched on, or after a start instruction has been executed by the NOTIFY Primitive (ENABLE SPINUP).

## Table 5.5 Sense data error classification (2/3)

| K* | C* | Q* | Outline of Error | L* | Recovery Method (See Table 5.6.) |
|---|---|---|---|---|---|
| 3 | 31 | 00 | Medium form at corrupted | Need | 18 |
| | 31 | 01 | FORMAT command failed<br>The data format on the disk media is not correct. | | |
| | | | The data format on the disk media is not correct. | | |
| 4 | 03 | xx | Peripheral device write fault | Need | 7 |
| | | | This is an error of the disk drive's write system. | | |
| | 32 | 01 | Defect list update failure | | |
| | | | These are errors detected in the operation of the disk drive. | | |
| 4 | 32 | 00 | No defect spare location available | None | 19 |
| | | | No usable alternate blocks exist on the disk drive. | | |
| 4 | 40 | nn | Diagnostic failure on component 'nn' | Need | 13 |
| | | | An error was detected in the IDD's self-diagnosis. | | |
| 4 | 44 | nn | Internal target failure | Need | 20 |
| | | | An internal hardware error or a microcode detection error was detected in the IDD. | | |
| 4 | 4C | xx | Calibration failed | Need | 10 |
| | C4 | xx | Drive failure | | |
| | | | The initial seek was terminated abnormally. Or, a serious error was detected in the drive's control system. | | |
| 5 | 20 | 00 | Invalid command operation code | None | 2 |
| | 21 | 00 | Logical block address out of range | | |
| | 24 | 00 | Invalid field in CDB | | |
| | 25 | 00 | Logical unit not supported | | |
| | 26 | 00 | Invalid field in parameter list | | |
| | | | There is an error in the command specification contents. | | |

* K: Sense Key C: Additional Sense Code
Q: Additional Sense Code Qualifier L: Logging Necessary? (shown in Section 5.2.3)

## Table 5.5 Sense data error classification (3/3)

| K* | C* | Q* | Outline of Error | L* | Recovery Method (See Table 5.6.) |
|---|---|---|---|---|---|
| 6 | 29 | xx | Power on, reset, or HARD RESET occurred<br>The IDD was initialized by a Power on or HARD RESET sequence. | None | 14 |
| 6 | 2A | 01 | Mode parameters changed<br>The MODE SELECT parameters were changed by another INIT. | None | 21 |
| 6 | 2F | 00 | Commands cleared by another INIT<br>Commands were cleared by another INIT. | None | 25 |
| 6 | 3F | 01 | Microcode has been changed | None | 27 |
| | | 02 | Changed operation definition | | |
| 7 | 27 | 00 | Write protected<br>Access to a read protected or write protected. | None | 15 |
| B | 03 | xx | Peripheral device write fault | Need | 12 |
| | 11 | xx | Unrecovered read error | | |
| | 13 | xx | Sync byte not found for data field | | |
| | 14 | xx | Record not found | | |
| | 15 | xx | Mechanical positioning error | | |
| B | 0E | 02 | Information Unit Too Long | | |
| | 47 | 01 | Information Unit iuCRC Error Detected | Need | 6 |
| | 4B | 01 | Invalid Target Port Transfer Tag Received | | |
| | 4B | 02 | Too Much Write Data | | |
| | 4B | 03 | ACK/NAK Time Out | | |
| | 4B | 04 | NAK Received | | |
| | 4B | 05 | Data Offset Error<br>An unrecoverable SAS related error occurred in the command execution sequence. | | |
| B | 4E | 00 | Overlapped commands attempted<br>Before execution of a command was completed, a new command was issued by the same INIT. | None | 2 |
| | 4D | nn | Tagged overlapped commands | | |
| E | 1D | 00 | Miscompare during verify operation<br>Data failed to match in the Byte check mode of the Verify command. | None | 24 |

* K: Sense Key C: Additional Sense Code

Q: Additional Sense Code Qualifier L: Logging Necessary? (shown in Section 5.2.3)

**Table 5.6 Error recovery processing procedures (1/4)**

| Recovery Method | Recovery Processing Procedure |
|---|---|
| 0 | It is not necessary to perform the error recovery processing. Continue processing. |
| 1 | Error recovery processing is impossible. Terminate processing. |
| 2 | This is a programming error and error recovery processing is impossible. Terminate processing and correct the error in the system (INIT) programming. |
| 3 | This is an error in the SAS I/F and error recovery processing is impossible. Terminate processing and check the system's SAS connection. |
| 4 | 1) Reissue the original command (Retry).<br>2) If the command is terminated with the same error when retried, perform recovery method 3 or 1.<br>3) If the command is terminated with a different error when retried, execute the recovery processing procedure for that error. |
| 5 | 1) After waiting about 1 second, reissue the original command (Retry).<br>2) If it doesn't recover after 10 retries, perform recovery method 1. |
| 6 | 1) Reissue the original command (Retry).<br>2) If it doesn't recover after 10 retries, perform recovery method 3. |
| 7 | 1) Reissue the original command (Retry).<br>2) If it doesn't recover after 10 retries, perform recovery method 1. |
| 8 | 1) If the DTE flag in the MODE SELECT parameter is "0," perform recovery method 0.<br>2) If the DTE flag in the MODE SELECT parameter is "1," execute one of the following according to the content indicated by the sense data.<br>– If the "Valid" bit is "1," and if the address of the final data block in the data block group in the area specified in the command is indicated in the information field, perform recovery method 0.<br>– If the "Valid" bit is "0," or even if the "Valid" bit is "1," but the address of a data block which is not that of the final data group in the area specified in the command is indicated in the information field, reissue the original command.<br>3) If this error (Other than a positioning error [15-xx]) occurs repeatedly in the same data block, implement alternate block allocation processing (shown in Section 6.4). |

**Table 5.6 Error recovery processing procedures (2/4)**

| Recovery Method | Recovery Processing Procedure |
|---|---|
| 9 | 1) Issue the MODE SENSE command and when a RECOVERED ERROR is reported, read the "Current" value in the changed MODE SELECT or MODE SELECT EXTENDED parameter.<br>2) If the value actually set in that parameter page is within the INIT's permissible range, perform recovery method 0.<br>3) If the value actually set in that parameter page is not within the INIT's permissible range, adjust the value specified in the parameter and issue the MODE SELECT or MODE SELECT EXTENDED command again. |
| 10 | 1) Issue the START instruction using the NOTIFY Primitive (ENABLE SPINUP).<br>2) When the START/STOP UNIT command is terminated abnormally, perform recovery method 1.<br>3) When the START/STOP UNIT command is terminated normally, reissue the original command (Retry). |
| 11 | 1) Wait for formatting (FORMAT UNIT command) to be completed.<br>2) Reissue the original command (Retry). |
| 12 | 1) Set the "Number of Retries" value in the MODE SELECT parameters at the "Default" value.<br>2) Reissue the original command (Retry). (Note)<br>3) If the error is not recovered from after the first retry, issue the REZERO UNIT command.<br>4) Reissue the original command (Retry). (Note)<br>5) If the error is not recovered from, perform one of the following.<br>– When the sense key is "HARDWARE ERROR [=4]," perform recovery method 1.<br>– When the sense key is "MEDIUM ERROR [=3]," implement alternate block allocation processing (shown in Section 6.4).<br>Note When the original command is the REASSIGN BLOCKS command, it may be necessary to reconfigure the defect list. For details, see the description of the REASSIGN BLOCKS command (Section 4.3.2). |

**Table 5.6 Error recovery processing procedures (3/4)**

| Recovery Method | Recovery Processing Procedure |
|---|---|
| 13 | 1) Execute a HARD RESET sequence.<br>2) After waiting 2 seconds or longer, reissue the original command (Retry), and if the spindle motor's start mode is set on "Start by Command," issue the START instruction by the NOTIFY Primitive (ENABLE SPINUP) before retrying.<br>3) If the retry procedure 2) does not terminate normally, perform recovery method 1. |
| 14 | 1) The parameter is initialized at the "Save" value (if the "Save" value does not exist, the "Default" value), so when it is necessary to set the inherent parameter, issued the MODE SELECT command.<br>2) Reissue the original command (Retry). |
| 16 | 1) Issue the LOG SENSE command and read the "Current" values in the LOG SELECT parameters.<br>2) If the parameters' values are appropriate, reissue the original command.<br>Note This error could also be caused by a UNIT ATTENTION condition being generated, caused by a programming error of another INIT, so when the value in the parameter read in ( is illegal, recovery method 2 should be performed, or the operations of the other INITs should be confirmed.) |
| 17 | If the PRIORITY RESERVE command issued by another INIT is proper in the system, perform the necessary recovery processing in the system. If not, perform recovery method 2. |
| 18 | 1) Issue the MODE SENSE or MODE SENSE EXTENDED command and confirm the values of the disk media data format related parameters (Block descriptor, Page 3: Format parameters, Page 4: Drive parameters).<br>2) If the parameter values are correct, issue the FORMAT UNIT command and initialize the entire disk media surface. (Note)<br>3) If the parameter values are not correct, issue a MODE SELECT or MODE SELECT EXTENDED command and reset the necessary parameters, then reinitialize the entire disk media surface by the FORMAT UNIT command. (Note)<br>Note In a system where multiple INITs are connected together, an error may have been reported due to a MODE SELECT or MODE SELECT EXTENDED command, or a FORMAT UNIT command issued by another INIT, so before executing this recovery method, it is necessary to confirm the operations of the other INITs. |

### Table 5.6 Error recovery processing procedures (4/4)

| Recovery Method | Recovery Processing Procedure |
|---|---|
| 19 | Initialize the entire disk media surface. It is desirable at this time to increase the number of spare sectors as much as possible. If this error occurs repeatedly, it is necessary to perform alternate block allocation processing through the system (shown in Chapter 5) or reconfirm the use conditions of the disk drive, such as the installation environment. |
| 20 | 1) Reissue the original command (Retry).<br>2) If it doesn't recover after 10 retries, perform recovery method 13. |
| 21 | 1) Issue the MODE SENSE or MODE SENSE EXTENDED command and read the "Current" values in the MODE SELECT parameters.<br>2) If the parameters' values are appropriate, reissue the original command.<br>Note This error could also be caused by a UNIT ATTENTION condition being generated, caused by a programming error of another INIT, so when the values in the parameters read in ( are illegal, recovery method 2 should be performed, or the operations of the other INITs should be confirmed.) |
| 24 | 1) Issue the READ or READ EXTENDED command and read the data for the block where the error occurred.<br>2) Investigate the cause of the data not matching and perform data recovery processing from the INIT. |
| 25 | Reissue the original command (Retry). It is desirable at this time to confirm the operations of the other INITs. |
| 26 | 1) Issue the LOG SENSE command and read the "Current" values of the LOG SELECT parameters.<br>2) Search for any parameter values which exceed the threshold value or have reached the maximum value, then issue the LOG SELECT command from the INIT and perform resetting.<br>3) Reissue the original command. |
| 27 | 1) Issue the INQUIRY command and read the operation mode information.<br>2) If the parameter values are appropriate, reissue the original command.<br>Note: This error could also be caused by a UNIT ATTENTION condition being generated, caused by a programming error of another INIT, so when the values in the parameters read in ( are illegal, recovery method 2 should be performed, or the operations of the other INITs should be confirmed.) |

### 5.2.3 Error logging

In order to collect information that is effective in maintenance, it is desirable for the INIT to accumulate (log) error information related to the SAS interface which it has detected itself (error frame detection, command completion wait time-out, etc.) and error information reported by the IDD.

By specifying "1" in the PER bit in the "Read/Write Error Recovery parameter (Page 1) and the "Verify Error Recovery parameter (Page 7) of the MODE SELECT or MODE SELECT EXTENDED command, the INIT can know of the occurrence of errors which were recovered from successfully by the IDD's internal error recovery processing and their contents. By logging that error information, the INIT can obtain data for more detailed analysis of the disk drive's operating condition.

Concerning the contents of the error log, it is recommended that the data have a time stamp affixed so that they can be edited in a time series of the times the errors were detected, and that they include the following information.

- The source which issued the command and the ID of the device which was the target of the command.
- The CDB which was issued.
- The receiving status, or, when the status was that the command could not be received, the code showing the type of error detected by the INIT and its content.
- All bytes reported by the IDD.

## 5.3 Disk Drive Error Recovery Processing

This section explains concerning error recovery processing methods and procedures executed by the IDD for each type of disk drive related error. The INIT can control the error recovery processing methods executed by the IDD using the MODE SELECT parameters.

### 5.3.1 Error states and retry processing procedures

(1) Seek error

Mechanical malfunctions of the disk drive during a seek operation and failure of serial addresses detected during verification of the ID area to match are included in this error.

When a seek error occurs, the IDD first executes rezero seek, then tries repositioning at the target cylinder and restarts the original processing. If the error is not recovered from, retry processing (rezero seek and repositioning) is performed up to the number of times specified in "Number of Retries during Seek Error" in the MODE SELECT parameters.

If the error cannot be recovered from even when retry processing is executed the specified number of times, the IDD terminates the command which is currently being executed with a CHECK CONDITION status. The sense key in the sense data at this time is "HARDWARE ERROR [=4]" and the ASC/ASCO indicates "Mechanical positioning error [=15-01]" or "Positioning error detected by read of medium [=15-02]."

### (2) Read error in uncorrectable data

This error is a failure to detect the Sync Mark pattern during reading of data or an ECC error for which correction processing is impossible. If this error is detected, the IDD, after waiting one revolution of the disk media, tries reading again. When the error is not recovered from, reading is retried repeatedly the number of times specified in the MODE SELECT parameter ("Number of Retries during Read" or "Number of Retries during Write").

In cases where correction is possible during execution of retry processing, the processing procedure is according to "Correctable Data Read Error" in item (3). If errors cannot be recovered from even after retry is executed the specified number of times, the IDD terminates the command that is currently being executed with a CHECK CONDITION status. The sense key in the sense data at this time is "MEDIUM ERROR [=3]" and the ASC/ASCO indicates "Sync Mark not found for data field [=13-00]" or "Unrecovered read error [=11-01]."

In this error retry processing, rereading accompanied by head offset processing is performed.

### (3) Correctable data read error

This error is a correctable ECC error when data are being read. Processing methods when this error is detected differ depending on the values specified in the EER flag and DCR flag in the MODE SELECT parameters.

If immediate correction of errors is permitted (DCR = 0, EER = 1), the IDD immediately makes error corrections in the data buffer and sends the corrected data to the INIT. Also, in the case of Verify processing, at the point when it judges that correction is possible, it regards verification as being successful and continues processing of subsequent data blocks.

If error correction is permitted but immediate correction is not permitted (DCR = 0, EER = 0), reading of data as in item (2) is retried up to the number of times specified in the other MODE SELECT parameters ("Number of Retries during Read" or "Number of Retries during Write").

If error correction is prohibited (DCR = 1, EER = 0), reading of data as in item (2) is retried up to the number of times specified in "Number of Retries during Read" or "Number of Retries during Write."

If the error cannot be recovered from even when this retry processing is executed, the IDD terminates the command that is currently being executed with a CHECK CONDITION status. The sense key in the sense data at this time is "MEDIUM ERROR [=3]" and the ASC/ASCO indicates "Unrecovered read error [=11-00]."

(4) Other internal IDD errors

If an irrecoverable error other than those in items (1) to (3) above is detected internally in the IDD, the IDD terminates the command that is currently being executed with a CHECK CONDITION status. The sense key in the sense data at this time is "HARDWARE ERROR [=4]."

### 5.3.2 Auto alternate block allocation processing

The IDD is equipped with a function which automatically executes alternate block allocation processing for defective data blocks detected during execution of the READ and READ EXTENDED commands.

(1) Auto alternate block allocation processing during a read operation

This function is enabled by specifying "1" in the ARRE flag in the MODE SELECT parameters. Furthermore, this function is applicable to the following commands only.

- READ command
- READ EXTENDED command

When this function is permitted, if, during read processing to the data area, an error which is an object of retry processing is detected, and which it is impossible to recover from even when reading is retried (see Section 5.3.1 (2)) the number of times specified in the "Number of Retries during Read" field in the MODE SELECT parameters, the IDD allocates an alternate block for that data block and executes copying of the alternate block to the data area. Alternate block allocation processing is the same as processing with the REASSIGN BLOCKS command. Furthermore, recovered data copied to the alternate block are data which are read out, skipping the ID area, if there is an ID area, or they are data which have been corrected through the ECC.

This function is applied once only during execution of one command. Alternate block allocation processing and copying are executed for the first defective data block to be detected during execution of a command, but if a second defective data block is detected, the command that is being executed at that point is terminated with an error. However, by the INIT's reissuing the same command, auto alternate block allocation is applied sequentially and error recovery can be attempted.

Remark:

1. When this function is specified (ARRE = "1"), the EER flag's specification in the MODE SELECT parameter is made invalid and Read retry processing is performed up to the number of times specified in the "Number of Retries during Read" parameter. If "0" is specified in the DCR flag, correction processing of the data is performed afterward (see Section 5.3.1 (3)). When "1" is specified in the DCR flag, ECC correction processing is prohibited, so even if "1" is specified in the ARRE flag, auto alternate block allocation processing will not be executed for errors in the data area.

2. When errors in the data area are recovered from by ECC correction processing, before implementing alternate block allocation processing, rewriting of the recovered data and a verify check (rereading) are performed. If data are recovered by rewriting, alternate block allocation of that data block is not performed.

### (2) Auto alternate block allocation processing during a write operation 1

This function is enabled by specifying "1" in the AWRE flag in the MODE SELECT parameters. Furthermore, this function is applicable to the following commands only.

- WRITE command
- WRITE EXTENDED command
- WRITE AND VERIFY command

The function handles the unrecoverable media error (MEDIUM ERROR [= 3]/Read Retries Exhausted [= 11 - 01]) detected when the number of read retries for an error reaches the specified value in the "Number of retries during READ" field of the MODE SELECT parameter (refer to Section 5.3.1 (3)). In such cases, if this function is enabled, the IDD registers the data block as the target block of AWRE processing. If the WRITE, WRITE EXTENDED, or WRITE AND VERIFY command is executed for the same data block, an alternate block is allocated to the data block. The data field of the alternate block is verified, and the required write data is written in the data field. This alternate block allocation is applied with the same processing as that of the REASSIGN BLOCKS command.

If multiple data blocks are the target blocks of AWRE processing when a single command is executed, this function applies to all of these data blocks. If an unrecoverable media error (MEDIUM ERROR [= 3]/Read Retries Exhausted [= 11 - 01]) is then detected during the read operation for a data block, INIT should issue the WRITE, WRITE EXTENDED, or WRITE AND VERIFY command to the data block. Thus, auto alternate block allocation is applied, and error recovery is possible.

Remark 1: When this function has been set (AWRE = "1"), up to eight unrecoverable media errors (MEDIUM ERROR [= 3]/Read Retries Exhausted [= 11 - 01]) detected during the read operation of the READ or READ EXTENDED command can be recorded. This recorded information is cleared when power is turned off or microcode is downloaded with the WRITE BUFFER command (regardless of whether save is specified).

Remark 2: Before data for a data block is allocated to an alternate block in AWRE processing, the data is written again to the data block and verified (re-read).

If error recovery is completed by rewriting the data to the data block, alternate block allocation is not performed for this data block. The data block is removed as the target of AWRE processing.

(3) Auto alternate block allocation processing during a write operation 2 (servo auto alternate)

This function is enabled by specifying "1" in the AWRE flag in the MODE SELECT parameters. Furthermore, this function is applicable to the following commands only.

- WRITE command
- WRITE EXTENDED command
- WRITE AND VERIFY

When this function is permitted, if, during WRITE/WRITE EXTENDED command detects any Servo error (e.g. Write offtrack error) and cannot be recovered within pre-determined retry number (specified in Mode Parameter). For the sectors around defective Servo, alternate blocks are allocated and the data of this WRITE commands are re-written.

Sectors to be made AWRE shall be following:

- the sector where the error occurs and the latter sectors and,
- the sectors whose data are logically continual and stored in Cache,
- the sectors which will be processed in this Write command and,
- the sectors which locate between erroneous Servo -1 and +1 (including Split sector)

This function is also applied for the sector which has already been re-assigned.

### 5.3.3 Error recovery processing control

The INIT can, by specifying the MODE SELECT parameters, can control the error recovery processing (retries) of the IDD with respect to each type of error related to the disk drive.

Table 5.7 shows the types of error and the method of specifying the number of retries for those errors. for those items where the INIT can specify the number of retries, normally, it is recommended that the default value or a greater number of times be specified. If a value smaller than the default value is specified, and commands are terminated abnormally without error recovery processing succeeding, the INIT should reset the corresponding MODE SELECT parameters at the default value, then reexecute the original commands.

The MODE SELECT parameters related to disk drive error recovery processing which the INIT can specify are shown below. See the description of the MODE SELECT command (Section 4.1.4) concerning details of the functions of each parameter. The INIT can issue the MODE SELECT or MODE SELECT EXTENDED command as necessary and select the error recovery flags and the number of retries.

a. Read/Write Error Recovery Parameters (Page Code = 1)

- AWRE (automatic write reallocation enabled)
- ARRE (automatic read reallocation enabled)
- TB (transfer block)
- EER (enable early recovery)
- PER (post error)
- DTE (disable transfer on error)
- DCR (disable correction)
- Number of retries during read (See Table 5.7)
- Number of retries during write (See Table 5.7)

b. Verify Error Recovery Parameters (Page Code = 7)

- EER (enable early recovery)
- PER (post error)
- DTE (disable transfer on error)
- DCR (disable correction)
- Number of retries during verify (See Table 5.7)

c. Additional Error Recovery Parameters (Page Code = 21)

- Number of retries during seek error (See Table 5.7)

**Table 5.7 Disk drive errors and number of retries**

| Item | Type of Error | Number of Tries Specification [Default value] | |
|---|---|---|---|
| 1 | Seek Error | Number of Retries during a Seek Error | [15] |
| 2 | Data field Read Error of Data field | Number of Retries during Read or<br>Number of Retries during Verify | [63] |
| 3 | Data field Write Error | Number of Retries during Write | [63] |

Remark:

The number of retries is calculated single logical sector processing units, except in the following cases.

- The number of retries is calculated as individual retries.
- In processing of data blocks for which alternate sector processing is completed, the number of retries on the defective sectors is calculated separately from the number of retries on the alternate sectors.

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# CHAPTER 6 Disk Media Management

In this chapter, disk media defect management methods, treatment methods for media defects which occur during operation, reinitialization procedures and other disk media management methods are discussed. Furthermore, see Chapter 3, "Data Format" in the "Product Manual" concerning details of the data recording format on the disk media.

## 6.1 Defect Management

### (1) Defect lists

Information on the positions of defects in the disk media are managed by the types of defect list shown below. See the description of the FORMAT UNIT command (Section 4.3.1) concerning methods for using the defect lists.

- P List Defect position information at the point when the disk drive was shipped from the factory is recorded in this list. The defective portions included in this list are permanent defects, and when the disk media is initialized, it is necessary that this list be used and alternate block processing be executed.

- D List This list includes defect position information specified by the INIT in the FORMAT UNIT command when initializing the disk media.

- C List This list contains information on the positions of defective blocks detected during the data block Verify operation (Certification) after initialization by the FORMAT UNIT command. This information is generated internally by the IDD when the FORMAT UNIT command is executed.

- G List This list is composed from the defective logical data block position information specified by the INIT in the REASSIGN BLOCKS command, defective logical data block position information from alternate blocks which have been allocated by the IDD's auto alternate block allocation processing, information specified as the D List and information generated as the C List.

The P List and G List are recorded in the system space on the disk media. The INIT can read the contents of these lists by the READ DEFECT DATA command.

### (2) Alternate block allocation

Alternate data blocks are allocated in defective sector units for defective data blocks (= sectors) on the disk media by the IDD's internal defect management methods.

a. Spare sector area

Spare sectors for allocation as alternate blocks are secured in one or both of the following areas. When the INIT initializes the disk media, it can specify the spare sector area to be prepared on the disk drive and the size of that area.

– Spare sectors within a cell

Spare sectors are secured in the final track of each cell. They are used as alternate blocks for defective sectors within the same cell.

– Alternate cells

This is an exclusive cells for allocation of alternate blocks. Alternate cells are secured only in the specified quantity in order from the topmost cells. Spare sectors in an alternate cell are used only in the case that the spare sectors within each cell are used up and alternate block allocation is not possible within the same cell.

b. Alternate block allocation methods

Alternate block allocation processing is performed using one of the following methods.

– Sector slip processing

This is a method of skipping defective sectors and writing the logical data blocks corresponding to those sectors in order in physically consecutive sectors. Sector slip processing is performed only within the same cell as the defective sectors and until all the spare sectors within that cell are used up.

– Alternate sector processing

This is a method of allocating logical data blocks corresponding to defective sectors to unused spare sectors in an alternate cell.

c. Alternate block allocation processing

Alternate block allocation processing is implemented by the FORMAT UNIT command, REASSIGN BLOCKS command or "Auto Alternate Block Allocation Processing." In sector slip processing, the defective sectors re excluded and logical data blocks are located in physically consecutive sectors, but when alternate block processing is performed, the affected logical data blocks are located in spare sectors which are not physically consecutive with the previous and following logical data blocks which are physically located on the disk.

– Alternate block allocation processing during FORMAT UNIT command execution

With the FORMAT UNIT command, alternate block allocation is done by sector slip processing until all the spare sectors within the same cell have been used up for defective sectors included in the type of defect list (P, G or D) specified in the command. When all the spare sectors in the same cell have been used up, subsequent defective sectors in that cell are treated by allocating spare sectors in an alternate cell by alternate sector processing.

After implementing this alternate block allocation and initializing the disk media, at times when a data block Verify (Certification) operation is not prohibited, the IDD, reads all the initialized data blocks and verifies their normalcy. If a defective data block is detected during this processing, the IDD generates the C List as defect position information and allocates alternate blocks by alternate sector processing for those defective data blocks. In this case, alternate blocks are allocated in spare sectors in an alternate cell.

– Alternate block allocation processing by the REASSIGN BLOCKS command

With the REASSIGN BLOCKS command, alternate block allocation is performed by alternate sector processing for defective logical data blocks specified by the INIT. In this case, alternate blocks are allocated in spare sectors in an alternate cell.

– Auto alternate block allocation processing

If auto alternate block allocation processing is permitted by the AWRE flag or the ARRE flag of the MODE SELECT parameters, the IDD executes alternate clock allocation automatically by alternate sector processing for defective data blocks detected during execution of the WRITE, WRITE EXTENDED, WRITE AND VERIFY, READ and READ EXTENDED commands. The alternate block allocation method in this case is the same as in the case of the REASSIGN BLOCKS command. See the description in Section 5.3.2 concerning "Auto Alternate Block Allocation Processing".

# 6.2 Disk Media Initialization

## 6.2.1 Initialization during installation

The disk drive is initialized for the inherent (default) data format for each respective model name (model class) when it is shipped from the factory, so ordinarily, it is not necessary to initialized (format) the disk media when it is installed in a system. However, in cases where data attributes which differ from the default format are necessary, initialization (formatting) of the entire disk media by the following procedures is necessary. At this time, the INIT can change the following data format attributes.

- The logical data block length.
- The number of logical data blocks or the number of cylinders in the User Space.
- The size of the spare area for alternate blocks.

(1) Issuing the MODE SELECT command

The MODE SELECT or MODE SELECT EXTENDED command is issued and the format attributes on the disk media are specified. The necessary parameters at this time are as follows.

a. Block descriptor

The logical data block size (byte length) is specified in the "Data block length" field. Also, when desiring to clearly specify the logical data block count, specify that value in the "Data block count" field. If not, zero may be specified in the "Data block count" field. In that case, the number of logical data blocks after initialization will be determined by the values specified in the Format parameters (Page 3) and the Drive parameters (Page 4).

b. Format parameters (Page 3)

Specify the number of spare sectors secured in each cylinder in the "Alternate sector count/zone" field. It is desirable not to specify a value that is lower than the IDD's default value in this field.

c. Drive parameters (Page 4)

The number of cylinders in the "User Space," cannot be changed. The number of cylinders necessary to secure the number of logical data blocks specified in the "Data block count" field in the block descriptor will be allocated to the user space.

(2) Issuing the FORMAT UNIT command

Issue the FORMAT UNIT command and initialize the entire disk media surface.

In this FORMAT UNIT command, the entire disk media surface is initialized using the P List, then after initialization, the data blocks are verified. If any defective blocks are detected in the Verify operation, alternate blocks are allocated for those data blocks. Also, the defect position information for only the defective data blocks detected in the Verify operation is recorded in the G List.

The contents which need to be specified at this time are as follows.

a. CDB specification

Specify "0" in the "FmtData" bit and the "CmpLst" and "000" in the "Defect List Format" field in the CDB.

b. FORMAT parameters

If the items values in the previous item are specified in the CDB, the Format parameter is not necessary.

### 6.2.2 Re-initialization

The INIT can reinitialize the disk drive after it has been operated using the FORMAT UNIT command.

**IMPORTANT**

If it is necessary after reinitialization to restore the data that were stored on the disk media, it is necessary to save the data before executing reinitialization, then execute data restore using system software after reinitialization.

The INIT can change the size of the spare sector area and its location as well as the number of logical data blocks before reinitialization. The recommended procedure for reinitialization is shown below. However, in cases where the logical data block length is changed, the initialization procedure described in Section 6.2.1 must be followed during installation.

(1) MODE SELECT command

If the logical data block count (size of the User Space) or the size of the spare sector area and its location are changed, issue the MODE SELECT EXTENDED command and specify the disk media format attributes. The parameter specification method is the same as in the case of initialization processing during installation, described in Section 6.2.1. If the same format attributes as at present will continue to be used, it is not necessary to issue the MODE SELECT EXTENDED command.

### (2) FORMAT UNIT command

Issue the FORMAT UNIT command in either of the following two formats and initialize the entire disk media surface.

a) Specify "1" in the "FmtData" bit, "0" in the "CmpLst" bit and "000" in the "Defect List Format" field. Also, prepare only a 4-byte header, specify "0" in the "FOV," "DPRY," "DCRT" and "STPF" bits and zero in the "Defect List Length" field.

  – In this FORMAT UNIT command, the entire disk media surface is initialized using the P List and the previously existing G List, then after initialization, the data blocks are verified. If any defective blocks are detected in the Verify operation, alternate blocks are allocated for those data blocks. Also, the previously existing G List is saved, and the defect position information for the defective data blocks detected in the Verify operation is added to the G List. During initialization, alternate blocks for which sector slip processing was applied for previously known defects are reallocated, so optimization of the logical data block locations on the disk media can be expected.

b) Specify "0" in the "FmtData" bit and in the "CmpLst" bit and "000" in the "Defect List Format" field. In this case, specification of the format parameters is not necessary.

  – In this FORMAT UNIT command, the disk media is initialized using only the P List, then after initialization, the data blocks are verified. If any defective blocks are detected in the Verify operation, alternate blocks are allocated for those data blocks. Also, the previously existing G List is erased and defect position information for the defective data blocks detected in the Verify operation is recorded in a new G List.

## 6.3 Data Block Verification Methods (Recommended)

The recommended procedure for verifying from the INIT the normalcy of logical data blocks located on the disk media is as shown below. It is desirable for the INIT to verify the data blocks after initialization of the disk media is completed or when executing alternate block allocation processing by the REASSIGN BLOCKS command.

**IMPORTANT**

The INIT must not recognize the defective data blocks included in the P List as normal data blocks in the verification operation.

After the INIT has written a specific data pattern for logical data blocks which is the object of verification using the procedure described below, it next reads those data or verifies the data blocks by executing Verify.

### (1) Setting parameters by the MODE SELECT command

Issue the MODE SELECT or the MODE SELECT EXTENDED command and prohibit retry processing, data correction and operation of the Read-Ahead Cache feature. The necessary parameter settings are as shown below.

a. Read/Write Error Recovery Parameters (Page 1)

- AWRE = 0, ARRE = 0
- TB = 0
- EER = 0, PER = 1, DTE = 1, and DCR = 1
- Number of Retries during Read = Zero
- Number of Retries during Write = Zero

b. Verify Error Recovery Parameters (Page 1)

- EER = 0, PER = 1, DTE = 1, and DCR = 1
- Number of Retries during Verify = Zero

c. Caching Parameters (Page 8)

- RCD = 1

### (2) Writing a data pattern

Write a data pattern for verification in the data block which is the object. The recommended data pattern at this time is X '0123456789ABCDEF' repeated. The WRITE, WRITE EXTENDED or WRITE SAME command can be used to write data.

### (3) Reading and verification of data

Issue the READ, READ EXTENDED or VERIFY command and verify that the data written to the disk media in item (2) were read correctly.

To verify reading of data, it is recommended that reading of the same data block be done at lease 2 times, but the number of times verification is performed is determined by the conditions on the system. If reading of all data is completed normally, it can be recognized that use of that data block can be used normally.

### (4) Error verification

When an error related to the disk media (Sense Key = 3: MEDIUM ERROR) occurs during writing of the data pattern (see item (2)) or verification of data reading (see item (3)), reexecute the rewriting and reading verification combination (two times) at least 8 times.

When the same type of error occurs even once during reexecution, it is recommended that the INIT treat that data block as a defective block. If the reexecution of verification is completed normally every time, it should be regarded that that data block can be used normally.

## 6.4 Alternate Block Allocation Processing

If errors on the disk media which cannot be recovered from are detected, or if a recoverable error occurs repeatedly in the same data block, it is necessary for the INIT to allocate an alternate block for the data block where the error occurred using the REASSIGN BLOCKS command. The procedure for alternate block processing is shown below.

**IMPORTANT**

> An attempt will be made to copy the contents of the data area of the logical data block specified in the "Defect Data" list to the alternate block allocated by this command, but in some cases, the data cannot be copied. Confirmation of the contents of data in the allocated alternate block, saving of data before issuing this command and restoring of data after executing this command are the responsibility of the INIT.

1) Verify data blocks in accordance with the procedure in Section 6.3 for data blocks where error occur. When such a data block is judged to be normal, alternate block allocation need not be implemented. In this case, rewrite the original data to that data block if necessary. When the data block is judged to be defective, implement the processing in item 2) and after.

2) Specify a logical block address for a data block which is judged to be defective and issue the REASSIGN BLOCKS command.

3) If the REASSIGN BLOCKS command is terminated normally, verify that logical data block according to the procedure in Section 6.3. If that data block is judged to be correct, allocate an alternate block and terminate processing. When the data block is judged to be defective, return to 2) and issue the REASSIGN BLOCKS command again, then try reallocating another alternate block for that logical data block.

The alternate block allocation history (defect position information) is registered as an addition to the defect list (G List). Therefore, when reinitializing the hard disk with the FORMAT UNIT command (see Section 6.2.2), if use of the G List is specified, defect processing can be performed which reflects the operation results up to that time. Also, since "Alternate sector processing" is applied in alternate block allocation in the REASSIGN BLOCKS command, the physical connectivity of the logical data block positions on the disk media is destroyed, but by reinitializing the disk, as long as the number of defective sectors in the cylinder does not exceed the number of spare sectors per cylinder, the logical data blocks are relocated by sector slip processing so that their physical connectivity is maintained.

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# Glossary

### Additional Sense Code

This is a 1-byte code displayed in the sense data and is information which specifies the type of error that was detected.

### CDB

Command Descriptor Block
A series of data which describes commands related to input/output operations, sent from the initiator to the target.

### Command

This is a command to a target to perform an input/output operation, and it is described as the CDB.

### Common Command Set (CCS)

SCSI standard logical specifications established by a working group of the American National Standard Institute (ANSI). Requirements and features for supported direct-access devices (e.g., hard disk devices) are stipulated with the CCS.

### Initiator (INIT)

This is a FC device which initiates input and output operations on the FC bus. In this manual, initiator has been abbreviated to "INIT."

### Sense Data

When several items of error information are included in a command's completion status, this is information generated by the target for reporting detailed information on that status.

### Sense Key

This is a 4-bit code displayed in the sense data. It contains information for classifying the type of error that was detected.

### Small Computer System Interface (SCSI)

Input/output interface standardized by the American National Standard Institute (ANSI)
[Specification Number: ANSI X3.131-1986]

### Status

This is 1 byte of information reported to the initiator by the target device when execution of each command is completed, which displays the command's completion state.

### Target (TARG)

This is the FC device that executes the input/output operations initiated by the initiator (INIT). In this manual, target is abbreviated "TARG."

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# Acronyms and Abbreviations

### A

| | |
|---|---|
| ACK | ACKnowledge |
| AEN | Asynchoronous Event Notification |
| ALT | ALTernated (block) |
| ARRE | Automatic Read Reallocation Enabled |
| ASCII | American Standard Code for Information Interchange |
| ASG | ASiGned block |
| ATN | ATTeNtion |
| AWG | American Wire Gauge |
| AWRE | Automatic Write Reallocation Enabled |

### B

| | |
|---|---|
| bpi | bits per inch |
| BSY | BuSY |
| BytChk | Byte Check |

### C

| | |
|---|---|
| C list | Target Certification list |
| C/D | Control/data |
| CCS | Common command set |
| CDB | Common descriptor block |
| CE | Customer Engineer |
| CmpLst | Complete List |
| CRC | Cyclic Redundancy Check |
| CSS | Contact Start Stop |
| CYL | CYLinder |

### D

| | |
|---|---|
| D | Depth |
| D list | Data Defect List |
| DBD | Disable Block Descriptor |
| DC | Direct Current |
| DCR | Disable Correction |
| DCRT | Disable CeRtificaTion |
| DE | Disk Enclosure |
| DEF | DEFective block |
| DevOfi | Device Offine |
| DPO | Disable Page Out |
| DPRY | Disable PRimarY |
| DSP | Disable Saving Parameters |
| DTDC | Data Transfer Disconnect Control |
| DTE | Disable Transfer on Error |

### E

| | |
|---|---|
| ECC | Error Correction Code |
| EER | Enable Early Recovery |
| EVPD | Enable Vital Product Data |

### F

| | |
|---|---|
| FC | Fibre Channel |
| FG | Frame Ground |
| FIFO | First In First Out |
| FmtData | Format Data |
| FOV | Format Options Valid |
| FUA | Force Unit Access |

### G

| | |
|---|---|
| G | Gap |
| G list | Grown defect list |

### H

| | |
|---|---|
| H | Height |
| HSEC | Hard SECtor |

### I

| | |
|---|---|
| I/O | Input/Output |
| ID | IDentifier |
| IDD | Intelligent Disk Drive |
| ILBN | Ideal Logical Block Number |
| Immed | Immediate |
| INDX/SCT | INDeX/SeCTor |
| IP | Initialization Pattern |
| ISG | InterSector Gap |

### L

| | |
|---|---|
| LBdata | Logical Block data |
| LBN | Logical Block Number |
| LED | Light Emitting Diode |

### M

| | |
|---|---|
| MR | Magnetro Resistive |
| MS | Multiple Select |
| MSG | MeSsaGe |

### O

| | |
|---|---|
| OEM | Original Equipment Manufacturer |

### P

| | |
|---|---|
| P list | Primary defect list |
| P/N | Parts/Number |
| PBdata | Physical Block data |
| PC board | Printed Circuit board |
| PCA | Printed Circuit Assembly |
| PER | Post ERror |
| PF | Page Format |
| PLOSync | Phase Lock Oscillator Syncronous |
| PMI | Partial Medium Indicator |
| PR4ML | Partial Response class 4 Maximum Likelihood |

### R

| | |
|---|---|
| RC | Read Continuous |
| RCD | Read Cache Disable |
| REQ | Request |
| RH | Relative Humidity |
| RMB | ReMovaBle |
| RST | ReSeT |
| RSV | ReSerVed |

### S

| | |
|---|---|
| S/N | Serial/Number |
| SBd | Synchronized Byte data area |
| SBi | Synchronized Byte identifier area |
| SCSI | Small Computer System Interface |
| SCT | SeCTor |
| SEL | SELect |
| SelfTest | Self Test |
| SG | Signal Ground |
| SP | Save Page |
| SPR | SPaRe block |
| SR | Servo |
| SSEC | Soft sector |
| STPF | Stop sector |
| SURF | SURFace |

### T

| | |
|---|---|
| TB | Transfer Block |
| TPI | Tracks Per Inch |
| TRM | TeRMinator |

### U

| | |
|---|---|
| UnitOfl | Unit Offline |

### V

| | |
|---|---|
| VCM | Voice Coil Motor |
| VPD | Vital Product Data |
| VU | Vendor Unique |

### W

| | |
|---|---|
| W | Width |
| WCE | Write Cache Enable |
| WP | Write Protect |

# Index

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