

C141-E198-02EN

**MAS3735FC**  
**MAS3367FC**

**DISK DRIVES**

**PRODUCT/MAINTENANCE MANUAL**

# 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.

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# Revision History

(1/1)

Edition	Date	Revised section (*1) (Added/Deleted/Altered)	Details
01	2003.07.29	—	—
02	2003.10.07	<ul style="list-style-type: none"><li>• Table 2.1, 2.2 and 3.2 are altered.</li><li>• Table 2.3 is altered</li></ul>	Capacity notation is changed. Misdescription is corrected.

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

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# Preface

This manual describes the MAS3735FC and MAS3367FC (hereafter, MAS series), 3.5 type fixed disk drives with an embedded fibre channel controller.

This manual details the specifications and functions of the above disk drive, and gives the requirements and procedures for installing it into a host computer system.

This manual is written for users who have a basic understanding of fixed disk drives and their use in computer systems. The MANUAL ORGANIZATION section describes organization and scope of this manual. The need arises, use the other manuals.

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

## Overview of Manual

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

### **Chapter 1 General Description**

This chapter introduces the MAS series disk drives and discusses their standard features, hardware, and system configuration.

### **Chapter 2 Specifications**

This chapter gives detailed specifications of the MAS series disk drives and their installation environment.

### **Chapter 3 Data Format**

This chapter describes the data structure of the disk, the address method, and what to do about media defects.

### **Chapter 4 Installation Requirements**

This chapter describes the basic physical and electrical requirements for installing MAS series disk drives.

### **Chapter 5 Installation**

This chapter explains how to install MAS series disk drives. It includes the notice and procedures for setting device number and operation modes, mounting the disk drive, connecting the cables, and confirming drive operation.

### **Chapter 6 Diagnostics and Maintenance**

This chapter describes the automatic diagnosis, and maintenance of MAS series disk drive. This chapter also describes diagnostic methods for operation check and the basics of troubleshooting the disk drives.

### **Chapter 7 Error Analysis**

This chapter describes in details how collect the information for error analysis and how analyze collected error information.

## APPENDIX A Connector Signal Allocation

The appendix gives supplementary information, including the signal assignments of interface connectors.

### 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:



This indicates a hazardous situation *likely* to result in *serious personal injury* if the user does not perform the procedure correctly.



This indicates a hazardous situation *could* result in *serious personal injury* if the user does not perform the procedure correctly.



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)



#### Data loss

For MAS series, Reed Solomon codes are applied for their ECC. The sector-data is divided into 4 interleaving sectors, and ECC is performed in each sector where the maximum number of errors (up to 5 byte) can be corrected. [Total maximum byte: 5 byte  $\times$  4 (interleave) = 20 byte]

If the error of read sector keeps allowable error byte number, correction is performed. However, if error byte exceeds its allowable number, correction may not be performed properly.

The main alert messages in the text are also listed in the "Important Alert Items."

### CONVENTIONS USED IN THIS MANUAL

The MAS3735FC and MAS3367FC disk drives are described as "the intelligent disk drive (IDD)", "the drive" or "the device" in this manual.

Decimal number is represented normally.

Hexadecimal number is represented as X'17B9', 17B9h or 17B9H.

Binary number is represented as "010".

### 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.

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# Important Alert Items

## Important Alert Messages

The important alert messages in this manual are as follows:



A hazardous situation *could* result in *minor* or *moderate personal injury* if the user does not perform the procedure correctly. Also, damage to the product or other property, *may* occur if the user does not perform the procedure correctly.

Task	Alert message	Page
Mounting Installation	<i>Data loss</i> <i>For MAS series, Reed Solomon codes are applied for their ECC.</i> <i>The sector-data is divided into 4 interleaving sectors, and ECC is performed in each sector where the maximum number of errors (up to 5 byte) can be corrected. [Total maximum byte: 5 byte × 4 (interleave) = 20 byte]</i> <i>If the error of read sector keeps allowable error byte number, correction is performed.</i> <i>However, if error byte exceeds its allowable number, correction may not be performed properly.</i>	2-5
	<i>Hot temperature</i> <i>To prevent injury, do not handle the drive until after the device has cooled sufficiently after turning off the power. The DE and LSI become hot during operation and remain hot immediately after turning off the power.</i>	5-1

Task	Alert message	Page
Mounting Installation	<p><i>Damage</i></p> <ol style="list-style-type: none"> <li>1. <i>When dismantling the drive which is mounted on the system while power is supplied to it.</i> <ul style="list-style-type: none"> <li>• <i>The drive to be dismantled must be separated from the loop. Dismantling the drive which is not separated from the loop may cause an unexpected error.</i></li> <li>• <i>If the drive is not separated from the loop, issue an LPB to the drive from the initiator in a primitive sequence of the order set.</i></li> <li>• <i>It is recommended to stop the spindle motor prior to this loop separation operation. The spindle motor can be stopped by a START/STOP command. It takes about 30 seconds for the spindle motor to stop completely.</i></li> <li>• <i>Then, dismount the drive using the drive mounting/dismounting mechanism, etc. of the system. If the drive is dismantled while the spindle motor is running, special care is required to avoid excessive vibration or shock to the drive. It is recommended to stop the operation once the SCA connector breaks off contact and wait until the spindle motor stops (about 30 seconds) before dismount the drive.</i></li> <li>• <i>When storing or transporting the drive, put it in an antistatic bag. (Shown in Section 5.1).</i></li> </ul> </li> <li>2. <i>When dismantling the drive which is mounted on the system while power is not supplied to it.</i> <ul style="list-style-type: none"> <li>• <i>Do not move the drive until the drive stops completely (about 30 seconds if the spindle motor was stopped by a START/STOP UNIT command, and about 30 seconds after powering-off when the power was simply turned off).</i></li> <li>• <i>Then, dismount the drive using the drive mounting/dismounting mechanism, etc. of the system.</i></li> <li>• <i>When storing or transporting the drive, put it in an antistatic bag. (Shown in Section 5.1).</i></li> </ul> </li> </ol>	5-5
	<p><i>Data loss</i></p> <p><i>When the SEND DIAGNOSTIC command terminates with the CHECK CONDITION status, the INIT must collect the error information using the REQUEST SENSE command. The RECEIVE DIAGNOSTIC RESULTS command cannot read out the error information detected in the self-diagnostics.</i></p>	6-4
	<p><i>Caution</i></p> <ol style="list-style-type: none"> <li>1. <i>To avoid injury, do not touch the mechanical assembly during disk drive operation.</i></li> <li>2. <i>Do not use solvents to clean the disk drive.</i></li> </ol>	6-5

Task	Alert message	Page
Mounting Installation	<p><i>Caution</i></p> <ol style="list-style-type: none"> <li>1. <i>Always ground yourself with a wrist strap connected to ground before handling. ESD (Electrostatics Discharge) may cause the damage to the device.</i></li> <li>2. <i>Do not remove a PCA. This operation is required to prevent unexpected or unpredictable operation.</i></li> <li>3. <i>Do not use a conductive cleaner to clean a disk drive assembly.</i></li> </ol>	6-6
	<p><i>Damage</i></p> <p><i>Never open the disk enclosure in the field. Opening the disk enclosure in the field may cause an irreparable fault.</i></p>	6-6
	<p><i>Data loss</i></p> <p><i>Save data stored on the disk drive before requesting repair. Fujitsu does not assume responsibility if data is destroyed during servicing or repair.</i></p>	6-7
	<p><i>Damage</i></p> <p><i>Never open the disk enclosure in the field. Opening the disk enclosure may cause an irreparable fault.</i></p>	6-15

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MANUAL ORGANIZATION

<p>PRODUCT/ MAINTENANCE MANUAL</p> <p>(This manual)</p>	<ol style="list-style-type: none"><li>1. General Description</li><li>2. Specifications</li><li>3. Data Format</li><li>4. Installation Requirements</li><li>5. Installation</li><li>6. Diagnostics and Maintenance</li><li>7. Error Analysis</li></ol>
<p>Fibre Channel Interface Specifications</p>	<ol style="list-style-type: none"><li>1. Command Processing</li><li>2. Data Buffer Management</li><li>3. Command Specification</li><li>4. Sense Data and error Recovery Procedure</li><li>5. Disk Medium Management</li></ol>

# REFERENCED STANDARDS

The product specifications and functions described in this manual conform to the following ANSI (\*1) standards:

Document number	Title
NCITS TR-19	FIBRE CHANNEL PRIVATE LOOP SCSI DIRECT ATTACH (FC-PLDA)
ANSI X3.230-1994	FIBRE CHANNEL PHYSICAL AND SIGNALING INTERFACE (FC-PH)
ANSI X3.297-1996	FIBRE CHANNEL PHYSICAL AND SIGNALING INTERFACE-2 (FC-PH-2)
ANSI X3.272-199X	FIBRE CHANNEL ARBITRATED LOOP (FC-AL)
ANSI X3.269-199X	FIBRE CHANNEL PLOTOCOL FOR SCSI (SCSI-FCP)

\*1 ANSI = American National Standards Institute

In case of conflict between this manual and any referenced document, this manual takes precedence.

# CONTENTS

<b>CHAPTER 1</b>	<b>General Description .....</b>	<b>1-1</b>
1.1	Standard Features .....	1-2
1.2	Hardware Structure .....	1-5
1.3	System Configuration.....	1-7
<b>CHAPTER 2</b>	<b>Specifications .....</b>	<b>2-1</b>
2.1	Hardware Specifications .....	2-1
2.1.1	Model name and order number .....	2-1
2.1.2	Function specifications .....	2-2
2.1.3	Environmental specifications.....	2-4
2.1.4	Error rate .....	2-5
2.1.5	Reliability.....	2-5
<b>CHAPTER 3</b>	<b>Data Format .....</b>	<b>3-1</b>
3.1	Data Space.....	3-1
3.1.1	Cylinder configuration .....	3-1
3.1.2	Alternate spare area.....	3-4
3.1.3	Track format.....	3-5
3.1.4	Sector format.....	3-7
3.1.5	Format capacity.....	3-9
3.2	Logical Data Block Addressing .....	3-9
3.3	Defect Management .....	3-11
3.3.1	Defect list .....	3-11
3.3.2	Alternate block allocation .....	3-11
<b>CHAPTER 4</b>	<b>Installation Requirements .....</b>	<b>4-1</b>
4.1	Mounting Requirements.....	4-1

4.1.1	External dimensions .....	4-1
4.1.2	Mounting .....	4-3
4.1.3	Notes on mounting .....	4-3
4.2	Power Supply Requirements .....	4-7
4.3	Connection Requirements .....	4-9
4.3.1	Connector .....	4-9
4.3.2	Interface connector .....	4-9
<b>CHAPTER 5</b>	<b>Installation .....</b>	<b>5-1</b>
5.1	Notes on Handling Drives .....	5-1
5.2	Setting.....	5-3
5.2.1	Loop ID setting.....	5-3
5.2.2	Mode settings .....	5-3
5.3	Mounting Drives.....	5-4
5.3.1	Mounting procedures.....	5-4
5.4	Dismounting Drives.....	5-5
5.5	Checking Operation after Installation and Preparing the IDD for Use...5-6	
5.5.1	Checking initial operation .....	5-6
5.5.2	Checking connection .....	5-7
5.5.3	Formatting .....	5-10
5.5.4	Setting parameters .....	5-12
5.6	Spare Disk Drive .....	5-16
<b>CHAPTER 6</b>	<b>Diagnostics and Maintenance.....</b>	<b>6-1</b>
6.1	Diagnostics .....	6-1
6.1.1	Self-diagnostics .....	6-1
6.1.2	Test programs .....	6-4
6.2	Maintenance Information .....	6-5
6.2.1	Precautions .....	6-5
6.2.2	Maintenance requirements .....	6-6
6.2.3	Maintenance levels .....	6-8

6.2.4	Revision numbers.....	6-9
6.2.5	Tools and test equipment .....	6-10
6.2.6	Tests .....	6-10
6.3	Operation Check.....	6-12
6.3.1	Initial seek operation check .....	6-12
6.3.2	Operation test .....	6-12
6.3.3	Diagnostic test.....	6-12
6.4	Troubleshooting Procedures.....	6-13
6.4.1	Outline of troubleshooting procedures.....	6-13
6.4.2	Troubleshooting with disk drive replacement in the field .....	6-13
6.4.3	Troubleshooting at the repair site .....	6-15
6.4.4	Troubleshooting with parts replacement in the factory .....	6-16
6.4.5	Finding possibly faulty parts.....	6-16
<b>CHAPTER 7</b>	<b>Error Analysis.....</b>	<b>7-1</b>
7.1	Error Analysis Information Collection .....	7-1
7.1.1	Sense data.....	7-1
7.1.2	Sense key, sense code, and subsense code.....	7-1
7.2	Sense Data Analysis .....	7-3
7.2.1	Error information indicated with sense data .....	7-3
7.2.2	Sense data (3-0C-03), (4-40-xx), (4-44-xx), and (4-C4-xx) .....	7-4
7.2.3	Sense data (1-1x-xx), (3-1x-xx) and (E-1D-00): Disk read error .....	7-4
7.2.4	Sense data (5-2x-xx), (5-3D-00), (B-47-xx), (B-49-00), (B-4D-xx) and (B-4E-00): fibre channel interface error .....	7-4
<b>APPENDIX A</b>	<b>Connector Signal Allocation .....</b>	<b>A-1</b>
A.1	Interface (FC-SCA) Connector Signal Allocation .....	A-2
<b>Glossary</b> .....		<b>GL-1</b>
<b>Abbreviation</b> .....		<b>AB-1</b>
<b>Index</b> .....		<b>IN-1</b>

## Illustrations

### Figures

Figure 1.1	FC model drives outer view .....	1-5
Figure 1.2	Disk/head configuration .....	1-6
Figure 1.3	Example of FC-AL system configuration .....	1-7
Figure 3.1	Cylinder configuration .....	3-2
Figure 3.2	Spare area in cell .....	3-5
Figure 3.3	Alternate cylinder .....	3-5
Figure 3.4	Track format .....	3-6
Figure 3.5	Track skew/head skew .....	3-7
Figure 3.6	Sector format .....	3-7
Figure 3.7	Alternate block allocation by FORMAT UNIT command .....	3-12
Figure 3.8	Alternate block allocation by REASSIGN BLOCKS command .....	3-13
Figure 4.1	External dimensions .....	4-2
Figure 4.2	IDD orientations .....	4-3
Figure 4.3	Mounting frame structure .....	4-4
Figure 4.4	Limitation of side-mounting .....	4-4
Figure 4.5	Surface temperature measurement points .....	4-5
Figure 4.6	Service clearance area .....	4-6
Figure 4.7	Current waveform (+12 VDC) .....	4-7
Figure 4.8	AC noise filter (recommended) .....	4-8
Figure 4.9	Connector location .....	4-9
Figure 4.10	SCA2 type connector .....	4-10
Figure 5.1	Checking the IDD connection (A) .....	5-8
Figure 5.2	Checking the IDD connection (B) .....	5-9
Figure 6.1	Revision label (example) .....	6-9
Figure 6.2	Indicating revision numbers .....	6-10
Figure 6.3	Test flowchart .....	6-11
Figure 7.1	Format of extended sense data .....	7-2

**Tables**

Table 2.1	Model names and order numbers.....	2-1
Table 2.2	Function specifications .....	2-2
Table 2.3	Environmental/power requirements.....	2-4
Table 3.1	Zone layout and track capacity .....	3-3
Table 3.2	Format capacity.....	3-9
Table 4.1	Surface temperature check point .....	4-5
Table 5.1	Motor start mode.....	5-3
Table 6.1	Self-diagnostic functions .....	6-1
Table 6.2	System-level field troubleshooting .....	6-14
Table 6.3	Disk drive troubleshooting.....	6-15
Table 7.1	Definition of sense data .....	7-3
Table A.1	FC-SCA connector: CN1 .....	A-2

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# CHAPTER 1    **General Description**

- |   |
|---|
| <ul style="list-style-type: none"><li><b>1.1    Standard Features</b></li><li><b>1.2    Hardware Structure</b></li><li><b>1.3    System Configuration</b></li></ul> |
|---|

This chapter describes the feature and configuration of the MAS series intelligent disk drives (IDD).

IDDs are high performance large capacity 3.5 type fixed disk drives with an embedded Fibre-Channel controller.

The interface used to connect the MAS series disk drives to the host system complies with NCITS TR-19 Fibre Channel Private Loop SCSI Direct Attach (FC-PLDA), which is the Fibre Channel PLDA standard covering items ranging from Fibre Channel physical layers to SCSI command protocols.

The high-speed data transfer and long-distance transmission capabilities of Fibre Channel technology and the powerful command set of the MAS disk driver facilitate creation of high-performance and highly reliable disk subsystems with large storage capacities.

The data format can be changed from the format at factory shipment by re-initializing with the use's system. Refer to the Fibre Channel Interface Specification.

## 1.1 Standard Features

### (1) Compactness

In a compact enclosure having the 3.5-inch HDD form factor, the IDD contains an FC-AL controller, which supports the Arbitrated Loop technology (FC-AL), a Fibre Channel technology defined by the related ANSI standard.

### (2) FC-AL standard

The IDD provides not only FC-AL basic functions but also the following features:

- Arbitration
- Disconnection/Reconnection
- Data bus parity

The SCSI commands can manipulate data through logical block addressing regardless of the physical characteristics of the disk drive. This allows software to accommodate future expansion of system functions.

### (3) Dual-port support

The IDD has two pairs of driver and receiver sets for the Fibre Channel to support dual-port connection.

### (4) High-speed data transfer

The maximum data-transfer speed on the Fibre Channel loop is 212.5 MB/s. The large-capacity data buffer of the IDD enables the effective use of such high-speed data transfers available on the Fibre Channel loop.

### (5) Continuous block processing

The addressing method of data blocks is logical block address. The initiator can access data by specifying block number in a logically continuous data space without concerning the physical structure of the track or cylinder boundaries.

The continuous processing up to [64K-1] blocks in a command can be achieved, and IDD can perform continuous read/write operation when processing data blocks on several tracks or cylinder.

### (6) Programmable multi-segment data buffer

The data buffer is 32M bytes. Data is transferred between Fibre Channel Loop and disk media through this data buffer. This feature provides the suitable usage environment for users.

Since the initiator can control the disconnect/reconnect timing on the Fibre Channel Loop by specifying the condition of stored data to the data buffer or empty condition of the data buffer, the initiator can perform the effective input/output operations with utilizing high data transfer capability of the Fibre Channel Loop regardless of actual data transfer rate of the disk drive.

## (7) Cache feature

After executing the READ command, the IDD reads automatically and stores (prefetches) the subsequent data blocks into the data buffer (Read-ahead caching).

The high speed sequential data access can be achieved by transferring the data from the data buffer without reaccessing the disk in case the subsequent command requests the prefetched data blocks.

The Write Cache feature is supported. When this feature is enabled, the status report is issued without waiting for completion of write processing to disk media, thereby enabling high speed write processing.

**IMPORTANT**

*When Write Cache is enabled, you should ensure that the cached data is surely flushed to the disc media before you turn off the drive's power. To ensure it, you should issue either the SYNCHRONIZE CACHE command or the STOP UNIT command with specifying "0" to the Immediate bit, and then confirm that the command is surely terminated with the GOOD STATUS.*

## (8) Command queuing feature

The IDD can queue maximum 128 commands, and optimizes the issuing order of queued commands by the reordering function. This feature realizes the high speed processing.

## (9) Reserve and release functions

The IDD can be accessed exclusively in the multi-host or multi-initiator environment by using the reserve and release functions.

## (10) Enclosure service function

The IDD supports the enclosure service interface (ESI), which complies with SFF-8067. The ESI interface enables use of the SCSI-3 enclosure service command set (SES) so that the functions that specify and read enclosure service information can be used.

## (11) Error recovery

The IDD can try to recover from errors in Fibre Channel Loop or the disk drive using its powerful retry processing. If a recoverable data check occurs, error-free data can be transferred to the initiator after being corrected in the data buffer. The initiator software is released from the complicated error recover processing by these error recovery functions of the IDD.

- (12) Automatic alternate block reassignment  
If a defective data block is detected during read or write the IDD can automatically reassign its alternate data block.
- (13) Programmable data block length  
Data can be accessed in fixed-block length units. The data block length is programmable, and can be specified at initializing with a multiple of four within the range of 512 to 528 bytes.

## **IMPORTANT**

### *Error rate increase*

- 1. The drive format at factory shipment is generally 512 bytes.*
- 2. The recoverable Error of the drive might increase when the format would be modified from 512 bytes to the following values:  
516 bytes, 520 bytes, 524 bytes, 528 bytes.*
- 3. The recoverable Error referred here is sense data (1-13-xx).*

- (14) Defective block slipping  
A logical data block can be reallocated in a physical sequence by slipping the defective data block at formatting. This results in high speed contiguous data block processing without a revolution delay due to defective data block.
- (15) High speed positioning  
A rotary voice coil motor achieves fast positioning.
- (16) Large capacity  
A large capacity can be obtained from 3.5 type disk drives by dividing all cylinders into several partitions and changing the recording density on each partition (constant density recording). The disk subsystem with large capacity can be constructed in the good space efficiency.
- (17) Start/Stop of spindle motor  
Using the SCSI command, the host system can start and stop the spindle motor.
- (18) Diagnosis  
The IDD has a diagnostic capability which checks internal controller functions and drive operations to facilitate testing and repair.

## (19) Low power consumption

By using highly integrated LSI components, the power consumption of the IDD is very low, and this enables the unit to be used in wide range of environmental conditions.

## (20) Low noise and low vibration

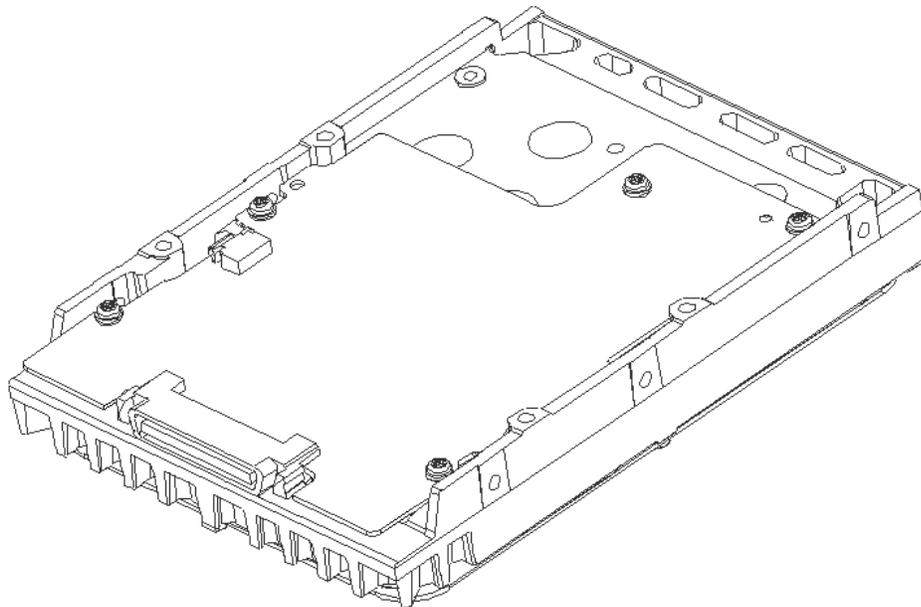
The noise level is low; approx. 3.6 Bels Ready for MAS series. This makes it ideal for office use.

## (21) Microcode downloading

The IDD implements the microcode download feature. This feature achieves easy maintainability of the IDD and function enhancing.

## 1.2 Hardware Structure

An outer view of the IDD is given in Figures 1.1. The IDD is composed of the disk, head, spindle motor, mounted disk enclosure (DE) with actuator and air circulation filter, as well as read/write pre-amp with the printed circuit assembly (PCA) of the controller.



**Figure 1.1 FC model drives outer view**

## (1) Disks

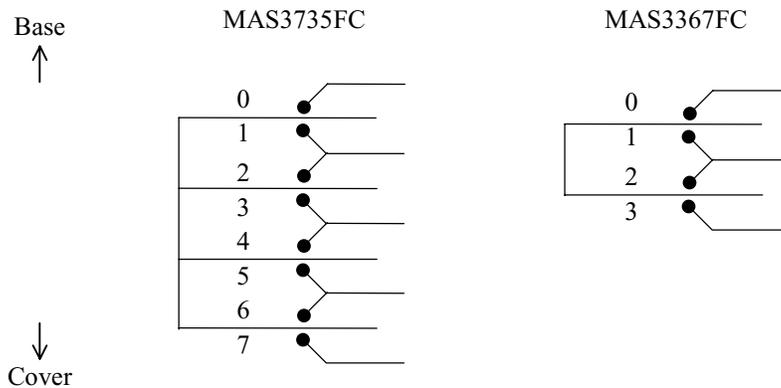
The disks have an outer diameter of 70 mm (2.8 inch) and an inner diameter of 25 mm (0.98 inch) for MAS series. The disks are good for at least 20,000 contact starts and stops. Each model contains following number of disks.

MAS3735FC: 4

MAS3367FC: 2

(2) Heads

The MR (Magnet - Resistive) of the CSS (contact start/stop) type heads are in contact with the disks when the disks are not rotating, and automatically float when the rotation is started. Figure 1.2 shows the configuration of disks and heads



**Figure 1.2 Disk/head configuration**

(3) Spindle motor

The disks are rotated by a direct-drive hall-less DC motor. The motor speed is controlled by a feedback circuit using the counter electromotive current to precisely maintain the specified speed.

(4) Actuator

The actuator, which uses a rotary voice coil motor (VCM), consumes little power and generates little heat. The heads at the end of the actuator arm is controlled and positioned via feedback of servo information in the data.

The heads are positioned on the CCS zone over the disks when the power is off or the spindle motor is stopped.

(5) Air circulation (recirculation filter, breather filter)

The disk enclosure (DE) configures a clean room to keep out particles and other contaminants. The DE has a closed-loop air recirculation system. Using the movement of the rotating disks, air is continuously cycled through a filter. This filter will trap any particles floating inside the enclosure and keep the air inside the DE contaminant free. To prevent negative pressure in the vicinity of the spindle when the disks begin rotating, a breather filter is attached. The breather filter also equalizes the internal air pressure with the atmospheric pressure due to surrounding temperature changes.

## (6) Read/write circuit

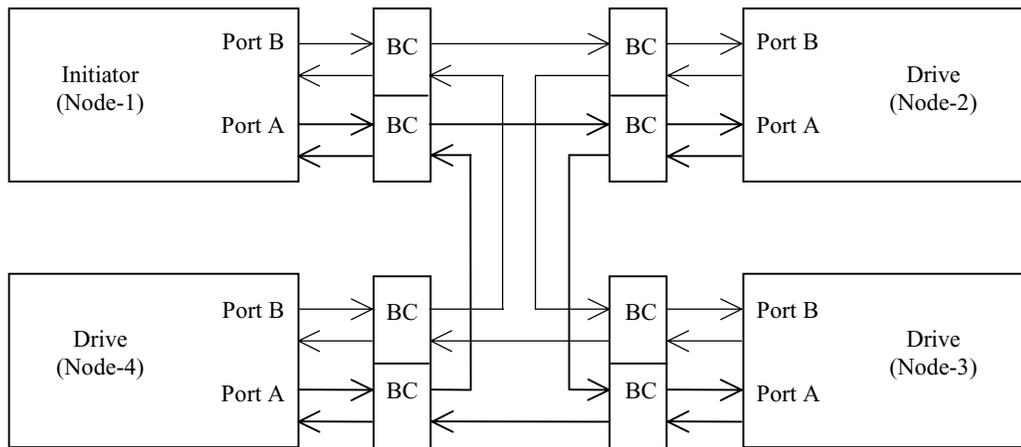
The read/write circuit utilizes a read channel mounted with a head IC that supports high-speed transmission and an MEEPR4ML (Modified Enhanced Extended Partial Response Class 4 Maximum Likelihood) modulation/demodulation circuit in order to prevent errors being triggered by external noise and to improve data reliability.

## (7) Controller circuit

The controller circuit uses LSIs to increase the reliability and uses a high speed microprocessing unit (MPU) to increase the performance of the SCSI controller.

### 1.3 System Configuration

For the Fibre Channel, the ANSI standard defines Arbitrated Loop, Fabric, and Point-to-Point technologies. The MAS series disk drives support the Arbitrated Loop technology. Figure 1.3 gives an example of the FC-AL system configuration.



**Figure 1.3 Example of FC-AL system configuration**

Any device connected to the Fibre Channel is called a node. The nodes shown in Figure 1.3 represent the initiator and individual disk drives. Each node has at least one port called an N<sub>port</sub>. For FC-AL, each port is called a Node-Loop port (NL<sub>port</sub>).

The MAS series disk drive has two ports, one of which is used for connections to an FC-AL. A maximum of 126 NL<sub>ports</sub> can be connected to a single port.

(1) Loop configuration

A port embedded with sending and receiving circuits uses differential signals to send and receive data on electric signal lines. A pair of signal lines is called a link. Since signals are sent in one direction on a link, the links in a system must be connected to form a loop. The FC-AL interface sends and receives data via nodes on the loop. Therefore, if a node connected to a loop is powered off or the interface signals of a node cannot be sent or received correctly, the loop does not work normally. A common solution preventing this problem from occurring is to add a port bypass circuit on the back plane of the system. BC in Figure 1.3 indicates the port bypass circuit.

(2) Node addressing

A specific device number called a SEL ID is assigned to each node on a Fibre Channel loop. The combination of signal levels on the back plane is used to define the SEL ID of a disk drive. The signal levels are sent on the seven signals (from SEL\_0 to SEL\_6) from CN1, which serves as an SCA interface connector. SEL\_6 is the most significant bit (MSB), having a bit weight of the sixth power of 2, and SEL\_0 is the least significant bit (LSB), having a bit weight of the zeroth power of 2. Any number from 0 (X'00) to 125 (X'7D) can be assigned as the SEL ID of a disk drive.

## CHAPTER 2 Specifications

### 2.1 Hardware Specifications

This chapter describes specifications of the IDD.

#### 2.1 Hardware Specifications

##### 2.1.1 Model name and order number

Each model has a different recording capacities when shipped.

Table 2.1 lists the model name and order number.

The data format can be changed by reinitializing with the user's system.

**Table 2.1 Model names and order numbers**

Model name	Order number	Interface type	Capacity (user area)	Number of disks	Number of heads
MAS3735FC	CA06244-B400	SCA2, FC-AL	73.49 GB (*)	4	8
MAS3367FC	CA06244-B200	SCA2, FC-AL	36.77 GB (*)	2	4

(\*) 1GB = 1,000,000,000 bytes

2.1.2 Function specifications

Table 2.2 shows the function specifications of the IDD.

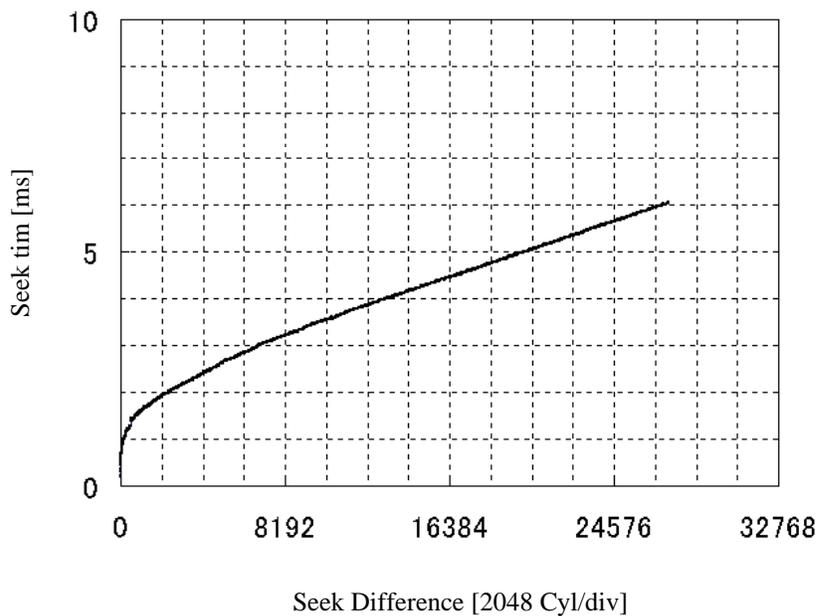
**Table 2.2 Function specifications**

Item		Specification	
		MAS3735FC	MAS3367FC
Formatted capacity/device (*1)		73.49 GB (*6)	36.77 GB (*6)
Number of disks		4	2
Number of heads		8	4
Number of cylinders (*2)		27,094	27,150
Formatted capacity/track (B)		285,696 to 360,960	
Number of rotations min <sup>-1</sup> (rpm)		15,000 ± 0.2%	
Average latency time		2.00 msec	
Seek time (*3) (Read/Write)	Track to Track	0.3 ms/0.5 ms	
	Average	3.3 ms/3.8 ms	
	Full stroke	8.0 ms/9.0 ms	
Start/stop time (*4)	Start time	30 s typ. (60 s max.)	
	Stop time	30 s typ.	
Recording mode		32/34 MEEPRML	
External dimensions	Height:	25.4 mm	
	Width:	101.6 mm	
	Depth:	146.0 mm	
Weight (max)		0.80kg	
Power consumption (*5)		13.0 W	10.2 W
Interface		Cable length: 30 m max	
Data transfer rate	Disk drive	93.11 to 118.22 MB/s	
	FC-AL	212.5 MB/s max.	
Logical data block length		512 to 528 byte (Fixed length)	
Command specification		FC-PLDA (NCITS TR-19), FC-PH (ANSI X3.230-1994), FC-PH-2 (ANSI X3.297-1996), FC-AL (ANSI X3.272-199X), SCSI-FCP (ANSI X3.269-199X)	
Data buffer		32 MB FIFO ring buffer (*7)	
Acoustic noise (Ready)		3.6 Bels typ. (4.1 Bels max.)	

(\*1) The formatted capacity can be changed by changing the logical block length and using spare sector space. See Chapter 3 for the further information. The formatted capacity listed in the table is an estimate for 512 bytes per sector.

(\*2) The number of user cylinders indicates the max., and includes the alternate cylinder. The number of user cylinders and alternate cylinders can be specified at format of the IDD.

(\*3) The positioning time is as follows:



- (\*4) The start time is the time from power on or start command to when the IDD is ready, and the stop time is the time for disks to completely stop from power off or stop command.
- (\*5) This value indicates at ready mode.
- (\*6) 1GB = 1,000,000,000 bytes
- (\*7) 1MB = 1,048,576 bytes

2.1.3 Environmental specifications

Table 2.3 lists environmental and power requirements.

**Table 2.3 Environmental/power requirements**

Item		Specification		
		MAS3735FC	MAS3367FC	
Temperature (*1)	Operating	5 to 55°C		
	Non-operating	-10 to 70°C		
	Transport (within a week)	-40 to 70°C		
	DE surface temperature at operating	5 to 60°C		
	Gradient	15°C/h or less		
Relative humidity	Operating	5 to 95%RH		
	Non operating	5 to 95%RH		
	Transport (within a week)	5 to 95%RH		
	Maximum wet bulb temperature	29°C (no condensation)		
Vibration (*2)	Operating (*3)	0.6 mm (5 to 20Hz)/9.8 m/s <sup>2</sup> (1G) (20 to 300 Hz) or less		
	Non-operating (*4)	3.1 mm (5 to 20Hz)/49m/s <sup>2</sup> (5G) (20 to 300Hz) or less		
	Transport (packaged)	3.1 mm (5 to 20Hz)/49m/s <sup>2</sup> (5G) (20 to 300Hz) or less		
Shock (*2)	Operating	637.4m/s <sup>2</sup> (65G) (2 ms)		
	Non-operating	2451.7m/s <sup>2</sup> (250G) (2 ms)		
	Transport (packaged)	2451.7m/s <sup>2</sup> (250G) (2 ms)		
Altitude (above sea level)	Operating	-300 m to 3,000 m		
	Non-operating	-300 m to 12,000 m		
Power requirements Input power (*5)	+12 VDC ±5%	Ready (Average)	0.75 A	0.52 A
		Peak within 100 μs at spin-up	3.0 A	
		Random W/R (about 80 IOPS)	1.0 A	
	+5 VDC ±5%	Ready (Average)	0.8 A	
		Random W/R (about 80 IOPS)	1.3 A	
	Ripple (*6)	+5 V/+12 V 250 mVp-p		

- (\*1) For detail condition, see Section 4.1.
- (\*2) Vibration applied to the drive is measured at near the mounting screw hole on the frame as much as possible.
- (\*3) At random seek write/read and default on retry setting with log sweep vibration.
- (\*4) At power-off state after installation  
Vibration displacement should be less than 2.5 mm.
- (\*5) Input voltages are specified at the drive connector side, during drive ready state.
- (\*6) High frequency noise (over 20MHz) is less than 100 mVp-p.

#### 2.1.4 Error rate

Errors detected during initialization and replaced by alternate block assignments are not included in the error rate. Data blocks to be accessed should be distributed over the disk medium equally.

- (1) Unrecoverable error rate

Errors which cannot be recovered within 63 retries and ECC correction should not exceed 1 per  $10^{15}$  bits.



*Data loss*

*For MAS series, Reed Solomon codes are applied for their ECC. The sector-data is divided into 4 interleaving sectors, and ECC is performed in each sector where the maximum number of errors (up to 5 byte) can be corrected. [Total maximum byte: 5 byte  $\times$  4 (interleave) = 20 byte]*

*If the error of read sector keeps allowable error byte number, correction is performed. However, if error byte exceeds its allowable number, correction may not be performed properly.*

- (2) Positioning error rate

Positioning errors which can be recovered by one retry should be 10 or less per  $10^8$  seeks.

#### 2.1.5 Reliability

- (1) Mean Time Between Failures (MTBF)

MTBF of the IDD during its life time is 1,200,000 hours (operating: 24 hours/day, 7 days/week average DE surface temperature: 50°C or less).

**Note:**

The MTBF is defined as:

$$\text{MTBF} = \frac{\text{Operating time (hours) at all field sites}}{\text{The number of equipment failures from all field sites}}$$

Failure of the equipment means failure that requires repair, adjustments, or replacement. Mishandling by the operator, failures due to bad environmental conditions, power trouble, host system trouble, cable failures, or other failures not caused by the equipment are not considered.

(2) Mean Time To Repair (MTTR)

MTTR is the average time taken by a well-trained service mechanic to diagnose and repair a drive malfunction. The drive is designed for a MTTR of 30 minutes or less.

(3) Service life

The service life under suitable conditions and treatment is as follows.

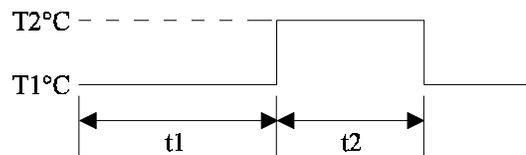
The service life is depending on the environment temperature. Therefore, the user must design the system cabinet so that the average DE surface temperature is as possible as low.

- DE surface temperature: 40°C or less      5 years
- DE surface temperature: 41°C to 45°C      4.5 years
- DE surface temperature: 46°C to 50°C      4 years
- DE surface temperature: 51°C to 55°C      3.5 years
- DE surface temperature: 56°C to 60°C      3 years
- DE surface temperature: 61°C and more      Strengthen cooling power so that DE surface temperature is 60°C or less.

Even if the IDD is used intermittently, the longest service life is 5 years.

**Note:**

The "average DE surface temperature" means the average temperature at the DE surface throughout the year when the IDD is operating.



$$\text{Average DE surface temperature} = \frac{T1 \times t1 + T2 \times t2}{t1 + t2}$$

- (4) Data security at power failure  
Integrity of the data on the disk is guaranteed against all forms of DC power failure except on blocks where a write operation is being performed. The above does not applied to formatting disks or assigning alternate blocks.

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## CHAPTER 3 Data Format

### 3.1 Data Space

### 3.2 Logical Data Block Addressing

### 3.3 Defect Management

This chapter explains data space definition, logical data block addressing, and defect management on the IDD.

### 3.1 Data Space

The IDD manages the entire data storage area divided into the following three data spaces.

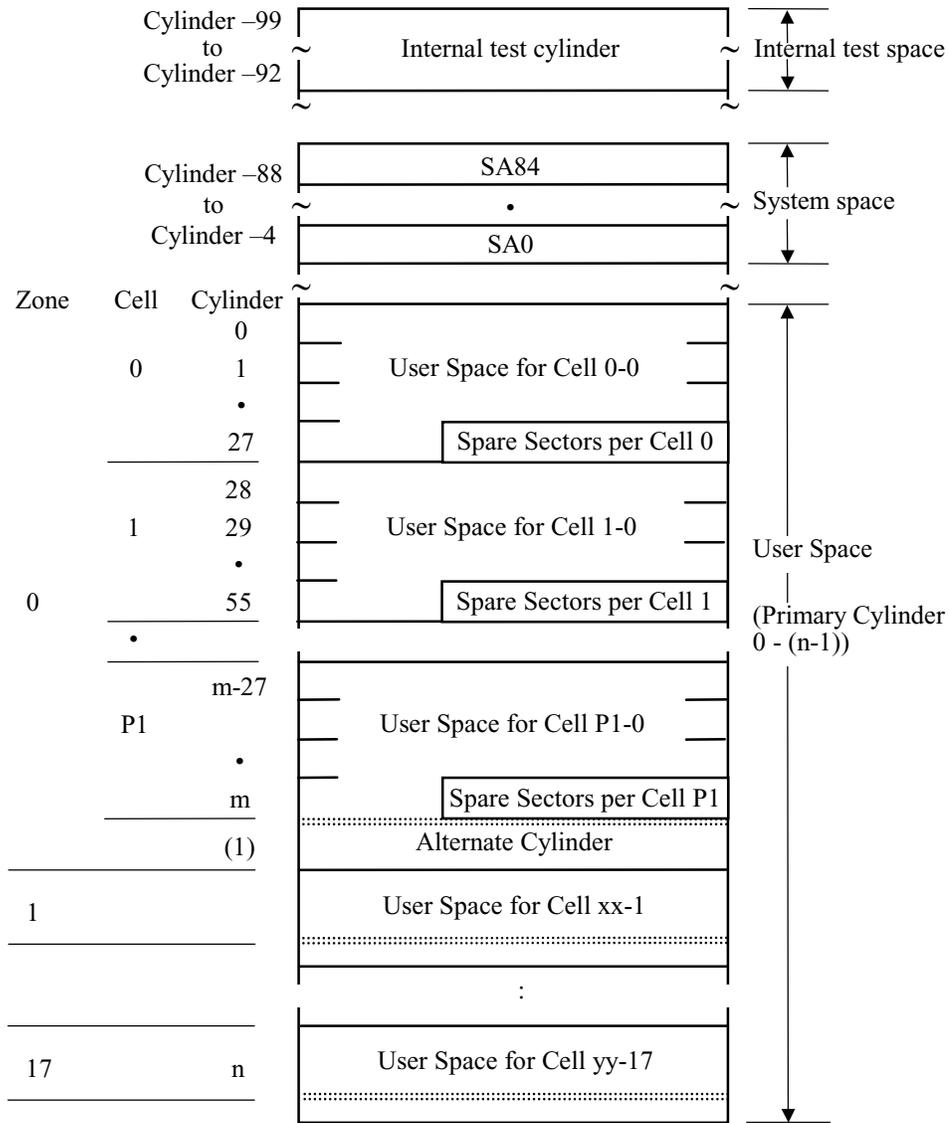
- User space: Storage area for user data
- Internal test space: Reserved area for diagnostic purposes
- System space: Area for exclusive use of IDD itself

The user space allows a user access by specifying data. These space can be accessed with the logical data block addressing method described in Section 3.2. The internal test space is used by Read/write test of self-diagnostics test, but user can't use direct access. The system space is accessed inside the IDD at power-on or during the execution of a specific command, but the user cannot directly access the system space.

#### 3.1.1 Cylinder configuration

The IDD allocates cylinders to the user space, Internal test space, and system space. Figure 3.1 is the cylinder configuration.

Spare areas (alternate areas) for defective sectors are provided in the user space. Several sectors in the last track of one cell and several cell (alternate cylinders) in the user space are allocated as alternate areas according to the user's assignment (MODE SELECT command). See Subsection 3.1.2 for details.



n = 27,093 (MAS3735FC)  
 27,149 (MAS3367FC)

Note: Spare sectors on the last track in each cylinder are not necessarily placed at the end of the track because of a track skew or a cylinder skew. (Details are explained in Subsection 3.1.3.)

**Figure 3.1 Cylinder configuration**

Apart from the above logical configuration, the IDD intends to increase the storage capacity by dividing all cylinders into several zones and changing a recording density of each zone. Tables 3.1 to 3.3 show the zone layout and the track capacity.

**Table 3.1 Zone layout and track capacity**

Zone	Cylinder		Byte/track	Sector/track
	MAS3735FC	MAS3367FC		
0	0 - 1,848		360,960	705
1	1,849 - 3,697		360,960	705
2	3,698 - 5,546		360,960	705
3	5,547 - 7,395		360,960	705
4	7,396 - 9,244		360,960	705
5	9,245 - 11,093		360,960	705
6	11,094 - 12,298		359,424	702
7	12,299 - 14,315		350,208	684
8	14,316 - 16,080		340,992	666
9	16,081 - 17,173		336,384	657
10	17,174 - 19,330		331,776	648
11	19,331 - 20,255		322,560	630
12	20,256 - 21,404		317,952	621
13	21,405 - 22,469		313,344	612
14	22,470 - 24,514		304,128	594
15	24,515 - 26,195		294,912	576
16	26,196 - 26,840		290,304	567
17	26,841 - 27,093	26,841 - 27,149	285,696	558

Note: When the logical data block length is 512 bytes, the sector/track capacity indicates above amount

(1) User space

The user space is a storage area for user data. The data format on the user space (the length of data block and the number of data blocks) can be specified with the MODE SELECT or MODE SELECT EXTENDED command.

The default value of cylinders in the user space is MAS3735FC = 27,094, MAS3367 FC = 27,150. These also equal the maximum cylinders number for each series. The user can also specify the number of logical data blocks to be placed in the user space with the MODE SELECT or MODE SELECT EXTENDED command. When the number of logical data blocks is specified, as many cylinders as required to place the specified data blocks are allocated in the user space.

A number starting with 0 is assigned to each cylinder required in the user space in ascending order. If the number of cylinders do not reach the maximum, the rest of the cylinders will not be used.

Always one cylinder that is located at the end of each zone in the user space can be established as an alternate cylinder. Alternate cylinders will be used for alternate blocks when primary cylinders in the user space are used up. See Subsections 3.1.2 and 3.3.2 for details.

(2) Internal test space

The Internal test space is an area for diagnostic purposes only and its data block length is always 512KByte. The Internal test space consists of 8 cylinders and outer-host cylinder is always assigned. The user cannot change the number of cylinders in the Internal test space or their positions.

(3) System space

The system space is an area for exclusive use of the IDD itself and the following information are recorded.

- Defect list (P list and G list)
- MODE SELECT parameter (saved value)
- Statistical information (log data)
- Controller control information

The above information is duplicated in several different locations for safety.

**Note:**

The system space is also called SA space.

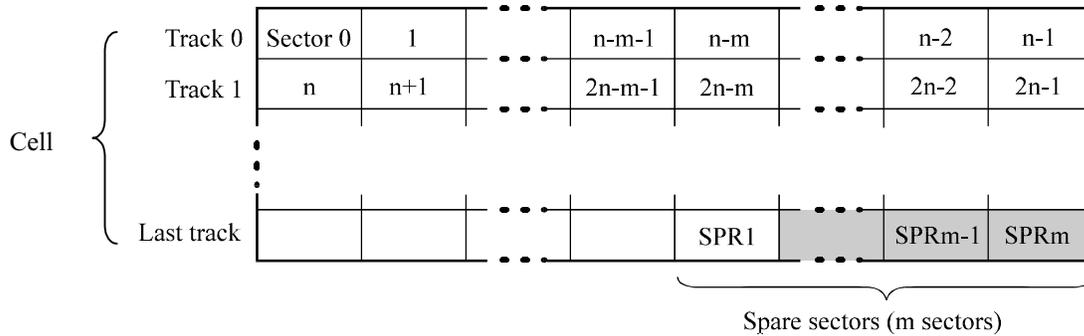
### 3.1.2 Alternate spare area

The alternate spare area consists of the last track of each cell in the user space and an alternate cylinder allocated to the last cylinder of each zone.

The spare area in each cell is placed at the end of the last track as shown in Figure 3.2. These spare sectors are located in the end of the track logically, not necessarily located at the end physically because of track skew or cylinder skew. (Details are explained on Subsection 3.1.3.)

Size can be specified by the MODE SELECT command.

The number of spare sectors per cell can be specified from 0 to 168. The default for the spare sectors number is 168.

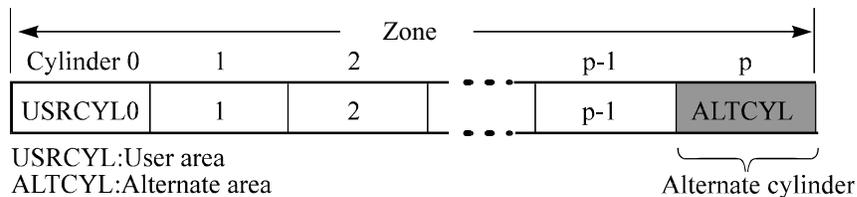


**Note:** This drive manages alternate spare areas for each cell, which is a set of cylinders. One cell consists of 28 cylinders.

**Figure 3.2 Spare area in cell**

An alternate cylinder is used when spare sectors in a cell are used up or 0 is specified as the number of spare sectors in a cell. 1 cylinder at the end of each zone of the user space is allocated as alternate cylinders as shown in Figure 3.3.

The user space and the CE space share the alternate cylinders.



**Figure 3.3 Alternate cylinder**

**Note:**

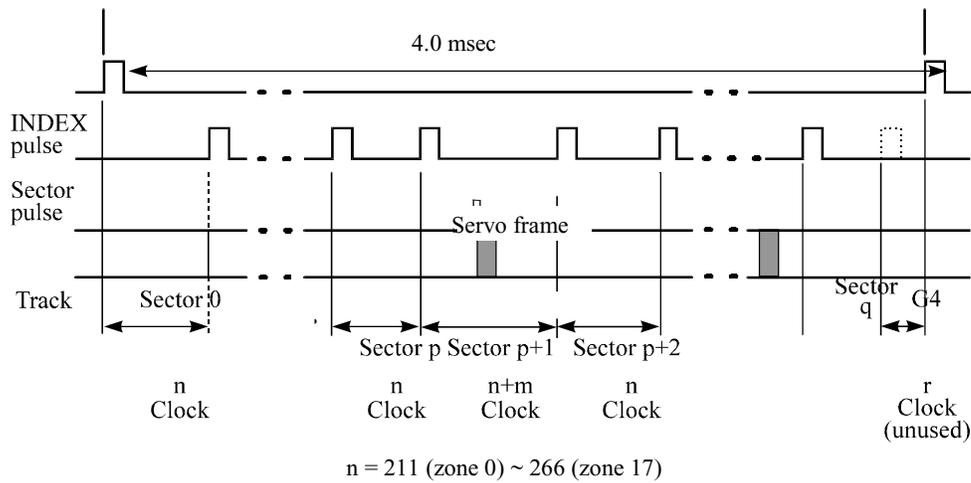
The number of alternate cylinders can not be changed.

### 3.1.3 Track format

#### (1) Physical sector allocation

Figure 3.4 shows the allocation of the physical sectors in a track. The length in bytes of each physical sector and the number of sectors per track vary depending on the logical data block length. The unused area (G4) exists at the end of the track in formats with most logical data block lengths.

The interval of the sector pulse (length of the physical sector) is decided by multiple of 40MHz free running frequency. This clock is not equal to the interval of the byte clock for each zone. Therefore, the physical sector length cannot be described with a byte length.



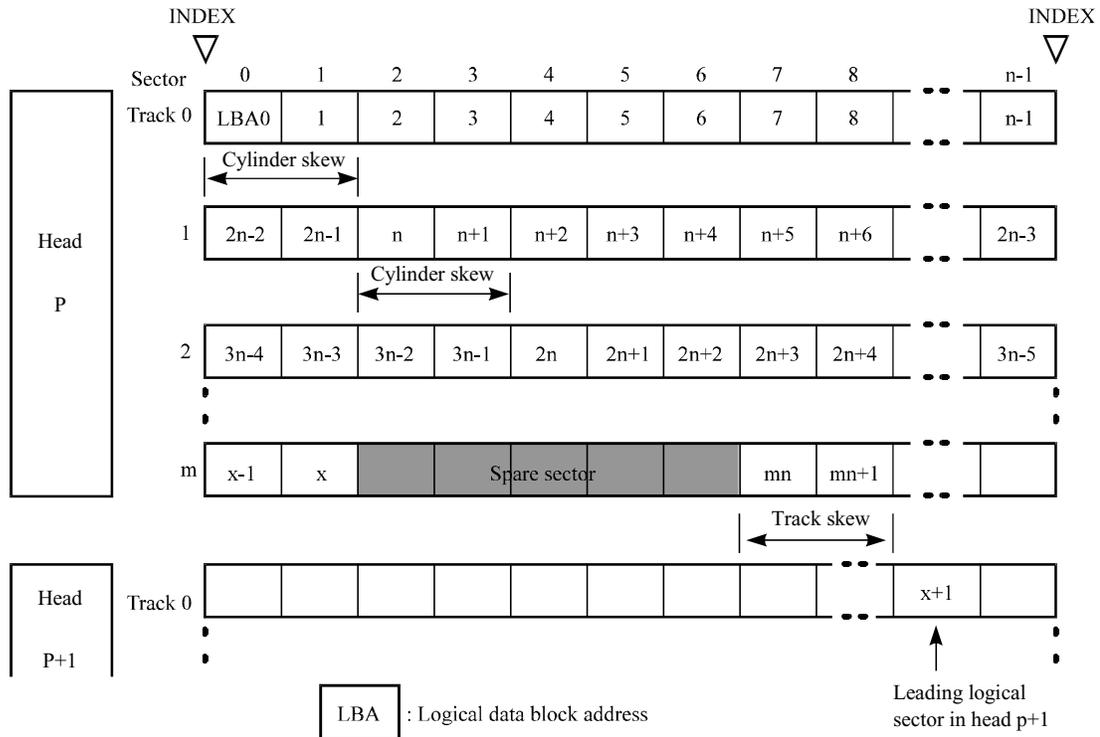
**Figure 3.4 Track format**

(2) Track skew and head skew

To avoid waiting for one turn involved in head and cylinder switching, the first logical data block in each track is shifted by the number of sectors (track skew and head skew) corresponding to the switching time. Figure 3.5 shows how the data block is allocated in each track.

At the head switching location in a cylinder, the first logical data block in track  $t + 1$  is allocated at the sector position which locates the track skew behind the sector position of the last logical data block sector in track  $t$ .

At the cylinder switching location, like the head switching location, the first logical data block in a cylinder is allocated at the sector position which locates the head skew behind the last logical sector position in the preceding cylinder. The last logical sector in the cylinder is allocated when formatting, and is an unused spare sector.

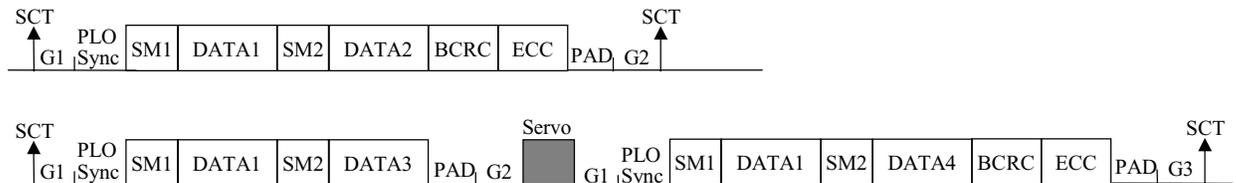


**Figure 3.5 Track skew/head skew**

The number of physical sectors (track skew factor and head skew factor) corresponding to the skew time varies depending on the logical data block length because the track skew and the head skew are managed for individual sectors. The IDD automatically determines appropriate values for the track skew factor and the head skew factor according to the specified logical data block length. The value can be read out by the MODE SENSE or MODE SENSE EXTENDED command after the track has been formatted.

### 3.1.4 Sector format

Each sector on the track consists of an ID field, a data field, and a gap field which separates them. Figure 3.6 gives sector format examples.



**Figure 3.6 Sector format**

Each sector on the track consists of the following fields:

(1) Gaps (G1, G2, G3)

No pattern is written on the gap field.

(2) PLO Sync

In this field, pattern X'00' is written.

(3) Sync Mark (SM1, SM2)

In this field, special pattern is written. This special pattern indicates the beginning of the data field.

(4) Data field (DATA1-DATA4)

User data is stored in the data field of the sector. The length of the data field is equal to that of the logical data block which is specified with a parameter in the MODE SELECT command. Any multiple of 4 between 512 and 528 bytes can be specified as the length.

(5) BCRC

It is a 4-byte error detection code. Errors in the ID field. Single burst errors with lengths of up to 32 bits for each logical block can be detected.

(6) ECC

This is the 40-byte code that allows detection and correction of errors in the data field, which is capable of correcting the single burst error up to 160 bits max. on the fly.

(7) PAD

A specified length of x'00' pattern is written in this field. This field includes the variation by rotation and circuit delay till reading/writing.

### 3.1.5 Format capacity

The size of the usable area for storing user data on the IDD (format capacity) varies according to the logical data block or the size of the spare sector area. Table 3.2 lists examples of the format capacity when the typical logical data block length and the default spare area are used. The following is the general formula to calculate the format capacity.

$$[\text{Number of sectors of each zone}] = [\text{number of sectors per track} \times \text{number of tracks per cell} - \text{number of alternate spare sectors per cell}] \times [\text{number of cells in the zone}]$$

$$[\text{Formatted capacity}] = [\text{total of sectors of all zones}] \div [\text{number of physical sectors in logical block}] \times [\text{logical data block length}]$$

The following formula must be used when the number of logical data blocks are specified with the parameter in the MODE SELECT or MODE SELECT EXTENDED command.

$$[\text{Format capacity}] = [\text{logical data block length}] \times [\text{number of logical data blocks}]$$

The logical data block length, the maximum logical block address, and the number of the logical data blocks can be read out by a READ CAPACITY, MODE SENSE, or MODE SENSE EXTENDED command after initializing the disk medium.

**Table 3.2 Format capacity**

Model	Data heads	Data block length	User blocks	Format capacity (GB)
MAS3735FC	8	512	143,552,136	73.49 (*)
MAS3367FC	4		71,819,496	36.77 (*)

(\*) 1GB = 1,000,000,000 bytes

**Note:**

Total number of spare sectors is calculated by adding the number of spare sectors in each primary cylinder and the number of sectors in the alternate cylinders.

## 3.2 Logical Data Block Addressing

Independently of the physical structure of the disk drive, the IDD adopts the logical data block addressing as a data access method on the disk medium. The IDD relates a logical data block address to each physical sector at formatting. Data on the disk medium is accessed in logical data block units. The INIT specifies the data to be accessed using the logical data block address of that data.

The logical data block addressing is a function whereby individual data blocks are given addresses of serial binaries in each drive.

(1) Block address of user space

The logical data block address number is consecutively assigned to all of the data blocks in the user space starting with 0 to the first data block.

The IDD treats sector 0, track 0, cylinder 0 as the first logical data block. The data block is allocated in ascending order of addresses in the following sequence (refer to Figure 3.5):

- 1) Logical data blocks are assigned in ascending order of sector number in the same track.
- 2) Subsequent logical data blocks are assigned to sectors in every track except the last track in ascending order of track number in the same track (head). Within the same track, logical data blocks are assigned in the same way as step 1).
- 3) Subsequent logical data blocks are assigned to sectors in every track except the last track in ascending order of track number in the same cell. Within the same track, logical data blocks are assigned in the same way as step 1).
- 4) For the last track in the same cell, subsequent logical data blocks are assigned to sectors other than spare sectors in ascending order of sector number.
- 5) After blocks have been assigned in the same cell according to steps 1) to 4), subsequent logical data blocks are assigned in ascending order of cell number in the same way as in steps 1) to 4). Logical data blocks are assigned starting from track 0 in the next cell until the last cylinder (immediately preceding the alternate cylinder n-1 shown in Figure 3.1) of the zone except alternate cylinders in cells in the user space.

When the logical data block is allocated, some sectors (track skew and head skew) shown in Figure 3.5 are provided to avoid waiting for one turn involving head and cylinder switching at the location where the track or the head is physically switched.

See Subsection 3.3.2 for defective/alternate block treatment and the logical data block allocation method in case of defective sectors exist on the disk.

(2) Alternate area

Alternate areas in the user space (spare sectors in the cell and alternate cylinders) are not included in the above logical data block addresses. Access to sectors which are allocated as an alternate block in the alternate area is made automatically by means of IDD sector slip treatment or alternate block treatment (explained in Subsection 3.3.2), so the user does not have to worry about accessing the alternate area. The user cannot access with specifying the data block on the alternate area explicitly.

### 3.3 Defect Management

#### 3.3.1 Defect list

Information of the defect location on the disk is managed by the defect list. The following are defect lists which the IDD manages.

- P list (Primary defect list): This list consists of defect location information available at the disk drive shipment and is recorded in a system space. The defects in this list are permanent, so the INIT must execute the alternate block allocation using this list when initializing the disk.
- D list (Data defect list): This list consists of defect location information specified in a FORMAT UNIT command by the INIT at the initialization of the disk. This information is recorded in the system space of the disk drive as the G list. To execute the alternate block allocation, the FORMAT UNIT command must be specified.
- G list (Growth defect list): This list consists of defective logical data block location information specified in a REASSIGN BLOCKS command by the INIT, information on defective logical data blocks assigned alternate blocks by means of IDD automatic alternate block allocation, information specified as the D list, and information generated as the C list. They are recorded in the system space on the disk drive.

The INIT can read out the contents of the P and G lists by the READ DEFECT DATA command.

#### 3.3.2 Alternate block allocation

The alternate data block is allocated to a defective data block (= sectors) in defective sector units by means of the defect management method inside the IDD.

The INIT can access all logical data blocks in the user space, as long as there is no error.

Spare sectors to which alternate blocks are allocated can be provided in either "spare sectors in a cell" or "alternate cylinders". See Subsection 3.1.2 for details.

The INIT can specify the size and area for spare sectors by the MODE SELECT command at the time of the initialization of the disk.

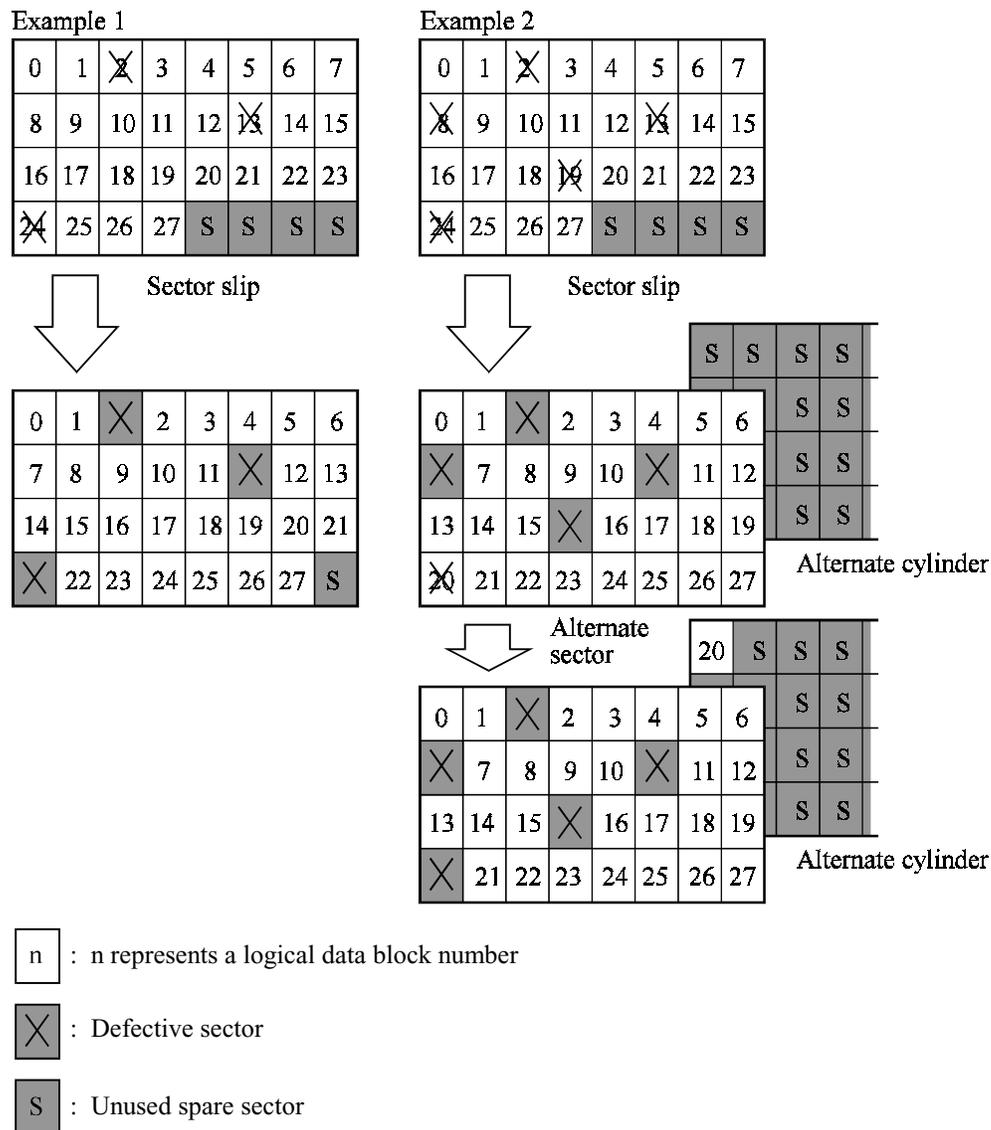
Both of the following are applicable to the alternate block allocation.

- Sector slip treatment: Defective sectors are skipped and the logical data block corresponding to those sectors is allocated to the next physical sectors. This treatment is made on the same cell as the defective sector's and is effective until all spare sectors in that cell are used up.
- Alternate sector treatment: The logical data block corresponding to defective sectors is allocated to unused spare sectors in the same cell or unused spare sectors in the alternate cylinder.

The alternate block allocation is executed by the FORMAT UNIT command, the REASSIGN BLOCKS command, or the automatic alternate block allocation. Refer to OEM Manual–Fibre Channel Specifications–for details of specifications on these commands. The logical data block is allocated to the next physically continued sectors after the above sector slip treatment is made. On the other hand, the logical data block is allocated to spare sectors which are not physically consecutive to the adjacent logical data blocks. If a command which processes several logical data blocks is specified, the IDD processes those blocks in ascending order of logical data block.

(1) Alternate block allocation during FORMAT UNIT command execution

When the FORMAT UNIT command is specified, the allocation of the alternate block to those defective sectors included in the specified lists (P, G, or D) is continued until all spare sectors in the same cell are used up. When they are used up, unused spare sectors in the alternate cylinder are allocated to the subsequent sectors in the cylinder by means of alternate sector treatment. Figure 3.7 is examples of the alternate block allocation during the FORMAT UNIT command execution.



**Figure 3.7 Alternate block allocation by FORMAT UNIT command**

During FORMAT UNIT command, alternate block allocation is conducted in following cases:

- 1) Unrecovered write offtrack condition during a media write
- 2) Uncorrectable Data Error during a media read (certification) \*1

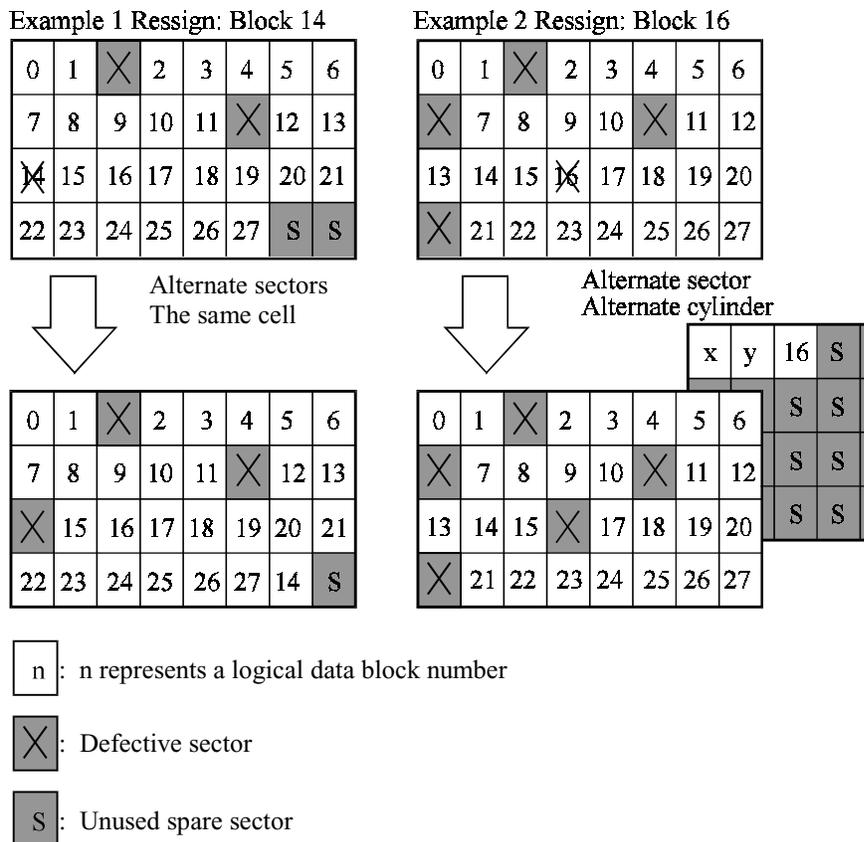
If above errors are detected during FORMAT UNIT command, the IDD allocates the alternate block(s) to the defective data blocks. Reassign procedure itself is the same as one in REASSIGN BLOCKS command.

\*1 Certification is permitted when DCRT flag is cleared (DCRT flag=0) in FORMAT UNIT command.  
 The IDD checks all initialized logical data blocks by reading them out after the above alternate block allocation is made to initialize (format) the disk.

(2) Alternate block allocation by REASSIGN BLOCKS command

When the REASSIGN BLOCKS command is specified, the alternate block is allocated to the defective logical data block specified by the initiator by means of alternate sector treatment. If there are unused spare sectors in the same cell as the specified defective logical data block, the alternate block is allocated to these unused spare sectors. However, the alternate block is allocated to unused spare sectors in the alternate cylinder when all spare sectors in the cell are used up.

Figure 3.8 is examples of the alternate block allocation by the REASSIGN BLOCKS command.



**Figure 3.8** Alternate block allocation by REASSIGN BLOCKS command

- (3) Automatic alternate block allocation
- Automatic alternate block allocation at read operation

If the ARRE flag in the MODE SELECT parameter permits the automatic alternate block allocation, the IDD automatically executes the alternate block allocation and data duplication on the defective data block detected during the READ or READ EXTENDED command. This allocation method is the same as with the REASSIGN BLOCKS command (alternate sector treatment).

- Automatic alternate block allocation at write operation

If AWRE flag in the MODE SELECT parameter permits the automatic alternate block allocation, the IDD executes two kinds of automatic alternate processing during WRITE command processing as described below:

Type 1 (Reassignment of Uncorrectable Read Error)

1) Commands to be applied

- WRITE
- WRITE EXTEND
- WRITE at executing WRITE AND VERIFY

2) Application requirements

When any of the above commands is issued to LBA registered in the uncorrectable error log of the READ command (LBA log of uncorrectable error while the READ command is executed), the AWRE processing is applied.

3) AWRE processing

The following processings are performed when the LBA matches the one in the uncorrectable error log:

a) Primary media check

- Creates an uncorrectable error pattern (invalid LBA pattern) in the position of the error LBA, repeats the primary media check up to three times. If the error still occurs after the check repeated three times, it is judged to be defective. Then, it performs the alternate processing.

b) Alternate processing

- Alternate media check  
Writes the data that causes an unrecoverable error into the alternate block, and performs the media check.  
(If the alternate block is a defective sector, the block is registered to the G list, another alternate block is allocated.)

c) SA and defect map update processing (on alternate side)

When an error occurs in the alternate processing, this WRITE command terminates with error.

When the alternate processing normally terminates, the WRITE command is executed.

Depending on the alternate processing result, one of the following sense codes is returned:

- Alternate processing is succeeded: 01-OC-01
- Fatal error (SA write retry out): 03-OC-02

Type 2 (Reassignment of write fail sector)

1) Commands to be applied

- WRITE command
- WRITE EXTENDED command

2) Application requirements / processing

When 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 that has already been re-assigned.

Remark:

When a write protection is prohibited through the setting terminal, the auto alternate block allocation processing specification is disabled.

## IMPORTANT

*Automatic alternate block allocation is made only once during the execution of one command. If second defective block is detected, the alternate block assignment processing for the first defective block is executed but the alternate block assignment processing for the second one is not executed and the command being executed terminates. However, the initiator can recover the twice error by issuing the same command again.*

*When an error is detected in a data block in the data area, recovery data is rewritten and verified in automatic alternate block allocation during the execution of the READ or READ EXTENDED command. Alternate block allocation will not be made for the data block if recovery is successful.*

*Example: Even if the data error which is recoverable by the WRITE LONG command is simulated, automatic alternate block allocation will not be made for the data block.*

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## CHAPTER 4    Installation Requirements

- |   |
|---|
| <ul style="list-style-type: none"><li><b>4.1    Mounting Requirements</b></li><li><b>4.2    Power Supply Requirements</b></li><li><b>4.3    Connection Requirements</b></li></ul> |
|---|

This chapter describes the environmental, mounting, power supply, and connection requirements.

### **4.1    Mounting Requirements**

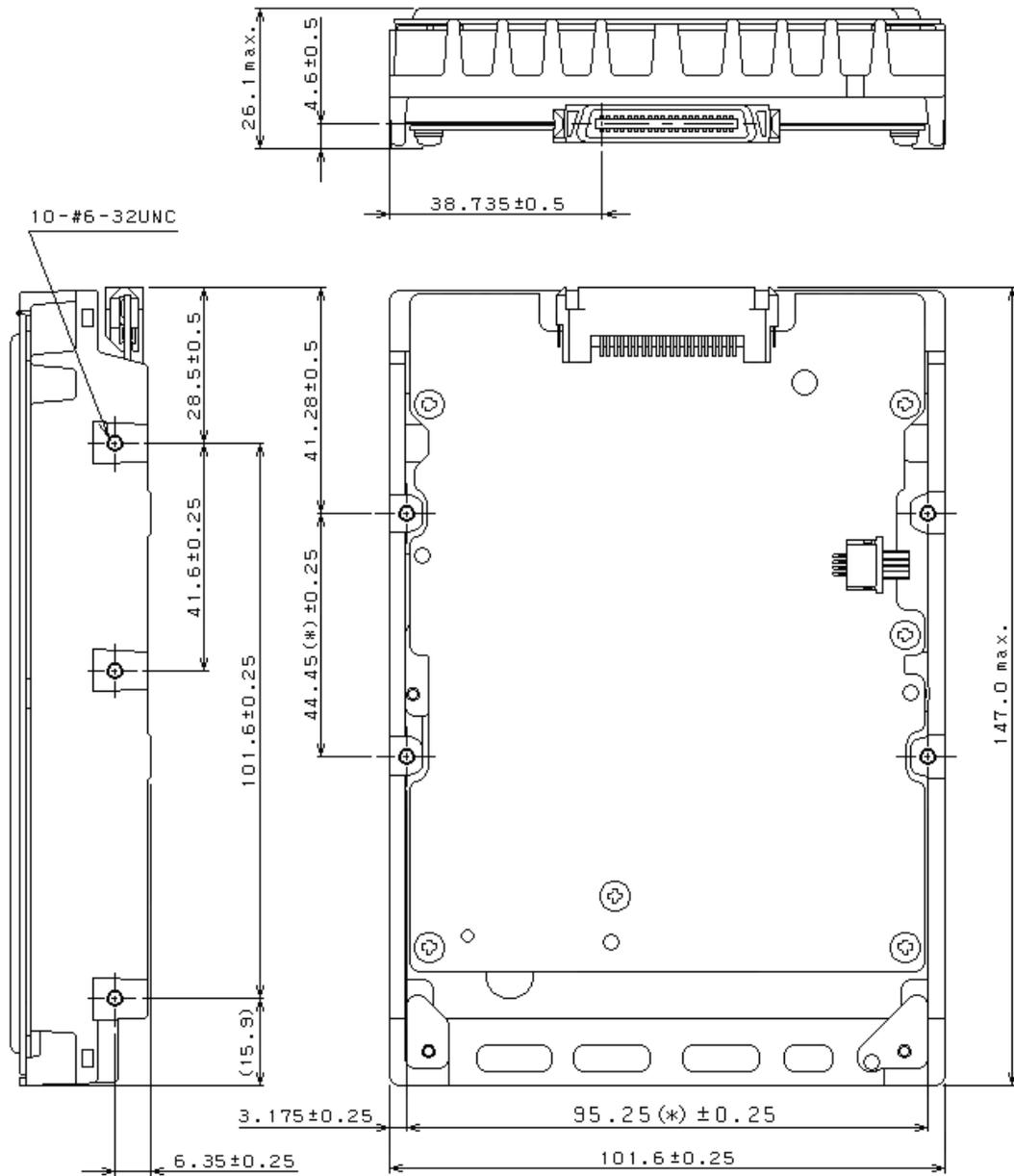
#### **4.1.1    External dimensions**

Figures 4.1 show the external dimensions of the IDD and the location of the holes for the IDD mounting screws.

**Note:**

Dimensions are in mm.

Mounting screw: #6-32UNC

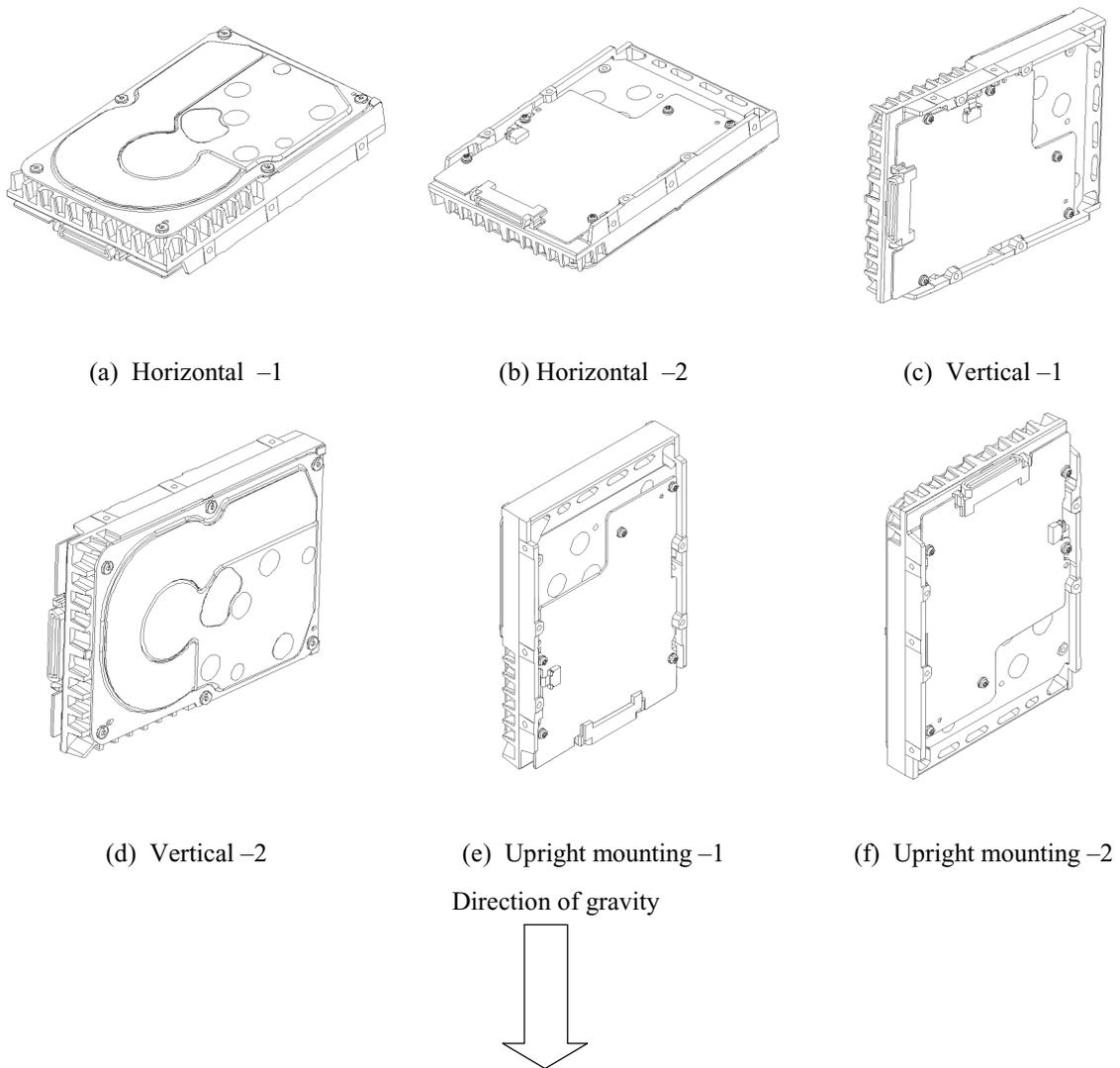


The value marked with (\*) indicates the dimension between mounting holes on the bottom face.

**Figure 4.1 External dimensions**

### 4.1.2 Mounting

The permissible orientations of the IDD are shown in Figure 4.2, and the tolerance of the angle is  $\pm 5^\circ$  from the horizontal plane.



**Figure 4.2** IDD orientations

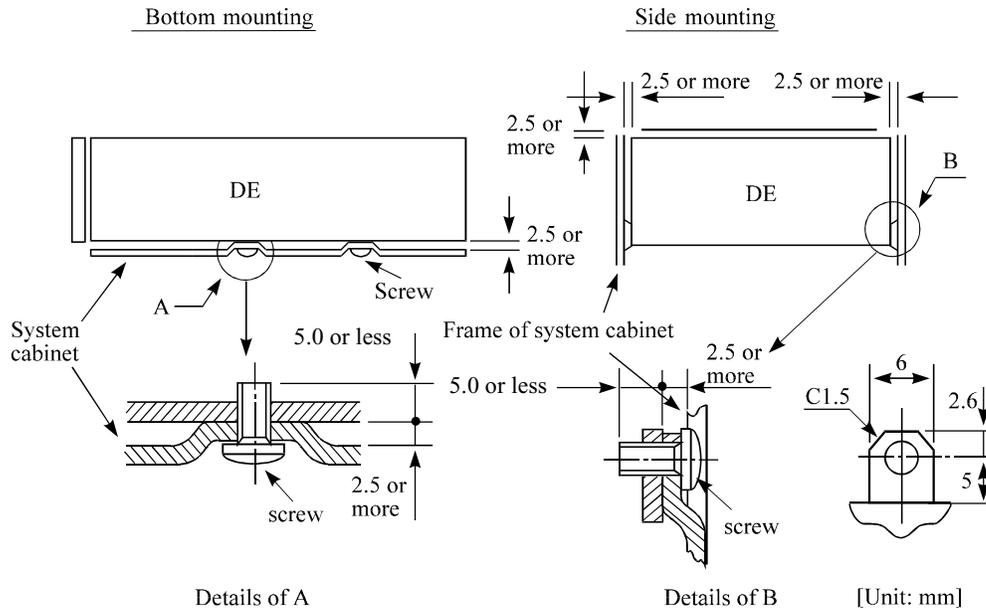
### 4.1.3 Notes on mounting

#### (1) Mounting frame structure

Special attention must be given to mount the IDD disk enclosure (DE) as follows.

- a) Use the frame with an embossed structure, or the like. Mount the IDD with making a gap of 2.5 mm or more between the IDD and the frame of the system.
- b) As shown in Figure 4.3, the inward projection of the screw from the IDD frame wall at the corner must be 5.0 mm or less.

- c) Tightening torque of screw must be secured with  $0.59\text{N}\cdot\text{m}$  ( $6\text{kgf}\cdot\text{cm}$ )  $\pm 12\%$ .
- d) Impact caused by the electric driver must be within the device specifications.
- e) Must be handled on an anti-static mat.

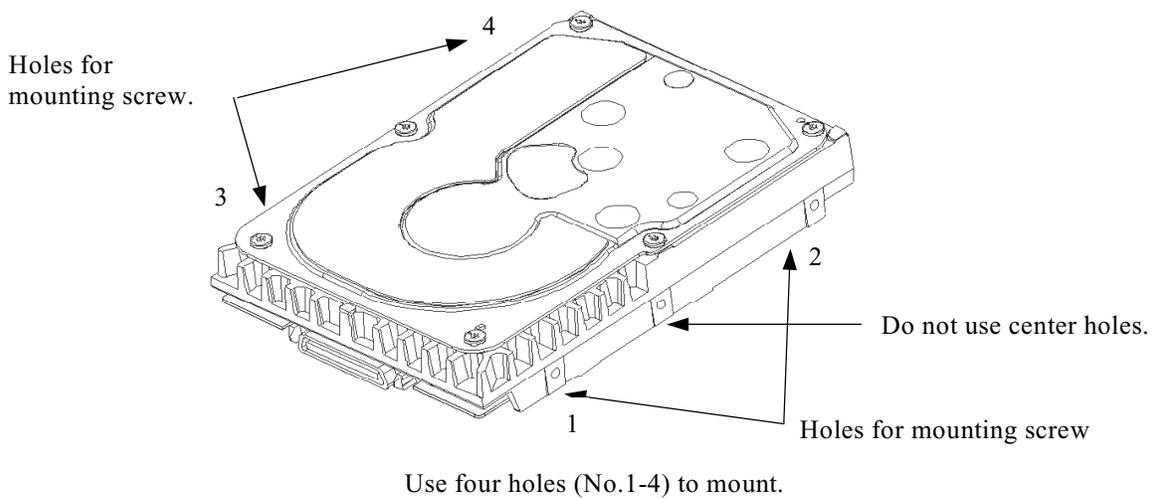


**Figure 4.3 Mounting frame structure**

(2) Limitation of side-mounting

Mount the IDD using the 4 screw holes at the both ends on the both sides as shown in Figure 4.4. Do not use the center hole by itself.

In case of using the center hole, it must be used in combination with 2 holes on both ends.  
(Total 6 screws for 6 holes enclosed)



**Figure 4.4 Limitation of side-mounting**

- (3) Limitation of bottom-mounting  
Use all 4 mounting holes on the bottom face.

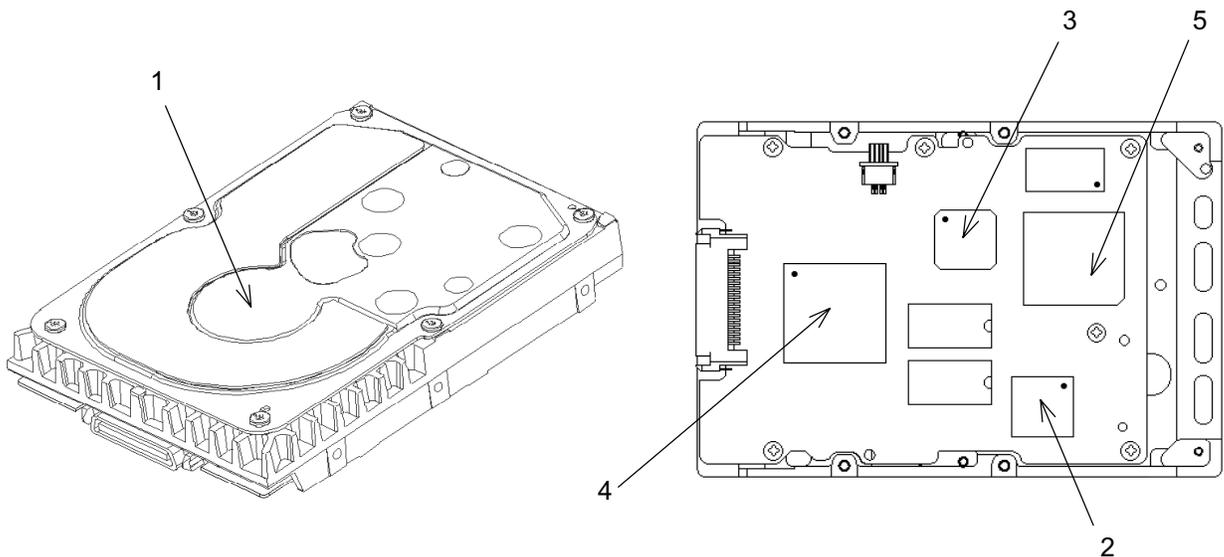
- (4) Environmental temperature

Temperature condition at installed in a cabinet is indicated with ambient temperature measured 3 cm from the disk drive. At designing the system cabinet, consider following points.

- Make a suitable air flow so that the DE surface temperature does not exceed 60°C.
- Cool the PCA side especially with air circulation inside the cabinet. Confirm the cooling effect by measuring temperature of specific ICs and the DE. These measurement results should be within a criteria listed in Table 4.1.
- Keeping the DE surface temperature at 50°C or below at ambient temperature 25°C, which is a condition for assuring an MTBF of 1,200,000 hours, requires an air flow of 0.7 m/s.

**Table 4.1 Surface temperature check point**

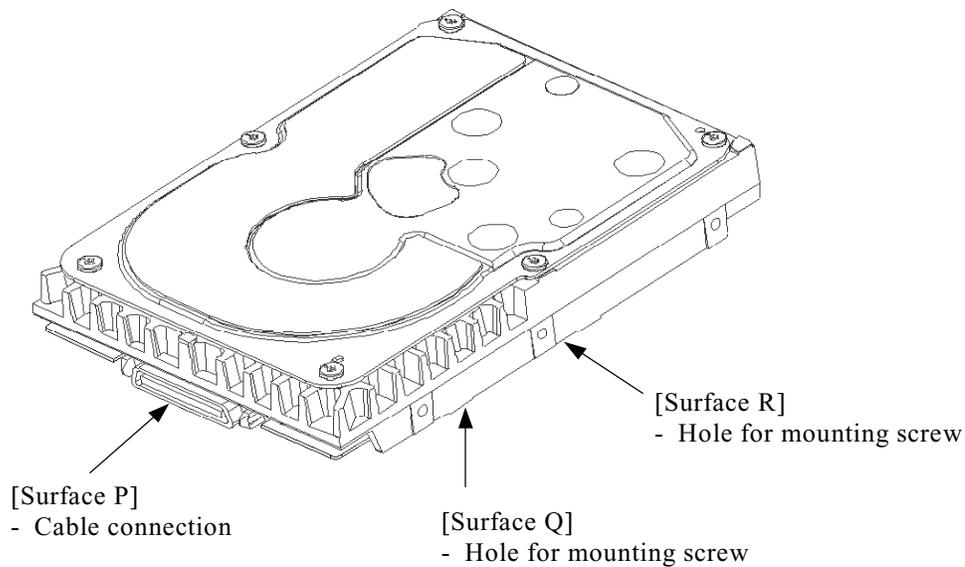
No.	Measurement point	Criteria
1	Center of DE cover	60°C
2	Read channel LSI	88°C
3	VCM/SPM Driver	92°C
4	HDC	90°C
5	MPU	91°C



**Figure 4.5 Surface temperature measurement points**

(5) Service clearance area

The service clearance area, or the sides which must allow access to the IDD for installation or maintenance, is shown in Figure 4.6.



**Figure 4.6 Service clearance area**

(6) External magnetic field

The drive should not be installed near the ferromagnetic body like a speaker to avoid the influence of the external magnetic field.

(7) Leak magnetic flux

The IDD uses a high performance magnet to achieve a high speed seek. Therefore, a leak magnetic flux at surface of the IDD is large. Mount the IDD so that the leak magnetic flux does not affect to near equipment.

(8) Others

Seals on the DE prevent the DE inside from the dust. Do not damage or peel off labels.

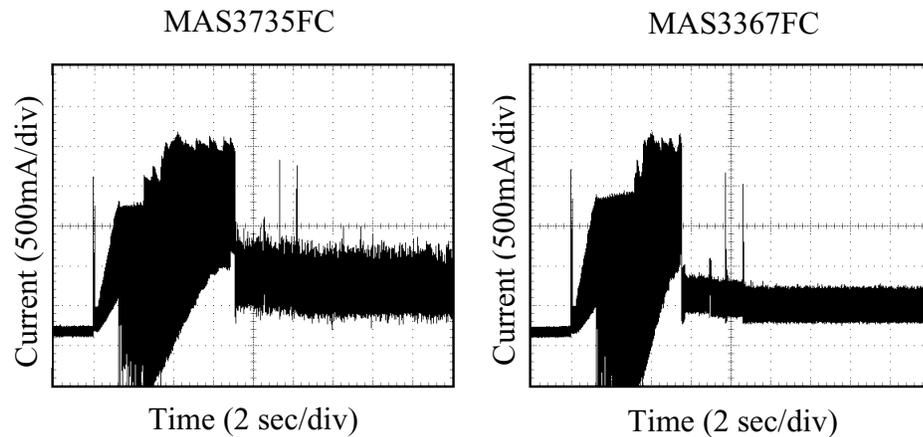
## 4.2 Power Supply Requirements

### (1) Allowable input voltage and current

The power supply input voltage measured at the power supply connector pin of the IDD (receiving end) must satisfy the requirement given in Subsection 2.1.3. (For other requirements, see Items (4) below.)

### (2) Current waveform (reference)

Figure 4.7 shows the waveform of +12 VDC.



**Figure 4.7** Current waveform (+12 VDC)

### (3) Power on/off sequence

The order of the power on/off sequence of +5 VDC and +12 VDC, supplied to the IDD, does not matter.

### (4) Sequential starting of spindle motors

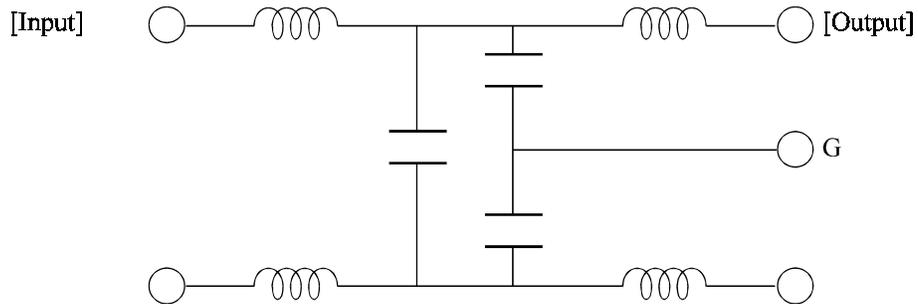
After power is turned on to the IDD, a large amount of current flows in the +12 VDC line when the spindle motor rotation starts. Therefore, if more than one IDD is used, the spindle motors should be started sequentially using one of the following procedures to prevent overload of the power supply unit.

- a) Issue START/STOP commands at more than 12-second intervals to start the spindle motors. For details of this command specification, refer to Fibre Channel Interface Specifications.
- b) Turn on the +12 VDC power in the power supply unit at more than 12-second intervals to start the spindle motors sequentially.

(5) Noise filter

To eliminate AC line noise, a noise filter should be installed at the AC input terminal on the IDD power supply unit. The specification of this noise filter is as follows:

- Attenuation: 40 dB or more at 10 MHz
- Circuit construction: T-configuration as shown in Figure 4.8 is recommended.

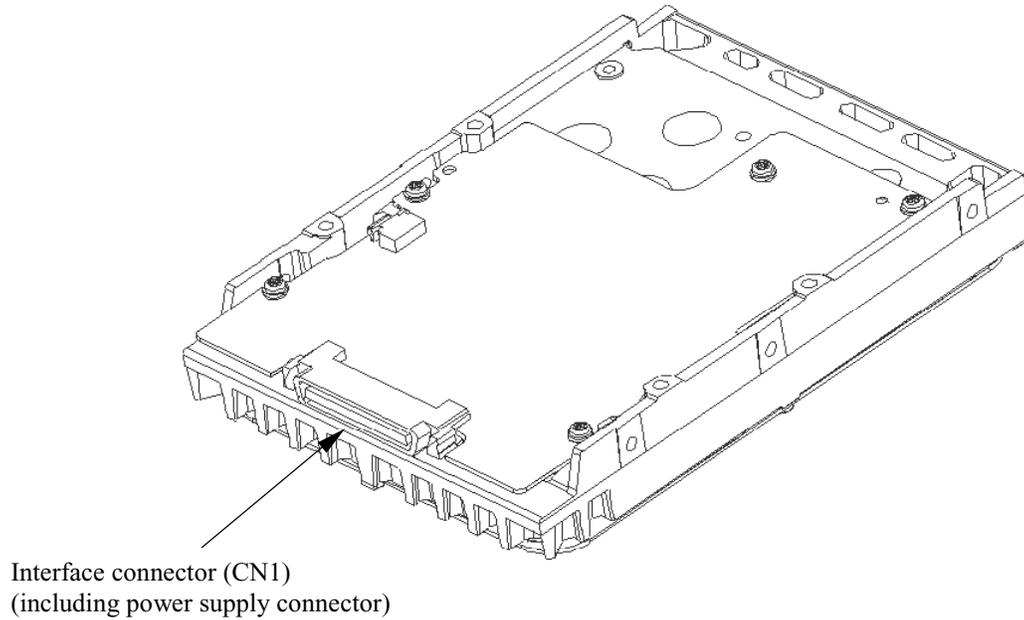


**Figure 4.8 AC noise filter (recommended)**

### 4.3 Connection Requirements

#### 4.3.1 Connector

Figure 4.9 shows the locations of interface connector.

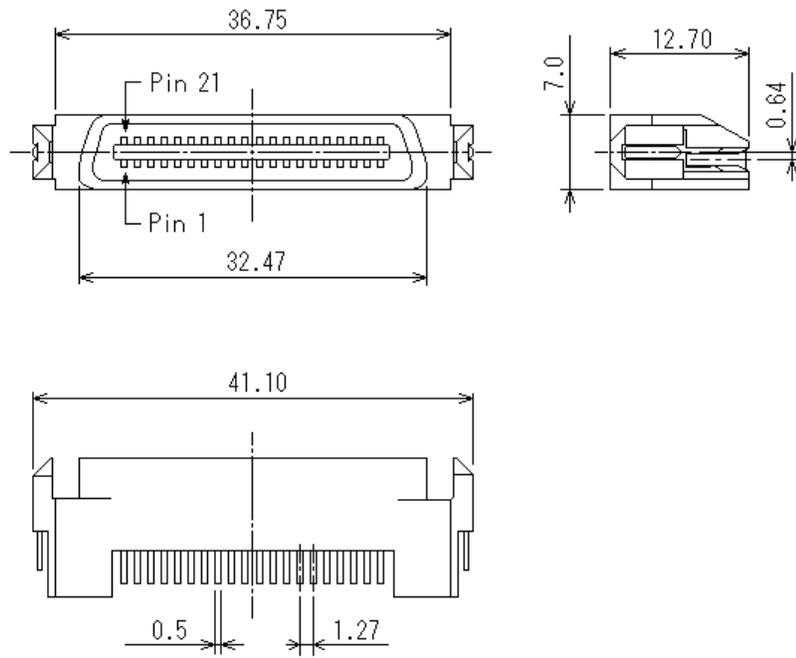


**Figure 4.9 Connector location**

#### 4.3.2 Interface connector

The connector for the Fibre Channel Loop is an unshielded SCA-2 connector which has two 20-pin rows spaced 1.27 mm (0.05 inch) apart. Figure 4.10 shows the connector. See Appendix A for signal assignments on the connector.

For details on the physical/electrical requirements of the interface signals, refer to Chapter 1 in Fibre Channel Interface Specifications.



**Figure 4.10 SCA2 type connector**

## CHAPTER 5 Installation

- 5.1 Notes on Handling Drives
- 5.2 Setting
- 5.3 Mounting Drives
- 5.4 Dismounting Drives
- 5.5 Checking Operation after Installation and Preparing the IDD for Use
- 5.6 Spare Disk Drive

This chapter describes the notes on handling drives, setting, mounting drives, confirming drive operations after installation and preparation for use, and dismounting drives.

### 5.1 Notes on Handling Drives

The items listed in the specifications in Table 2.1 must be strictly observed.

#### (1) General notes

- a) Do not give the drive shocks or vibrations exceeding the value defined in the standard because it may cause critical damage to the drive. Especially be careful when unpacking.
- b) Do not leave the drive in a dirty or contaminated environment.
- c) Since static discharge may destroy the CMOS semiconductors in the drive, note the following after unpacking:
  - Use an antistatic mat and body grounding when handling the drive.
  - Hold the DE when handling the drive. Do not touch PCAs except for setting.



#### *Hot temperature*

*To prevent injury, do not handle the drive until after the device has cooled sufficiently after turning off the power. The DE and LSI become hot during operation and remain hot immediately after turning off the power.*

- (2) Unpackaging
  - a) Use a flat work area. Check that the "This Side Up" sign side is up. Handle the package on soft material such as a rubber mat, not on hard material such as a desk.
  - b) Be careful not to give excess pressure to the internal unit when removing cushions.
  - c) Be careful not to give excess pressure to the PCAs and interface connector when removing the drive from the antistatic bag.
  - d) Do not remove the sealing label or cover of the DE and screws.
  
- (3) Installation/removal/replacement
  - a) Do not attempt to connect or disconnect connections when power is on.
  - b) Do not move the drive when power is turned on or until the drive completely stops (for 30 seconds) after power is turned off.
  - c) Place and keep removed screws and other parts where they will not get lost or damaged.
  - d) Keep a record of all maintenance work for replacing.
  
- (4) Packaging
  - a) Store the drive in an antistatic vinyl pack.
  - b) It is recommended to use the same cushions and packages as those at delivery. If those at delivery cannot be used, use a package with shock absorption so that the drive is free from direct shocks. In this case, fully protect the PCAs and interface connector so that they are not damaged.
  - c) Indicate "This Side Up" and "Handle With Care" on the outside of the package so that it is not turned over.
  
- (5) Delivery
  - a) When delivering the drive, provide packaging and do not turn it over.
  - b) Minimize the delivery distance after unpacking and avoid shocks and vibrations with cushions. For the carrying direction at delivery, use one of the mount allowable directions in Subsection 4.1.2 (vertical direction is recommended).
  
- (6) Storage
  - a) Provide vaporproof packaging for storage.
  - b) The storage environment must satisfy the requirements specified in Subsection 2.1.3 when the drive is not operating.
  - c) To prevent condensation, avoid sudden changes in temperature.

## 5.2 Setting

### 5.2.1 Loop ID setting

When setting the fibre channel loop ID, use SEL0 to SEL6 of interface connector CN1. IN bit weighting, SEL6 corresponds to the MSB, SEL0 to the LSB, and 126 types of X'00' to X'7D' can be specified as loop IDs.

### 5.2.2 Mode settings

#### (1) Motor start mode

The method for start control of the IDD spindle motor can be set in accordance with Table 5.1.

**Table 5.1 Motor start mode**

Setting		Start mode
Signal name		
Start_2/Mated	Start_1/Mated	
Connector pin		
CN1-10	CN1-09	
Open	Open	The drive is not connected to the system. The drive does not start the spindle motor.
Open	GND	The drive is connected to the system. After recognizing the connection, the drive starts the spindle motor upon receipt of a START/STOP UNIT command.
GND	Open	The drive is connected to the system. After recognizing the connection, the drive starts the spindle motor after a prescribed delay time has elapsed.
GND	GND	The drive is connected to the system. The driver starts the spindle motor immediately after recognizing the connection.

## IMPORTANT

*Set the loop ID so that there are no duplicates between devices on the same loop.*

## 5.3 Mounting Drives

### 5.3.1 Mounting procedures

Since mounting the drive depends on the system cabinet structure, determine the work procedures considering the requirements specific to each system. The general mounting method and items to be checked are shown below.

See Subsection 4.1 for the details of requirements for installing the IDD.

- 1) With a system to which an external operator panel is mounted, if it is difficult to access the connector after the drive is mounted on the system cabinet, connect the external operator panel cable before mounting the drive.
- 2) Fix the drive in the system cabinet with four mounting screws as follows:
  - The drive has 10 mounting holes (both sides:  $3 \times 2$ , bottom: 4). Fix the drive by using four mounting holes of both sides or the bottom. (See Figure 4.6)
  - Use mounting screws whose lengths inside the drive mounting frame are 5.0 mm or less when the screws are tightened (see Figure 4.3).
  - When mounting the drive, be careful not to damage parts on the PCAs.
- 3) Check to ensure that the DE is not touching the frame on the system side after tightening the screws. At least 2.5mm of clearance is required between the DE and the frame. (Indicated in Figure 4.3)
- 4) When an electric driver is in use, less than device specifications must be used.

## 5.4 Dismounting Drives

Since the method and procedure for dismounting the disk drive for replacement of the drive, etc. depends on the locker structure of the system, etc., the work procedure must be determined in consideration of the requirements specific to the system. This section describes the general procedure and notes on dismounting the drive.



### *Damage*

1. *When dismounting the drive which is mounted on the system while power is supplied to it.*
  - *The drive to be dismantled must be separated from the loop. Dismounting the drive which is not separated from the loop may cause an unexpected error.*
  - *If the drive is not separated from the loop, issue an LPB to the drive from the initiator in a primitive sequence of the order set.*
  - *It is recommended to stop the spindle motor prior to this loop separation operation. The spindle motor can be stopped by a START/STOP command. It takes about 30 seconds for the spindle motor to stop completely.*
  - *Then, dismount the drive using the drive mounting/dismounting mechanism, etc. of the system. If the drive is dismantled while the spindle motor is running, special care is required to avoid excessive vibration or shock to the drive. It is recommended to stop the operation once the SCA connector breaks off contact and wait until the spindle motor stops (about 30 seconds) before dismount the drive.*
  - *When storing or transporting the drive, put it in an antistatic bag. (Shown in Section 5.1).*
2. *When dismounting the drive which is mounted on the system while power is not supplied to it.*
  - *Do not move the drive until the drive stops completely (about 30 seconds if the spindle motor was stopped by a START/STOP UNIT command, and about 30 seconds after powering-off when the power was simply turned off).*
  - *Then, dismount the drive using the drive mounting/dismounting mechanism, etc. of the system.*
  - *When storing or transporting the drive, put it in an antistatic bag. (Shown in Section 5.1).*

## 5.5 Checking Operation after Installation and Preparing the IDD for Use

### 5.5.1 Checking initial operation

This section explains how to check operation after power is turned on. Since the initial operation of an IDD differs depending on the settings of the motor start mode, check the following initial operations according to the motor start mode set during installation.

- (1) Initial operation if the settings have been specified so that turning power on automatically starts rotating the motor
  - a) When power is turned on, the Active LED blinks and the IDD starts the initial self-diagnosis.
  - b) If the initial self-diagnosis detects a problem, the IDD sends the Fault LED Out signal to the interface connector, as specified by SFF8045.  
  
Remark: The spindle motor may or may not start rotating in this stage.
  - c) If the IDD is in idle mode, the Active LED remains lit. (When the initiator accesses the IDD, the LED goes off and then goes on again at the end of the processing requested by the initiator.)
- (2) Initial operation if the settings have been specified so that the START/STOP UNIT command is used to start rotating the motor
  - a) When power is turned on, the Active LED goes on momentarily and the IDD starts the initial self-diagnosis.
  - b) If the initial self-diagnosis detects a problem, the IDD sends the Fault LED Out signal to the interface connector, as specified by SFF8045.
  - c) The spindle motor does not rotate until the START/STOP UNIT command is received. The initiator is required to use the procedure described in Section 5.5.2 to send the START/STOP UNIT command.
  - d) About 60 seconds after the START/STOP UNIT command is received, the disk drive enters the READY state. The IDD then starts reading system information from the system space on disks.
  - e) The Active LED goes off while the command is being executed.
- (3) Take the following actions if a problem occurs:
  - a) Check if all cables are correctly connected.
  - b) Check if the power supply voltage is correct. (Measure the voltage at the power connector on the IDD.)

- c) Continuous sending of the Fault LED Out signal to the interface connector indicates the initial self-diagnosis has detected a problem. In this event and if the situation allows, sense data should be obtained by issuing the REQUEST SENSE command from the initiator (host system). Sense data is information required for troubleshooting.

## **IMPORTANT**

*The Active LED goes off while the IDD command is being executed.  
For some commands, however, since the Active LED goes off for only a  
fraction of a second, the Active LED looks like it flashes or remains lit.*

### **5.5.2 Checking connection**

When the initial operation is checked normally after power is turned on, check that the IDD is connected to the loop from the host system. Although checking the connection depends on the structure of the host system, this section describes the general procedures.

#### (1) Checking procedure

Issuing the commands and determining the end status depends on the start mode of the spindle motor and UNIT ATTENTION report mode (specified with setting terminal). Figure 5.1 shows the recommended checking procedure for the mode that the motor starts when power is turned on. Figure 5.2 shows for the mode that the motor starts by the START/STOP command. In these recommended checking procedures, following items are checked.

#### **Note:**

Following steps a) to e) correspond to a) to e) in Figures 5.1 and 5.2.

- a) Issue the TEST UNIT READY command and check that the IDD is connected correctly to the loop and the initial operation after power is turned on ended normally. The command issue period of the TEST UNIT READY command shall be more than 20 ms.
- b) To control starting of the spindle motor from the host system, issue the START/STOP UNIT command to start the spindle motor.
- c) Check the loop operations with the WRITE BUFFER and READ BUFFER commands.
- d) Start the IDD self-diagnostic test with the SEND DIAGNOSTIC command and check the basic operations of the controller and disk drive.

Motor starts when power is turned on

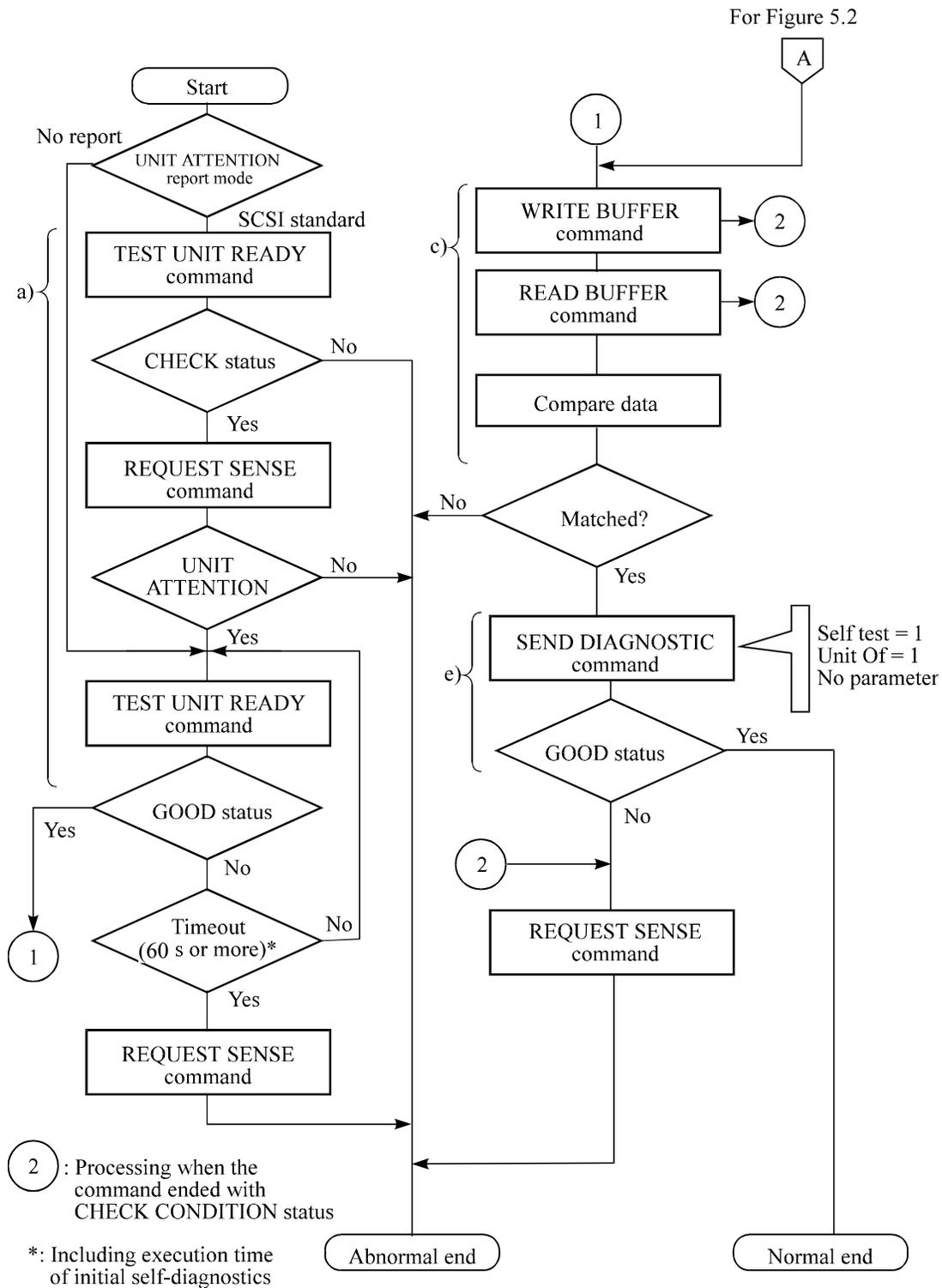
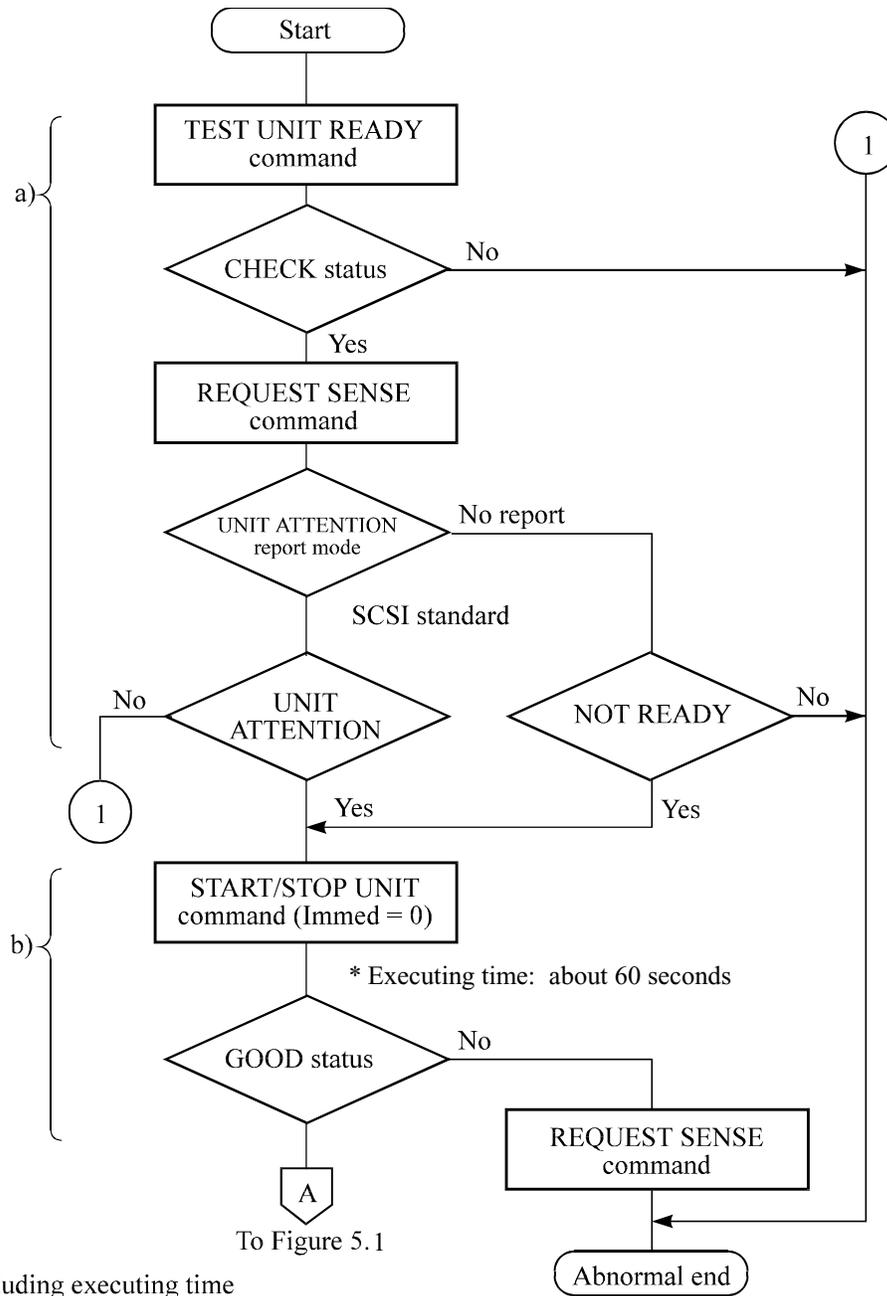


Figure 5.1 Checking the IDD connection (A)

Motor starts by START/STOP command



\*: Including executing time of initial self-diagnostics

Figure 5.2 Checking the IDD connection (B)

- (2) Checking at abnormal end
  - a) When sense data can be obtained with the REQUEST SENSE command, analyze the sense data and retry recovery for a recoverable error. Refer to Chapter 5 of Fibre Channel Interface Specifications for further details.
  - b) Check the setting of the terminals. Note that the checking procedure of loop connection differs depending on the setting of the motor start mode and UNIT ATTENTION report mode.

### 5.5.3 Formatting

Since the disk drive is formatted with a specific (default) data format for each model (part number) when shipped from the factory, the disk need not be formatted (initialized) when it is installed in the system.

However, when the system needs data attributes different from the default format, all sides of the disk must be formatted (initialized) according to the procedures below.

The user can change the following data attributes at initialization:

- Logical data block length
- Number of logical data blocks or number of cylinders in the user space
- Alternate spare area size

This section outlines the formatting at installation. Refer to Chapters 3 and 6 of Fibre Channel Interface Specifications for further details.

- (1) MODE SELECT/MODE SELECT EXTENDED command

Specify the format attributes on the disk with the MODE SELECT or MODE SELECT EXTENDED command. The parameters are as follows.

- a. Block descriptor

Specify the size (byte length) of the logical data block in the "data block length" field. To explicitly specify the number of logical data blocks, specify the number in the "number of data blocks" field. Otherwise, specify 0 in "number of data blocks" field. In this case, the number of logical data blocks after initialization is determined by the value specified in the format parameter (page code = 3) and drive parameter (page code = 4).

- b. Format parameter (page code = 3)

Specify the number of spare sectors for each cell in the "alternate sectors/zone" field and specify the number of tracks for alternate cylinders (= number of alternate cylinders × number of disk drive heads) in the "alternate tracks/zone" field. It is recommended not to specify values smaller than the IDD default value in this field.

(2) FORMAT UNIT command

Initialize all sides of the disk with the FORMAT UNIT command. The FORMAT UNIT command initializes all sides of the disk using the P lists, verifies data blocks after initialization, and allocates an alternate block for a defect block detected with verification. With initialization, the value "00" is written into all bytes of all logical data blocks. Only the position information of defect blocks detected with verification is registered in the G list. The specifications are as follows:

a. Specifying CDB

Specify 0 for the "FmtData" bit and the "CmpLst" bit on CDB, 000 for the "Defect List Format" field, and data pattern written into the data block at initialization for the "initializing data pattern" field.

b. Format parameter

When the values in step a. are specified with CDB, the format parameter is not needed.

#### 5.5.4 Setting parameters

The user can specify the optimal operation mode for the user system environments by setting the following parameters with the MODE SELECT or MODE SELECT EXTENDED command:

- Error recovery parameter
- Disconnection/reconnection parameter
- Caching parameter
- Control mode parameter

With the MODE SELECT or MODE SELECT EXTENDED command, specify 1 for the "SP" bit on CDB to save the specified parameter value on the disk. This enables the IDD to operate by using the parameter value set by the user when power is turned on again. When the system has more than one INIT, different parameter value can be set for each INIT.

When the parameters are not set or saved with the MODE SELECT or MODE SELECT EXTENDED command, the IDD sets the default values for parameters and operates when power is turned on or after reset. Although the IDD operations are assured with the default values, the operations are not always optimal for the system. To obtain the best performance, set the parameters in consideration of the system requirements specific to the user.

This section outlines the parameter setting procedures. Refer to Chapter 3 of Fibre Channel Interface Specifications for further details of the MODE SELECT and MODE SELECT EXTENDED commands and specifying the parameters.

### IMPORTANT

1. *At factory shipment of the IDD, the saving operation for the MODE SELECT parameter is not executed. So, if the user does not set parameters, the IDD operates according to the default value of each parameter*
2. *The model select parameter is not saved for each Loop ID of but as the common parameter for all IDs. In the multi-INIT System, parameter setting cannot be changed for each INIT.*
3. *Once parameters are saved, the saved value is effective as long as next saving operation is executed from the INIT. For example, even if the initialization of the disk is performed by the FORMAT UNIT command, the saved value of parameters described in this section is not affected.*
4. *When the IDD, to which the saving operation has been executed on a system, is connected to another system, the user must pay attention to that the IDD operates according to the saved parameter value if the saving operation is not executed at installation.*
5. *The saved value of the MODE SELECT parameter is assumed as the initial value of each parameter after the power-on, the RESET condition, or the BUS DEVICE RESET message. The INIT can change the parameter value temporary (actively) at any timing by issuing the MODE SELECT or MODE SELECT EXTENDED command with specifying "0" to the SP bit in the CDB.*

(1) Error recovery parameter

The following parameters are used to control operations such as IDD internal error recovery:

a. Read/write error recovery parameters (page code = 1)

Parameter	Default value
• AWRE: Automatic alternate block allocation at Write operation	1 (enabled)
• ARRE: Automatic alternate block allocation at read operation	1 (enabled)
• TB: Uncorrectable data transfer to the INIT	1 (enabled)
• EER: Immediate correction of correctable error	1 (enabled)
• PER: Report of recovered error	0 (disabled)
• DCR: Suppression of ECC error correction	0 (Correction is enabled.)
• Retry count at read operation	63
• Retry count at write operation	63
• Recovery time limit	30 sec

b. Verify error recovery parameters (page code = 7)

Parameter	Default value
• ERR: Immediate correction of recoverable error	1 (enabled)
• PER: Report of recovered error	0 (disabled)
• DTE: Stop of command processing at successful error recovery	0 (Processing is continued.)
• DCR: Suppression of ECC error correction	0 (Correction is enabled.)
• Retry count at verification	63

c. Additional error recovery parameters (page code = 21)

Parameter	Default value
• Retry count at seek error	15

**Notes:**

1. The user can arbitrarily specify the following parameters according to the system requirements:
  - ARRE
  - AWRE
  - TB
  - PER
2. The user also can arbitrarily specify parameters other than the above. However, it is recommended to use the default setting in normal operations.

(2) Disconnection/reconnection parameters (page code = 2)

The following parameters are used to optimize the start timing of reconnection processing to transfer data on the loop at a read (READ or READ EXTENDED command) or write operation (WRITE, WRITE EXTENDED, or WRITE AND VERIFY command) of the disk. Refer to Chapter 2 of Fibre Channel Interface Specifications for further details.

Parameter	Default value
• Buffer full ratio	00 (HEX)
• Buffer empty ratio	00 (HEX)

**Notes:**

1. In a system without the disconnection function, these parameters need not be specified.
2. Determine the parameter values in consideration of the following performance factors of the system:
  - Time required for reconnection processing
  - Average amount of processing data specified with a command

Refer to Chapter 2 of Fibre Channel Interface Specifications for how to obtain the rough calculation values for the parameter values to be set. It is recommended to evaluate the validity of the specified values by measuring performance in an operation status under the average system load requirements.

(3) Caching parameters

The following parameters are used to optimize IDD Read-Ahead caching operations under the system environments. Refer to Chapter 2 of Fibre Channel Interface Specifications for further details.

	Parameter	Default value
• IC:	Initiator control	0 (Drive-specific control (page cache))
• RCD:	Disabling Read-Ahead caching operations	0 (enabled)
• WCE:	Write Cache Enable	1 (enabled)
• MS:	Specifying the multipliers of "minimum prefetch" and "maximum prefetch" parameters	0 (Specifying absolute value)
• DISC:	Prefetch operation after track switching during prefetching	1 (enabled)
•	Number of blocks for which prefetch is suppressed	X'FFFF'
•	Minimum prefetch	X'0000'
•	Maximum prefetch	X'XXXX' (1 cache segment)
•	Number of blocks with maximum prefetch restrictions	X'FFFF'
•	Number of segments	X'08'

**Notes:**

1. When Read-Ahead caching operations are disabled by the caching parameter, these parameter settings have no meaning except write cache feature.
2. Determine the parameters in consideration of how the system accesses the disk. When the access form is not determined uniquely because of the processing method, the parameters can be re-set actively.
3. For sequential access, the effective access rate can be increased by enabling Read-Ahead caching operations and Write Cache feature.

(4) Control mode parameters

The following parameters are used to control the tagged queuing and error logging.

a. Control mode parameters

Parameter		Default value
• Queue algorithm modifier		0 (Execution sequence of read/write commands is optimized.)
• QErr:	Resume or abort remaining suspended commands after sense pending state	0 (command is resumed)
• DQue:	Disabling tagged command queuing	0 (enabled)

**5.6 Spare Disk Drive**

See Subsection 2.1.1, “Model name and order number,” to order a disk drive for replacement or as a spare

# CHAPTER 6     Diagnostics and Maintenance

<p><b>6.1   Diagnostics</b></p> <p><b>6.2   Maintenance Information</b></p> <p><b>6.3   Operation Check</b></p> <p><b>6.4   Troubleshooting Procedures</b></p>
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This chapter describes diagnostics and maintenance information.

## 6.1   Diagnostics

### 6.1.1   Self-diagnostics

The IDD has the following self-diagnostic function. This function checks the basic operations of the IDD.

- Initial self-diagnostics
- Online self-diagnostics (SEND DIAGNOSTIC command)

Table 6.1 lists the contents of the tests performed with the self-diagnostics. For a general check of the IDD including the operations of the host system and interface, use a test program that runs on the host system (see Subsection 6.1.2).

**Table 6.1    Self-diagnostic functions**

Test contents	Initial self-diagnostics	SEND DIAGNOSTIC command	
		Self Test=1 Unit Offline=0	Self Test=1 Unit Offline=1
Hardware function test	○	○	○
Seek test			↓ ○
Write/read test (Cylinder for internal test)			↓ ○

**Note:**

○ indicates the tests to be executed and arrows show the sequence of execution.

Brief test contents of self-diagnostics are as follows.

a. Hardware function test

This test checks the basic operation of the controller section, and contains following test.

- RAM (microcode is stored)
- Peripheral circuits of microprocessor (MPU)
- Memory (RAM)
- Data buffer

b. Seek test

This test checks the positioning operation of the disk drive using several seek modes (2 points seek, 1 position sequential seek, etc.). The positioning operation is checked with confirming the physical address information by reading the ID field (LBA) from the data block on track 0 after completion of the seek operation to the target cylinder.

c. Write/read test

This test checks the write/read function by using the Internal test space of the disk drive.

(1) Initial self-diagnostics

When power is turned on, the IDD starts initial self-diagnostics. The initial self-diagnostics checks the basic operations of the hardware functions.

If an error is detected in the initial self-diagnostics, the IDD sends the Fault LED Out signal to the interface connector. In this status, the IDD posts the CHECK CONDITION status to all I/O operation requests other than the REQUEST SENSE command. When the CHECK CONDITION status is posted, the INIT should issue the REQUEST SENSE command. The sense data obtained with the REQUEST SENSE command details the error information detected with the initial self-diagnostics.

Even if CHECK CONDITION status and sense data are posted, the IDD continues sending the Fault LED Out signal to the interface connector. Only when the power is turned off or re-turned on, this status can be cleared. When this status is cleared, the IDD executes the initial self-diagnosis again.

The IDD does not reply to the loop for up to 2 seconds after the initial self-diagnostics is started. After that, the IDD can accept the I/O operation request correctly, but the received command, except the executable commands under the not ready state (such as INQUIRY, START/STOP UNIT), is terminated with the CHECK CONDITION status (NOT READY [=2]/Logical unit is in process of becoming ready [=04-01] or Logical unit not ready, initializing command required [=04-02]) during the interval from the spindle motor becomes stable to the IDD becomes ready. The executable command under the not ready state is executed in parallel with the initial self-diagnostics, or is queued by the command queuing feature and is executed after completion of the initial self-diagnostics. When the command that comes under the exception condition of the command queuing is issued at that time, the IDD posts the BUSY status for the command. When the error is detected during the initial self-diagnostics, the CHECK CONDITION status is posted for all commands that were stacked during the initial self-diagnostics. For the command execution condition, refer to Section 1.4 and Subsection 1.7.4 in Fibre Channel Interface Specifications.

(2) Online self-diagnostics (SEND DIAGNOSTIC command)

The INIT can make the IDD execute self-diagnostics by issuing the SEND DIAGNOSTIC command.

The INIT specifies the execution of self-diagnostics by setting 1 for the SelfTest bit on the CDB in the SEND DIAGNOSTIC command and specifies the test contents with the UnitOfI bit.

When the UnitOfI bit on the CDB is set to 0, the IDD executes the hardware function test only once. When UnitOfI bit is set to 1, the IDD executes the hardware function test, seek (positioning) test, and data write/read test for the Internal test space only once.

a. Error recovery during self-diagnostics

During the self-diagnostics specified by the SEND DIAGNOSTIC command, when the recoverable error is detected during the seek or the write/read test, the IDD performs the error recovery according to the MODE SELECT parameter value (read/write error recovery parameter, additional error recovery parameter) which the INIT specifies at the time of issuing the SEND DIAGNOSTIC command.

PER	Operation of self-diagnostics
0	The self-diagnostics continues when the error is recovered. The self-diagnostics terminates normally so far as the unrecoverable error is not detected.
1	The self-diagnostics continues when the error is recovered. If the unrecoverable error is not detected, the consecutive tests are executed till last test but the self-diagnostics terminates with error. The error information indicates that of the last recovered error.

b. Reporting result of self-diagnostics and error indication

When all specified self-diagnostics terminate normally, the IDD posts the GOOD status for the SEND DIAGNOSTIC command.

When an error is detected in the self-diagnostics, the IDD terminates the SEND DIAGNOSTIC command with the CHECK CONDITION status.

The INIT should issue the REQUEST SENSE command when the CHECK CONDITION status is posted. The sense data collected by the REQUEST SENSE command indicates the detail information of the error detected in the self-diagnostics.

The IDD status after the CHECK CONDITION status is posted differs according to the type of the detected error.

- a) When an error is detected in the seek or write/read test, the subsequent command can be accepted correctly. When the command other than the REQUEST SENSE and NO OPERATION is issued from the same INIT, the error information (sense data) is cleared.
- b) When an error is detected in the hardware function test, the IDD posts the CHECK CONDITION status for all I/O operation request except the REQUEST SENSE command. The error status is not cleared even if the error information (sense data) is read. Only when the power is turned off or re-turned on, the status can be cleared. When this status is cleared, the IDD executes the initial self-diagnostics again (see item (1)).

Refer to Chapter 3 of Fibre Channel Interface Specifications for further details of the command specifications.



*Data loss*

*When the SEND DIAGNOSTIC command terminates with the CHECK CONDITION status, the INIT must collect the error information using the REQUEST SENSE command. The RECEIVE DIAGNOSTIC RESULTS command cannot read out the error information detected in the self-diagnostics.*

### **6.1.2 Test programs**

The basic operations of the IDD itself can be checked with the self-diagnostic function. However, to check general operations such as the host system and interface operations in a status similar to the normal operation status, a test program that runs on the host system must be used.

The structure and functions of the test program depend on the user system requirements. Generally, it is recommended to provide a general input/output test program that includes devices connected to the loop and input/output devices on other I/O ports.

Including the following test items in the test program is recommended to test the IDD functions generally.

(1) Interface (loop) test

The operations of the loop and data buffer on the IDD are checked with the WRITE BUFFER and READ BUFFER commands.

(2) Basic operation test

The basic operations of the IDD are checked by executing self-diagnosis with the SEND DIAGNOSTIC command (see Subsection 6.1.1).

(3) Random/sequential read test

The positioning (seek) operation and read operation are tested in random access and sequential access modes with the READ, READ EXTENDED, or VERIFY command.

(4) Write/read test

By using a data block in the internal test space, the write/read test can be executed with an arbitrary pattern for a disk drive in which user data is stored.

## 6.2 Maintenance Information

### 6.2.1 Precautions

Take the following precautions to prevent injury during maintenance and troubleshooting:



1. *To avoid injury, do not touch the mechanical assembly during disk drive operation.*
2. *Do not use solvents to clean the disk drive.*

Take the following precautions to prevent disk drive damage during maintenance and troubleshooting:

**⚠ CAUTION**

1. *Always ground yourself with a wrist strap connected to ground before handling. ESD (Electrostatics Discharge) may cause the damage to the device.*
2. *Do not remove a PCA.*
3. *Do not use a conductive cleaner to clean a disk drive assembly.*

**6.2.2 Maintenance requirements**

(1) Preventive maintenance

Preventive maintenance such as replacing air filters is not required.

**⚠ CAUTION**

*Damage*

*Never open the disk enclosure in the field. Opening the disk enclosure in the field may cause an irreparable fault.*

(2) Service life

See "(3) Service life," in Section 2.1.5.

## (3) Parts that can be replaced in the field

The PCA cannot be replaced in the field. The DE cannot be replaced in the field.

## (4) Service system and repairs

Fujitsu has the service system and repair facility for the disk drive. Contact Fujitsu representative to submit information for replacing or repairing the disk drive. Generally, the following information must be included:

- a) IDD model, part number (P/N), revision number, serial number (S/N), and date of manufacturing
- b) Error status
  - Date when the error occurred
  - System configuration
  - Environmental conditions (temperature, humidity, and voltage)
- c) Error history
- d) Error contents
  - Outline of inconvenience
  - Issued commands and specified parameters
  - Sense data
  - Other error analysis information

*Data loss*

*Save data stored on the disk drive before requesting repair. Fujitsu does not assume responsibility if data is destroyed during servicing or repair.*

See Section 5.1 for notes on packing and handling when returning the disk drive.

### **6.2.3 Maintenance levels**

If a disk drive is faulty, replace the whole disk drive since repair requires special tools and environment. This section explains the two maintenance levels.

(1) Field maintenance (disk drive replacement)

- This replacement is done at the user's site.
- Replacement uses standard tools.
- Replacement is usually done by the user, retail dealer, distributor, or OEM engineer.

(2) Factory maintenance (parts replacement)

- This replacement can only be done by Fujitsu.
- Replacement includes maintenance training and OEM engineer support. OEM engineers usually support retail dealers and distributors.
- Replacement uses factory tools and test equipment.

### 6.2.4 Revision numbers

The revision number of the disk drive is represented with a letter and a number indicated on the revision label attached to the DE. Figure 6.1 shows the revision label format.

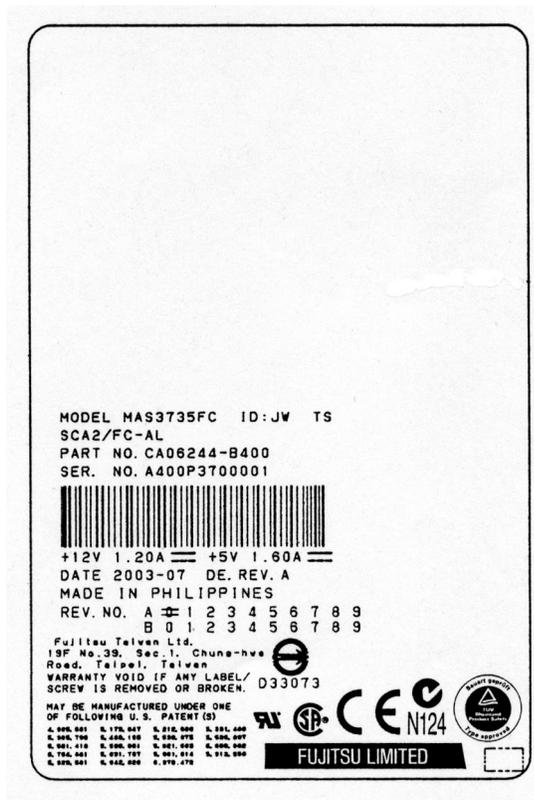


Figure 6.1 Revision label (example)

- (1) Indicating revision number at factory shipment

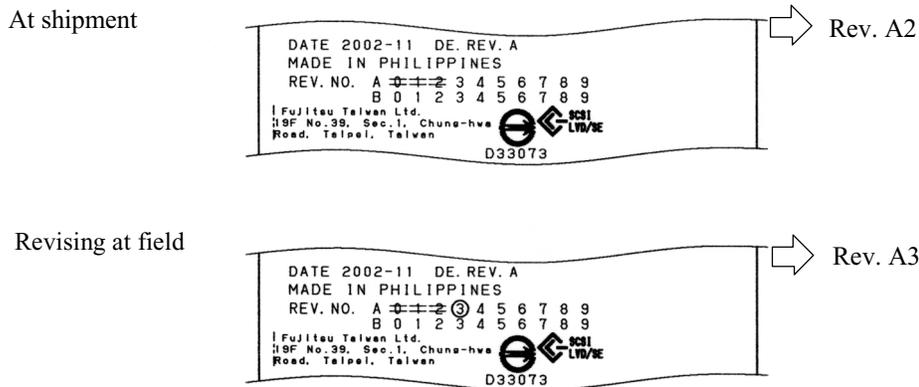
When the disk drive is shipped from the factory, the revision number is indicated by deleting numbers in the corresponding letter line up to the corresponding number with = (see Figure 6.2).

- (2) Changing revision number in the field

To change the revision number because parts are replaced or other modification is applied in the field, the new level is indicated by enclosing the corresponding number in the corresponding letter line with ; (see Figure 6.2).

## IMPORTANT

When the revision number is changed after the drive is shipped from the factory, Fujitsu issues "Engineering Change Request/Notice" in which the new revision number is indicated. When the user changes the revision number, the user should update the revision label as described in item (2) after applying the modification.



**Figure 6.2** Indicating revision numbers

### 6.2.5 Tools and test equipment

Disk drive troubleshooting and repair in the field require only standard hand tools. No special tools or test equipment are required.

This manual does not describe the factory-level tools and test equipment.

### 6.2.6 Tests

This disk drive can be tested in the following ways:

- Initial seek operation check (See Subsection 6.3.1)
- Operation test (See Subsection 6.3.2)
- Diagnostic test (See Subsection 6.3.3)

Figure 6.3 shows the flow of these tests.

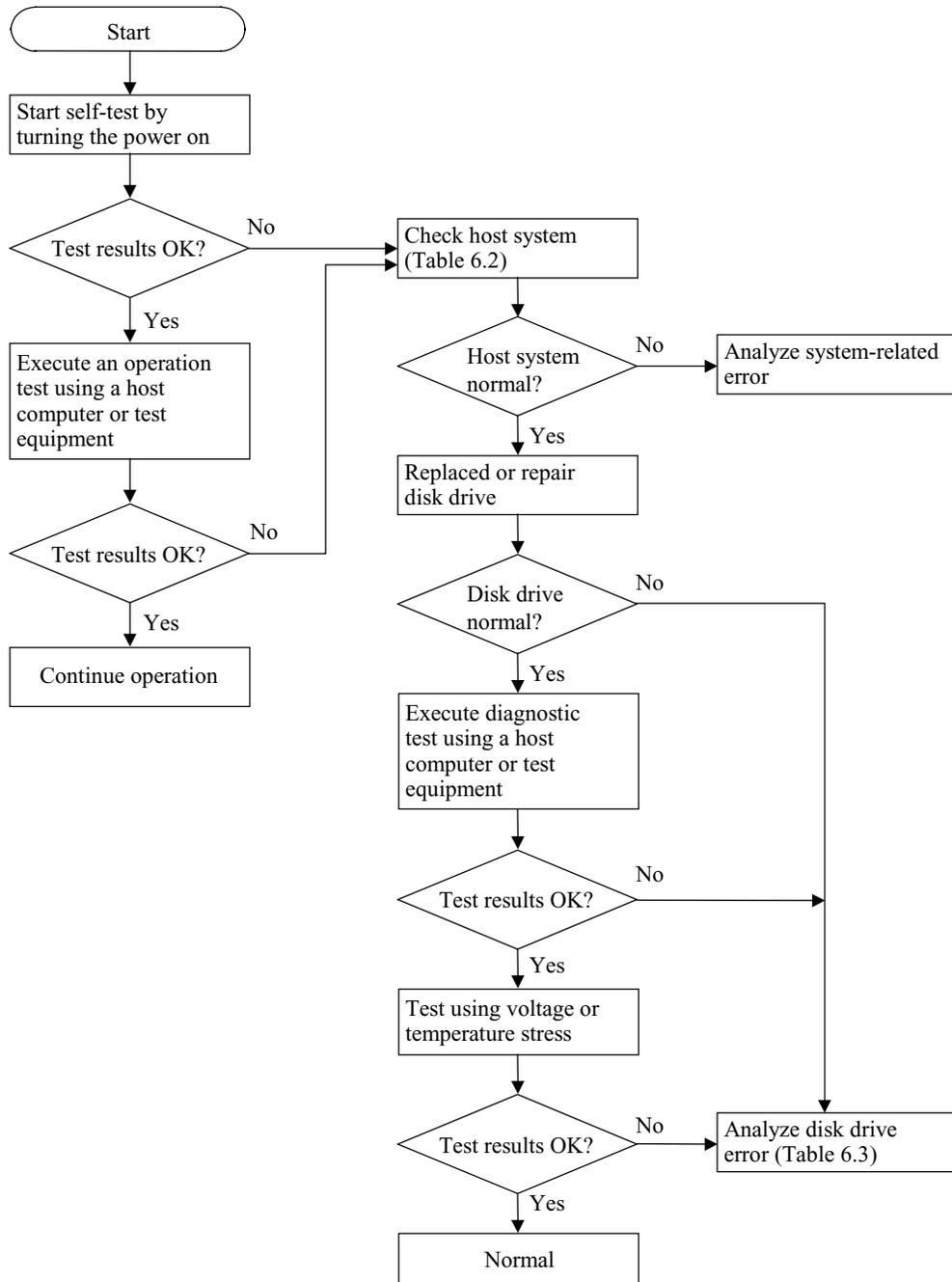


Figure 6.3 Test flowchart

## **6.3 Operation Check**

### **6.3.1 Initial seek operation check**

If an error is detected during initialization by the initial seek operation check routine at power-on, the IDD sends the Fault LED Out signal to the interface connector. The spindle motor of the disk drive then stops, and the disk drive is unusable.

For an explanation of the operation check before the initial seek, refer to the Section 5.5.

### **6.3.2 Operation test**

While the host computer is processing data, the IDD monitors disk drive operation including data processing, command processing, and seek operations. If the IDD detects an error, the IDD posts the error to the INIT. The INIT then posts the error to the user.

The user may detect an intermittent or nonfatal error such as abnormal noise, abnormal odor, or very slow operation.

An error posted in an operation test must be investigated. Replace the disk drive to see whether the error was caused by the disk drive.

Often, errors posted in an operation test may be caused by the host system. Possible causes include insufficient power capacity, loose cable connection, insufficient timing or insufficient mechanical play, and problems related to other systems.

If an operation error is detected by the error detection circuit of the disk drive, an interrupt occurs. The interrupt is posted to the MCU on the PCA. The MCU stops the currently processed command, and causes the CHECK CONDITION status to post the error to the INIT.

When receiving the CHECK CONDITION status, the INIT issues a REQUEST SENSE command to collect detailed information about the error. The INIT then issues a REZERO UNIT command to return the read/write head to track 00. In normal processing, the IDD itself or INIT determines how to handle the error (processing retry or stop).

To analyze the error posted in the operation test, reconstruct the conditions in which the error occurred. Then, start troubleshooting the whole host system by replacing the disk drive.

### **6.3.3 Diagnostic test**

The diagnostic test is executed to find a faulty subassembly in a faulty disk drive, or to check disk drive performance. This test is usually a combination of specific disk drive functions or group of functions. This test may be executed using a different host computers or test equipment and away from the environment where the error first occurred.

To analyze the error posted in the diagnostic test, reconstruct the conditions in which the error occurred. Then, look for a possibly faulty subassembly or part of the disk drive.

The procedures to be used in this test depend largely on the type of test equipment used, and are not covered by this manual.

## **6.4 Troubleshooting Procedures**

### **6.4.1 Outline of troubleshooting procedures**

This section explains the troubleshooting procedures for disk drive errors.

Depending on the maintenance level, analyze the error to detect a possibly faulty part (disk drive, or disk drive part).

Full-scale troubleshooting is usually required if the error cause is not known. If the error cause is clear (e.g., abnormal noise in disk enclosure or burning of a PCA), troubleshooting is straightforward.

### **6.4.2 Troubleshooting with disk drive replacement in the field**

At this level of maintenance, we recommend replacing the disk drive as a unit. If replacing the disk drive rectifies the fault, return the removed disk drive to the factory, for test and repair. If the newly installed disk drive does not rectify the fault another part of the system is faulty.

Table 6.2 summarizes system-level field troubleshooting. Troubleshooting must be done in the field, to find faulty part (disk drive or system).

**Table 6.2 System-level field troubleshooting**

Item	Recommended work
DC power level	<p>Check that the DC voltage is within the specified range (<math>\pm 5\%</math>).</p> <p>Check that the +5 VDC value (pin of the interface connector) is 4.75 to 5.25 VDC.</p> <p>Check that the +12 VDC supply (pin of the interface connector of disk drive) is 11.4 to 12.6 VDC.</p>
Electrical noise	<p>Make sure the maximum ripple peak-to-peak value of +5 VDC is within 250 mV and +12 VDC is within 250 mV.</p> <p>Make sure the high frequency noise (over 20 MHz) is less than 100 mVp-p.</p>
Drive selection address	Check that the disk drive selection address is set correctly.
System cables	Check that all system cables are connected correctly.
System diagnostic test	When possible, execute the system level diagnostic routine as explained in the host computer manual. This gives a detailed report of a possible fault.
Intermittent or nonfatal errors	<p>Check the AC voltage from the power supply. Check the DC voltage level at the power connector for the disk drive.</p> <p>If the AC voltage level is abnormal or there is a lot of electrical noise, notify the user of the error.</p> <p>If the DC voltage level is unstable, replace the power supply unit.</p> <p>If possible, replace the disk drive. If replacing the disk drive does not eliminate the error, the removed disk drive is probably not faulty. To continue error analysis, refer to the hardware and software manuals supplied with the system.</p>

### 6.4.3 Troubleshooting at the repair site

For maintenance at this level, we recommend additional testing of the disk drive and signal checking.

The sense data posted from the IDD helps with troubleshooting. This sense data makes the error type clear (functional, mechanical, or electrical error). Chapter 7 error analysis by sense data, and gives supplementary information on finding the error cause (faulty part).

Table 6.3 lists how to detect a faulty disk drive subassembly. This fault finding requires a working host computer or disk drive test equipment to recreate the error conditions.

If the detected error cannot be recreated in an ordinary test, disk drive conditions can be changed to force the error to recur. This is done by changing the DC voltage or the ambient temperature of the disk drive.

If the error does not recur with changed conditions, the disk drive is not faulty. If no error occurs in the disk drive test, notify the user of the test results, and find out from the user the environment conditions where the disk drive is used.

**Table 6.3 Disk drive troubleshooting**

Item	Recommended action
Frequent or repeated seek errors	Collect sense data, and see Chapter 7.  Replace the disk drive, and check that the test method is correct. If the error recurs, it is likely that the disk drive is normal but the test method is incorrect.
Intermittent or nonfatal errors	Replace the disk drive, and check that the test method is correct. If the error recurs, it is likely that the disk drive is normal but the test method is incorrect.  To check performance, change the disk drive conditions by changing the voltage or temperature.

If the disk drive error recurs or a possibly faulty part is found by troubleshooting, return the complete disk drive to the factory for repair. A media defect list must be included with a disk drive returned to the factory.

If the possibly faulty part is the disk enclosure, return the whole disk drive to the factory for repair. Also if a clear error (erroneous servo track information or noisy drive) is detected in the disk enclosure, return the whole disk drive to the factory. A media defect list must be included with a disk drive returned to the factory.



*Damage*

*Never open the disk enclosure in the field. Opening the disk enclosure may cause an irreparable fault.*

**6.4.4 Troubleshooting with parts replacement in the factory**

This manual does not cover troubleshooting at the factory level.

**6.4.5 Finding possibly faulty parts**

Finding possibly faulty parts in the field was explained in Subsection 6.4.2. This manual does not cover finding possibly faulty parts at the factory level.

## CHAPTER 7    **Error Analysis**

### **7.1    Error Analysis Information Collection**

### **7.2    Sense Data Analysis**

This chapter explains in detail how sense data collected from a disk drive is used for troubleshooting. Sense data reflects an error in the disk drive, and helps with troubleshooting.

A sense key, sense code, and subsense code, taken from various sense data are repeated. Also in this chapter, troubleshooting is performed using these three codes. Unless otherwise specified, "sense data" means the above three codes. When sense data is represented as (x-xx-xx), the leftmost x is a sense key, the middle xx is a sense code, and the rightmost x is a subsense code.

### **7.1    Error Analysis Information Collection**

#### **7.1.1    Sense data**

When IDD posts a CHECK CONDITION status or detects a fatal error in the loop, the current command or queued command is cleared. In such a case, the IDD generates sense data about the command-issuing INIT. The INIT can read the sense data by issuing a REQUEST SENSE command.

Even if a transfer byte length that is shorter than the sense data length of the tested device is specified, the command terminates normally. In this case, however, the INIT receives part of the sense data, but the remaining part of the sense data is lost.

For details of the REQUEST SENSE command, refer to the Fibre Channel Interface Specifications.

#### **7.1.2    Sense key, sense code, and subsense code**

If an error is detected in a disk drive, the error status is indicated in the sense data collected from the disk drive. Figure 7.1 shows the positions of a sense key, sense code, and subsense code.

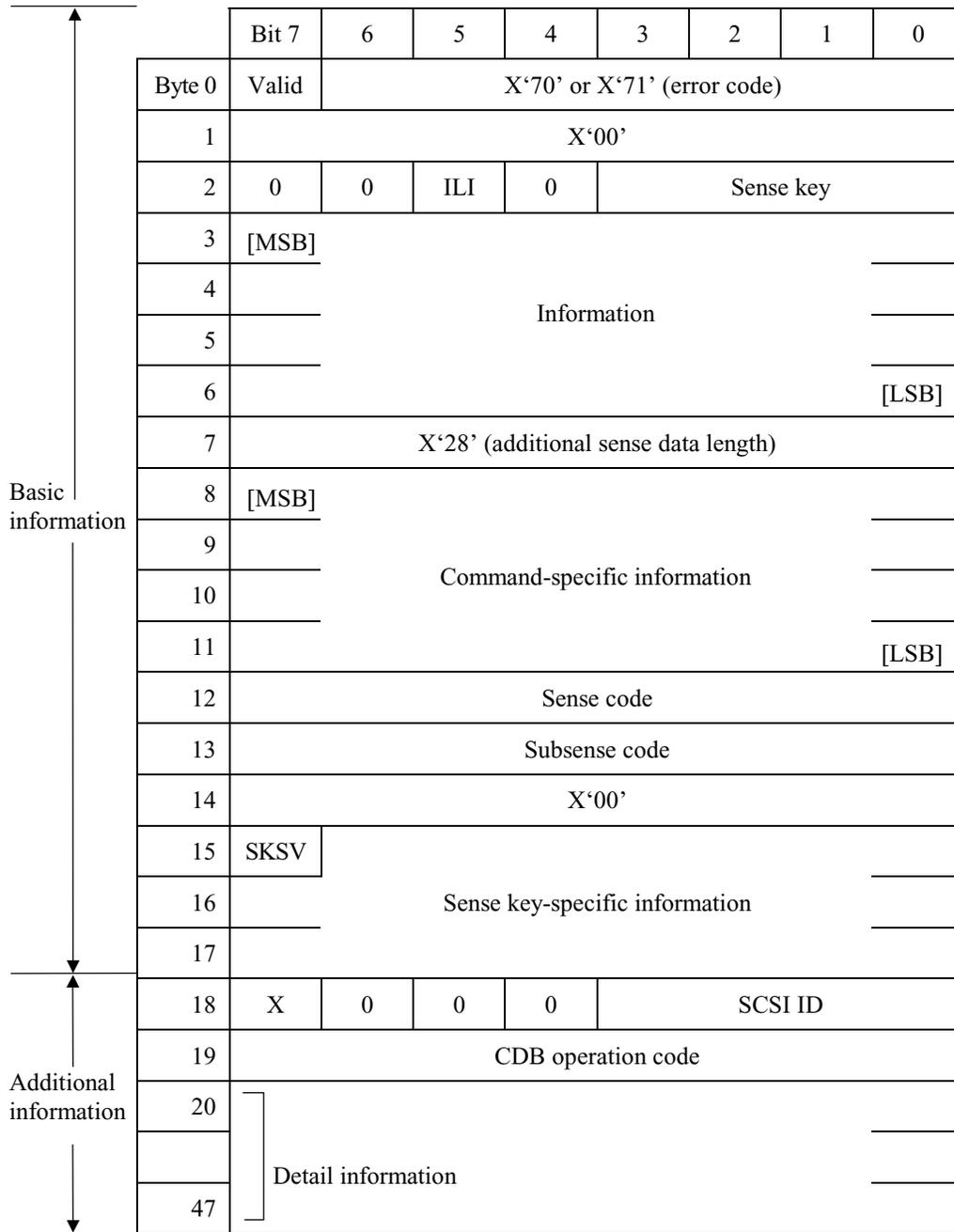


Figure 7.1 Format of extended sense data

## 7.2 Sense Data Analysis

### 7.2.1 Error information indicated with sense data

Subsection 7.2.2 onwards explain troubleshooting using sense data.

Table 7.1 lists the definition of sense data. For details of sense data, refer to the Fibre Channel Interface Specifications.

**Table 7.1 Definition of sense data**

Sense data			Definition
Sense key	Sense Code	Sub Sense Code	
00	00	00	Operation was normal.
3	0C	03	A write to a disk terminated abnormally.
4	32 40 44 C4	01 xx xx xx	Failed to update the defect list due to a disk medium write error, etc. An error occurred in power-on self-diagnosis. A hardware error occurred inside IDD. A drive error occurred.
1 3	1x 1x	xx xx	A disk read error occurred. A disk read error occurred.
E	1D	00	Data discrepancy found by VERIFY command byte check.
5  B B B B	2x 3D 47 49 4D 4E	xx 00 00 00 xx 00	A SCSI error, such as an invalid operation code, occurred. The Reserve bit of the IDENTIFY message was set to 1. A CRC error occurred in the fibre channel loop. An unmounted or inappropriate message was received. Before completion of a command, a command with the same tag number was issued. An overlap command was issued.

### 7.2.2 Sense data (3-0C-03), (4-40-xx), (4-44-xx), and (4-C4-xx)

Sense data (3-0C-03), (4-40-xx), (4-44-xx), and (4-C4-xx) indicate one of the following:

- A target sector could not be detected using the sector counter.
- A seek process overran the specified time.
- A write to a disk terminated abnormally.
- An error occurred in power-on self-diagnosis.
- A hardware error occurred inside IDD.
- A drive error occurred.

The symptoms above are generally caused by an error in a PCA or DE.

For details of the sense data above, refer to the Fibre Channel Interface Specifications.

### 7.2.3 Sense data (1-1x-xx), (3-1x-xx) and (E-1D-00): Disk read error

If sense data (1-1x-xx), (3-1x-xx) or (E-1D-00) occurs frequently in a specific block of a disk, there is disk damage that was not recorded in the media defect list. In this case, assign an alternate block to the error-detected block using a REASSIGN BLOCKS command. For an explanation of the REASSIGN BLOCKS command, refer to the Fibre Channel Interface Specifications.

If this error occurs in different blocks, a PCA or DE is faulty.

For details of the above sense data, refer to the Fibre Channel Interface Specifications.

### 7.2.4 Sense data (5-2x-xx), (5-3D-00), (B-47-xx), (B-49-00), (B-4D-xx) and (B-4E-00): fibre channel interface error

Sense data (5-2x-xx), (5-3D-00), (B-47-xx), (B-49-00), (B-4D-xx) and (B-4E-00) indicates one of the following symptoms:

- An invalid or unsupported command was issued, or invalid or unsupported parameters were specified.
- A SCSI error occurred.
- A CRC error occurred in the fibre channel loop.

If this error occurs, a PCA or the fibre channel interface is faulty.

For details of the above sense data, refer to the Fibre Channel Interface Specifications.

## **APPENDIX A Connector Signal Allocation**

### **A.1 Interface (FC-SCA) Connector Signal Allocation**

This appendix describes the connector signal allocation.

**A.1 Interface (FC-SCA) Connector Signal Allocation**

**Table A.1 FC-SCA connector: CN1**

Pin No.	Signal		Signal	Pin No.	
01	-EN bypass port A		+12V charge	21	
02	+12V		GND	22	
03	+12V		GND	23	
04	+12V		+PortA_in	24	
05	-Parallel ESI		-PortA_in	25	
06	-Drive present		GND	26	
07	Active LED out		+PortB_in	27	
08	-Spindle sync		-PortB_in	28	
09	Start_1/Mated		GND	29	
10	Start_2/Mated		+PortA_out	30	
11	-EN bypass port B		-PortA_out	31	
12*	SEL-6	-DSK_WR	GND	32	
13*	SEL-5	-DSK_RD	+PortB-out	33	
14*	SEL-4	-ENCL_ACK	-PortB-out	34	
15*	SEL-3	D(3)	GND	35	
16	Fault LED out		SEL-2	D(2)	36*
17	DEV_CTRL_CODE2		SEL-1	D(1)	37*
18	DEV_CTRL_CODE1		SEL-0	D(0)	38*
19	+5V		DEV_CTRL_CODE0		39
20	+5V		+5V charge		40

**Note:** \*1) Signal names in the right column of the table are those in parallel ESI operation.

# Glossary

## **CCS**

Common Command Set

This is the standard form of SCSI logical specifications stipulated by the operations subcommittee of the American National Standards Institute (ANSI) which stipulates functions which a direct access device (magnetic disk, etc.) should support.

## **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.

## **FC Device**

The general name given to a device which is connected to the FC bus (input/output device, I/O controller, host adapter, etc.).

## **Initiator (INIT)**

This is a SCSI device which initiates input and output operations on the SCSI bus. In this manual, initiator has been abbreviated to "INIT."

## **SCSI**

Small Computer System Interface

The standardized input/output interface of the American National Standards Institute (ANSI). [Standard No.: ANSI X3. 131-1986]

## **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.

## **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.

## **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."

# Acronyms and Abbreviations

## A

ACK	ACKnowledge
AEN	Asynchronous 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 Offline
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

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
LUN	Logical Unit Number

**M**

MR Magnetro Resistive  
MS Multiple Select  
MSG MeSsaGe

**T**

TB Transfer Block  
TPI Tracks Per Inch  
TRM TeRMinator

**O**

OEM Original Equipment Manufacturer

**U**

UnitOfI Unit Offline

**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 Synchronous  
PMI Partial Medium Indicator  
PR4ML Partial Response class 4 Maximum Likelihood

**V**

VCM Voice Coil Motor  
VPD Vital Product Data  
VU Vendor Unique

**W**

W Width  
WCE Write Cache Enable  
WP Write Protect

**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 Format  
SURF SURFace

# Index

+12 VDC .....	4-7
1-1x-xx .....	7-4
3-0C-03.....	7-4
3-1x-xx .....	7-4
4-40-xx .....	7-4
4-44-xx .....	7-4
4-C4-xx.....	7-4
5-2x-xx .....	7-4
5-3D-00 .....	7-4

## A

AC noise filter .....	4-8
actuator .....	1-6
air circulation.....	1-6
allowable input voltage and current.....	4-7
alternate area.....	3-10
alternate block allocation.....	3-11
alternate block allocation by FORMAT UNIT command.....	3-12
alternate block allocation by REASSIGN BLOCKS command.....	3-13
alternate block allocation during FORMAT UNIT command execution ....	3-12
alternate cylinder .....	3-5
alternate spare area .....	3-4
automatic alternate block allocation .....	3-14
automatic alternate block allocation at read operation.....	3-14
automatic alternate block allocation at write operation .....	3-14
automatic alternate block reassignment.....	1-4

## B

B-47-xx.....	7-4
B-49-00.....	7-4
B-4D-xx.....	7-4
B-4E-00 .....	7-4
basic operation test .....	6-5
BCRC .....	3-8
block address of user space .....	3-10
block descriptor .....	5-10

## C

cache feature.....	1-3
caching parameter.....	5-15
changing revision number in field .....	6-9
checking at abnormal end.....	5-10
checking connection .....	5-7
checking initial operation .....	5-6

checking operation after installation and preparing IDD for use .....	5-6
checking procedure.....	5-7
checking IDD connection .....	5-8, 5-9
command queuing feature .....	1-3
compactness.....	1-2
connection requirement .....	4-9
connector .....	4-9
continuous block processing.....	1-2
controller circuit .....	1-7
current waveform.....	4-7
cylinder configuration.....	3-1

## D

data field .....	3-8
data format.....	3-1
data security at power failure.....	2-7
data space.....	3-1
defect list.....	3-11
defect management.....	3-11
defective block slipping.....	1-4
definition of sense data .....	7-3
delivery .....	5-2
diagnosis .....	1-4
diagnostic.....	6-1
diagnostic test .....	6-12
diagnostics and maintenance .....	6-1
disconnection/reconnection parameter .....	5-14
disk .....	1-5
disk drive replacement.....	6-8
disk drive troubleshooting .....	6-15
disk read error.....	7-4
disk/head configuration .....	1-6
dismounting drive .....	5-5
dual-port support .....	1-2

## E

E-1D-00 .....	7-4
ECC .....	3-8
enclosure service function .....	1-3
environmental specification.....	2-4
environmental temperature .....	4-5
environmental/power requirement.....	2-4
error analysis.....	7-1
error analysis information collection .....	7-1
error information indicated with sense data....	7-3
error rate .....	2-5
error recovery .....	1-3
error recovery during self-diagnostic.....	6-3
error recovery parameter .....	5-13

- 
- example of FC-AL system configuration ..... 1-7  
external dimension..... 4-1  
external magnetic field ..... 4-6
- F**
- factory maintenance..... 6-8  
FC model drives outer view..... 1-5  
FC-AL standard ..... 1-2  
FC-SCA connector..... A-2  
fibre channel interface error..... 7-4  
field maintenance..... 6-8  
finding possibly faulty part..... 6-16  
format capacity ..... 3-9  
format of extended sense data..... 7-2  
format parameter..... 5-10, 5-11  
FORMAT UNIT command ..... 5-11  
formatting ..... 5-10  
function specification..... 2-2
- G**
- gap ..... 3-8  
general description..... 1-1  
general note..... 5-1
- H**
- hardware function test..... 6-2  
hardware specification ..... 2-1  
hardware structure ..... 1-5  
head..... 1-6  
high speed positioning ..... 1-4  
high-speed data transfer..... 1-2
- I**
- indicating revision number ..... 6-10  
indicating revision number at  
    factory shipment..... 6-9  
initial seek operation check..... 6-12  
initial self-diagnostic..... 6-2  
installation..... 5-1  
installation requirement ..... 4-1  
installation/removal/replacement..... 5-2  
interface connector signal allocation ..... A-2  
interface test..... 6-5  
internal test space..... 3-4
- L**
- large capacity ..... 1-4  
leak magnetic flux..... 4-6  
limitation of bottom-mounting ..... 4-5  
limitation of side-mounting ..... 4-4  
logical data block addressing..... 3-9  
loop ..... 6-5  
low noise and low vibration..... 1-5
- low power consumption..... 1-5  
maintenance level ..... 6-8  
maintenance requirement..... 6-6  
microcode downloading..... 1-5  
MODE SELECT/MODE  
    SELECT EXTENDED command ..... 5-10  
model name and order number ..... 2-1  
motor start mode ..... 5-3  
mounting ..... 4-3  
mounting drive..... 5-4  
mounting frame structure..... 4-3  
mounting procedure ..... 5-4  
mounting requirement..... 4-1  
MTBF..... 2-5  
MTTR ..... 2-6
- N**
- noise filter ..... 4-8  
note on handling drive ..... 5-1  
note on mounting ..... 4-3
- O**
- online self-diagnostic ..... 6-3  
operation check ..... 6-12  
operation test..... 6-12  
other ..... 4-6  
outline of troubleshooting procedure ..... 6-13
- P**
- packaging ..... 5-2  
PAD ..... 3-8  
page code = 1 ..... 5-13  
page code = 2 ..... 5-14  
page code = 3 ..... 5-10  
page code = 7 ..... 5-13  
part replacement..... 6-8  
part that can be replaced in field ..... 6-7  
physical sector allocation..... 3-5  
PLO Sync..... 3-8  
positioning error rate..... 2-5  
power on/off sequence ..... 4-7  
power supply requirement ..... 4-7  
precaution ..... 6-5  
preventive maintenance ..... 6-6  
programmable data block length..... 1-4  
programmable multi-segment data buffer..... 1-2
- R**
- random/sequential read test..... 6-5  
read/write circuit ..... 1-7  
read/write error recovery parameter..... 5-13  
reliability ..... 2-5  
reporting result of self-diagnostic and error  
    indication..... 6-3

reserve and release function ..... 1-3  
 revision label ..... 6-9  
 revision number ..... 6-9

**S**

sector format ..... 3-7  
 seek test ..... 6-2  
 self-diagnostic ..... 6-1  
 SEND DIAGNOSTIC command ..... 6-3  
 sense data ..... 7-1  
 sense data analysis ..... 7-3  
 sense key, sense code, and subsense code ..... 7-1  
 sequential starting of spindle motor ..... 4-7  
 service clearance area ..... 4-6  
 service life ..... 2-6, 6-6  
 service system and repair ..... 6-7  
 setting parameter ..... 5-12  
 spare area in cell ..... 3-5  
 spare disk drive ..... 5-16  
 specification ..... 2-1  
 spindle motor ..... 1-6  
 standard feature ..... 1-2  
 start/stop of spindle motor ..... 1-4  
 START/STOP UNIT command ..... 5-6  
 storage ..... 5-2  
 surface temperature check point ..... 4-5  
 surface temperature measurement point ..... 4-5  
 sync mark ..... 3-8  
 system configuration ..... 1-7  
 system space ..... 3-4

system-level field troubleshooting ..... 6-14

**T**

take following action if problem occur ..... 5-6  
 test ..... 6-10  
 test flowchart ..... 6-11  
 test program ..... 6-4  
 tool and test equipment ..... 6-10  
 track format ..... 3-5  
 track skew and head skew ..... 3-6  
 track skew/head skew ..... 3-7  
 troubleshooting at repair site ..... 6-15  
 troubleshooting with disk drive  
   replacement in field ..... 6-13  
 troubleshooting with part replacement  
   in factory ..... 6-16

**U**

unpackaging ..... 5-2  
 unrecoverable error rate ..... 2-5  
 user space ..... 3-3

**V**

verify error recovery parameter ..... 5-13

**W**

write/read test ..... 6-2, 6-5

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