MAX3147FC

MAX3073FC

MAX3036FC

HARD DISK DRIVES

PRODUCT/MAINTENANCE MANUAL

FUJITSU

FOR SAFE OPERATION

Handling of This Manual

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

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

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

Compliance With Taiwanese Standards on Radio Wave Use (BSMI).

警 告 使 用 者 ：

這是甲類的資訊產品，在居住的環境中使用時，可能會造成射頻干擾，

在這種情況下，使用者會被要求採取某些適當的對策。

Caution

This computer device shall meet FCC Class A environment. If you use this device at Home environment, it may affect to the Television set, Radio receiver, and so on.

In this case, you may require to take action to resolve any affection due to this device.

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REVISION RECORD		
Edition	Date published	Revised contents
01	June, 2005	
Specification No.: C141-E234-EN**		

C141-E234

Related Standards

Product specifications and functions described in this manual comply with the following ANSI (*1) standards.

Document number	Title
NCITS TR-19	FIBRE CHANNEL PRIVATE LOOP SCSI DIRECT ATTATH (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 PROTOCOL FOR SCSI (SCSI-FCP)

*1 ANSI = American National Standard Institute

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

Preface

This manual describes the MAX3147FC, MAX3073FC, and MAX3036FC 3.5" type hard 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 hard 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 and one appendix:

Chapter 1 General Description

This chapter introduces the standard features, hardware, and system configuration of the HDD.

Chapter 2 Specifications

This chapter gives detailed specifications of the 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 the disk drives.

Chapter 5 Installation

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

Chapter 6 Diagnostics and Maintenance

This chapter describes the automatic diagnosis and maintenance of the 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 USED IN THIS MANUAL

The MAX3147FC, MAX3073FC, and MAX3036FC disk drives are described as "the hard disk drive (HDD)", "the disk 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".

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:

⚠CAUTION   This indicates a hazardous situation *could* result in *minor* or *moderate personal injury* if the user does not perform the procedure correctly. This alert signal also indicates that damages to the product or other property, *may* occur if the user does not perform the product correctly.

IMPORTANT   This indicates information that could help the user use the product more efficiently.

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

(Example)

⚠CAUTION

Damage
Never remove any labels from the drive or deface them in any way.

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

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:

⚠**CAUTION** 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
Specification	*Data loss* *The drive adopts Reed-Solomon code for ECC. The sector-data is divided into 3 interleaving sectors, and ECC is performed in each sector where the maximum number of errors (up to 9 byte) can be corrected. [Total maximum byte: 9 byte $\times$ 3 (interleave) = 27 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.*	2-5
Installation	*Damage* *Never remove any labels from the drive or deface them in any way.*	4-3
	Hot temperature *To prevent injury, never touch the drive while it is hot. The DE and LSI become hot during operation and remain hot immediately after turning off the power.*	5-1

Task	Alert message	Page
Installation	*Damage*	
	1. When dismounting the drive which is mounted on the system while power is supplied to it.	5-16
	• *The drive to be dismounted 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 dismounted 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 case (Fcell). (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 case (Fcell). (Shown in Section 5.1).*	
Diagnostics and Maintenance	*Data loss*	
	When the SEND DIAGNOSTIC command terminates with the CHECK CONDITION status, the initiator 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.	6-4
	Caution	
	1. To avoid injury, do not touch the mechanical assembly during disk drive operation.	6-5
	2. Do not use solvents to clean the disk drive.	

Task	Alert message	Page
Diagnostics and Maintenance	*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. This operation is required to prevent unexpected or unpredictable operation.* *3. Do not use a conductive cleaner to clean a disk drive assembly.*	6-5
	Damage *1. Never remove any labels from the drive.* *2. Never open the disk enclosure for any reason. Doing so will void any warranties.*	6-14
	Data loss *Save data stored on the disk drive to other media before requesting repair. Fujitsu does not assume responsibility if data is destroyed during servicing or repair.*	6-7

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PRODUCT/ MAINTENANCE MANUAL (This manual)	1. General Description 2. Specifications 3. Data Format 4. Installation Requirements 5. Installation 6. Diagnostics and Maintenance 7. Error Analysis

FIBRE CHANNEL INTERFACE SPECIFICATIONS	1. Fibre Channel Interface 2. Command Processing 3. Data Buffer Management 4. Command Specifications 5. Sense Data and Error Recovery Methods 6. Disk Media Management

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CHAPTER 1 General Description

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This chapter describes the feature and configuration of the hard disk drives (HDDs).

The drives are high performance large capacity 3.5" type hard disk drives with an embedded Fibre-Channel controller.

The interface used to connect the 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 the HDDs 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 Chapter 6 "Disc Media Management" of the Fibre Channel Interface Specification for details.

1.1 Standard Features

(1) Compactness

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

(2) Restriction of Use of Hazardous Substances

The amounts of hazardous substances in use in these HDDs have been reduced in accordance with the Restriction of Use of Hazardous Substances (RoHS) Directive recently issued by European Union (EU).

Note:

At present, the permissible limits on the use of certain materials specified by the RoHS directive have not been determined. In such cases, we are using the original criteria set by Fujitsu Limited while referring to the restrictions already established by End-of-Life Vehicle (ELV) Directive or by the national environmental laws of the EU member nations.

(3) FC-AL standard

The HDD 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.

(4)   Dual-port support

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

(5)   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 HDD enables the effective use of such high-speed data transfers available on the Fibre Channel loop.

(6)   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 HDD can perform continuous read/write operation when processing data blocks on several tracks or cylinder.

(7)   Multi-segment data buffer
The data buffer is 8M 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.

(8)   Cache feature

After executing the READ command, the HDD 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 disk 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.

(9)   Command queuing feature

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

(10)   Reserve and release functions

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

(11)   Enclosure service function

The HDD 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.

(12)   Error recovery

The HDD 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 HDD.

(13)   Automatic alternate block reassignment
If a defective data block is detected during read or write the HDD can automatically reassign its alternate data block.

(14)   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).

(15)   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.

(16)   High speed positioning

A rotary voice coil motor achieves fast positioning with high performance access control.

(17)   Large capacity

A large capacity can be obtained from the HDD 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.

(18)   Start/Stop of spindle motor

Using the SCSI command, the host system can start and stop the spindle motor.

(19)   Diagnosis

The HDD has a diagnostic capability which checks internal controller functions and drive operations to facilitate testing and repair.

(20)   Low power consumption

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

(21)   Low noise and low vibration

The noise level is low; approx. 3.5 Bels at Ready for the drive. This makes it ideal for office use.

(22)   Microcode downloading

The HDD implements the microcode download feature. This feature easily achieves maintenance and function enhancement of the HDD.

1.2   Hardware Structure

An outer view of the HDD is given in Figures 1.1. The HDD has a disk enclosure (DE) and a printed circuit assembly (PCA). The DE includes heads on an actuator and disks on a spindle motor mounted on the DE. The PCA includes a read/write circuit and a controller circuit.
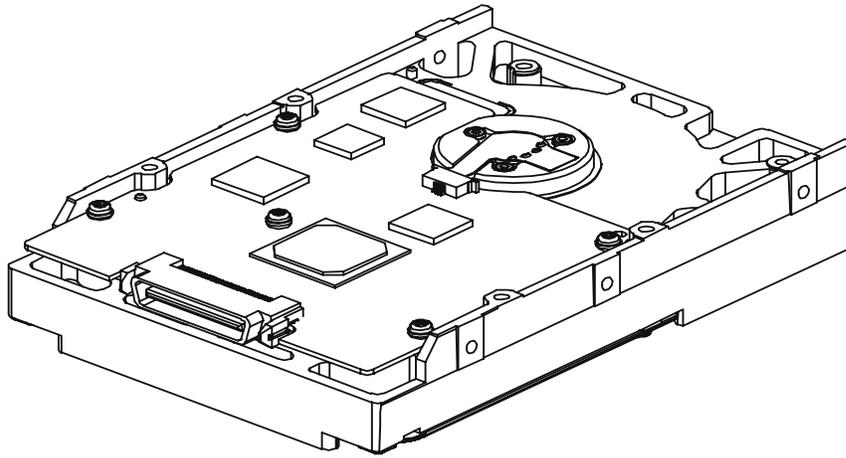
Figure 1.1   FC model drives outer view

(1)   Disks

The disks have an outer diameter of 70 mm (2.8 inch) and an inner diameter of 25 mm (0.98 inch). The disks are good for at least 50,000 contact starts and stops.

(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.

(3)   Spindle motor

The disks are rotated by a direct-drive hall-less DC spindle 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 are 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 FC controller.

1.3 System Configuration

For the Fibre Channel, the ANSI standard defines Arbitrated Loop, Fabric, and Point-to-Point technologies. The drives support the Arbitrated Loop technology. Figure 1.2 gives an example of the FC-AL system configuration.
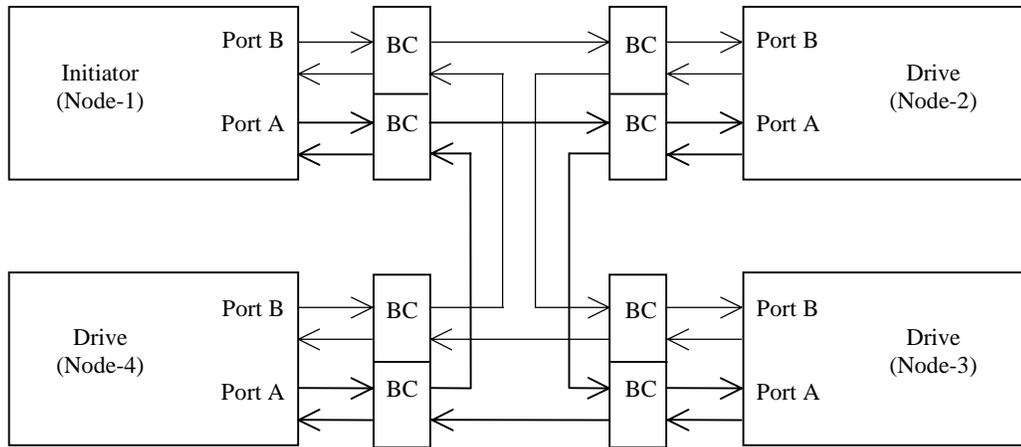
Figure 1.2   Example of FC-AL system configuration

Any device connected to the Fibre Channel is called a node. The nodes shown in Figure 1.2 represent the initiator and individual disk drives. Each node has at least one port called an N_port. For FC-AL, each port is called a Node-Loop port (NL_port).

The drives have two ports, one of which is used for connections to an FC-AL. A maximum of 126 NL_ports 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 1.2 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.

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CHAPTER 2   Specifications

2.1   Hardware Specifications

This chapter describes specifications of the HDD.

2.1   Hardware Specifications

2.1.1   Model name and order number

Each model has 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)
MAX3147FC	CA06693-B400	SCA2, FC-AL	147.0 GB (*)
MAX3073FC	CA06693-B200	SCA2, FC-AL	73.5 GB (*)
MAX3036FC	CA06693-B100	SCA2, FC-AL	36.7 GB (*)

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

2.1.2 Function specifications

Table 2.2 shows the function specifications of the HDD.

Table 2.2   Function specifications

Item		Specification		
		MAX3147FC	MAX3073FC	MAX3036FC
Formatted capacity/device (*1)		147.0 GB (*2)	73.5 GB (*2)	36.7 GB (*2)
Number of disks		4	2	1
Number of heads		8	4	2
Number of rotations min^{-1} (rpm)		15,000 ± 0.2%		
Average latency time		2.00 ms		
Seek time (*3) (Read/Write)	Track to Track	0.2 ms/0.4 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		0.8 kg max.		
Power consumption (*5)		14.0 W typ.		
Interface		Cable length: 30 m max.		
Areal density		58 Gbit/inch^2		
Data transfer rate (*6)	Disk drive	147.0 MB/s		
	FC-AL	212.5 MB/s max.		
Logical data block length		512, 516, 520, 524, 528 byte (Fixed length) (*7)		
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		8 MB FIFO ring buffer (*8)		
Acoustic noise (Idle)		3.5 Bels typ.		

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

(*3)   The seek time is as follows:

Seek Difference [4096 Cyl/div]
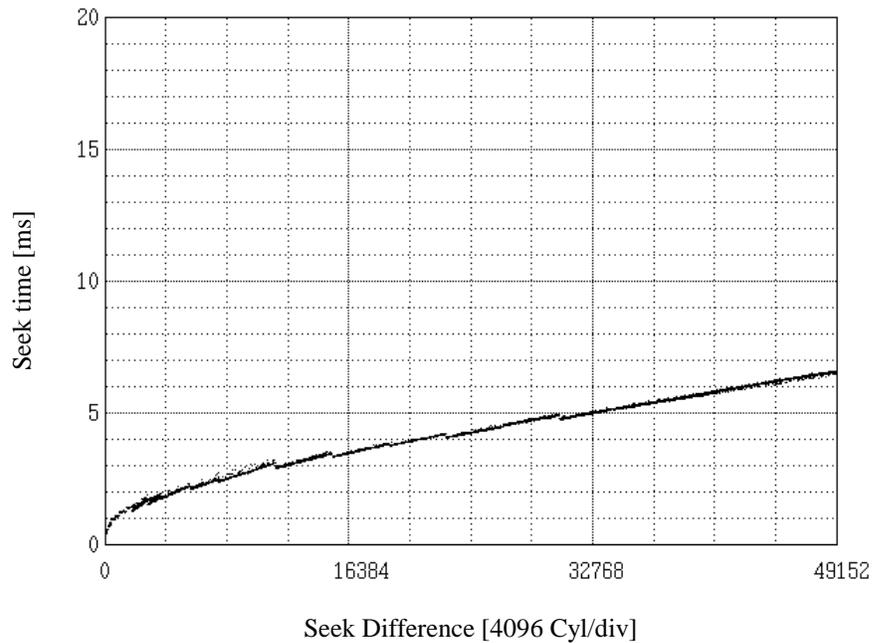
(*4)   The start time is the time from power on or start command to when the HDD is ready, and the stop time is the time for disks to completely stop from power off or stop command.

(*5)   This value indicates during idle mode. Power supply at nominal voltage ±1%. 25°C ambient.

(*6)   The maximum data transfer rate may be restricted to the response speed of initiator and by transmission characteristics. 1MB/s=1,000,000 bytes/s.

(*7)   Refer to 1.1 (14).

(*8)   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		
			MAX3147FC	MAX3073FC	MAX3036FC
Temperature (*1)	Operating		5 to 55°C		
	Non-operating		–40 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^2 (1G) (20 to 300 Hz) or less		
	Non-operating (*4)		3.1 mm (5 to 20Hz)/49m/s^2 (5G) (20 to 300Hz) or less		
	Transport (packaged)		3.1 mm (5 to 20Hz)/49m/s^2 (5G) (20 to 300Hz) or less		
Shock (*2)	Operating		637.4m/s^2 (65G) / 2 ms duration		
	Non-operating		2,451.7m/s^2 (250G) / 2 ms duration		
	Transport (packaged)		2,451.7m/s^2 (250G) / 2 ms duration		
Altitude	Operating		–305 to +3,048 m (–1,000 to +10,000 feet)		
	Non-operating		–305 to +12,192 m (–1,000 to +40,000 feet)		
Power requirements Input power (*5)	+12 VDC ±5%	Idle	0.75 A ave.		
		Spin-up	3.0 A (peak within 100 μs)		
		Random W/R	1.0 A (about 80 IOPS)		
	+5 VDC ±5%	Idle	0.96 A ave.		
		Random W/R	1.2 A (about 80 IOPS)		
	Ripple (+5 V and +12 V)		250 mVp –p or less (*6)		

(*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 10 per 10^{16} bits read.

⚠CAUTION

Data loss

The drive adopts Reed-Solomon code for ECC.   The sector-data is divided into 3 interleaving sectors, and ECC is performed in each sector where the maximum number of errors (up to 9 byte) can be corrected. [Total maximum byte: 9 byte $\times$ 3 (interleave) = 27 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 HDD 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:

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

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 low as possible.

- 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: Exceeding 60°C Without warranty
                   (keep the DE surface temperature 60°C or less)

Even if the HDD 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 HDD is operating.
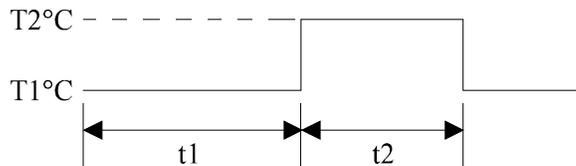
$$\text{Average DE surface temperature} = \frac{T1 \times t1 + T2 \times t2}{t1 + t2}$$

(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

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

3.1   Data Space

The HDD 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 the HDD itself

The user space allows a user access by specifying data. These spaces 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 HDD 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 HDD 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 the last cylinder (alternate cylinders) in one zone are allocated as alternate areas according to the user's assignment (MODE SELECT command). See Subsection 3.1.2 for details.

Figure 3.1   Cylinder configuration
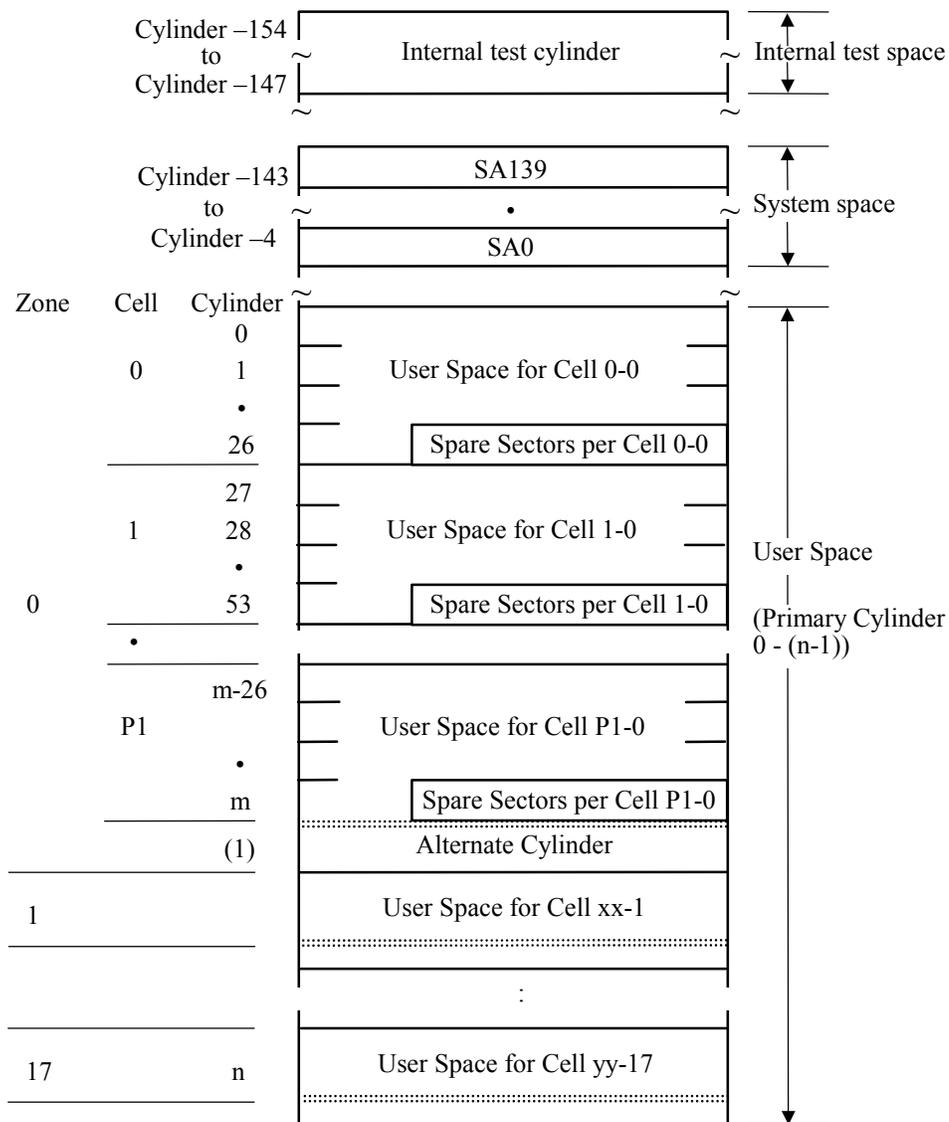
Note: Spare sectors on the last track in each cylinder are not necessarily placed at the end of the track because of a track skew or a cylinder skew. (Details are explained in Subsection 3.1.3.)

Apart from the above logical configuration, the HDD intends to increase the storage capacity by dividing all cylinders into several zones and changing a recording density of each zone.

(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 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 is located at the end of each zone in the user space as an alternate cylinder. Alternate cylinders will be used for alternate blocks. 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 512 bytes. The Internal test space consists of 8 cylinders and outer-most cylinder is always assigned (cylinder -147 to -154). 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 HDD 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 200. The default for the spare sectors number is 200.
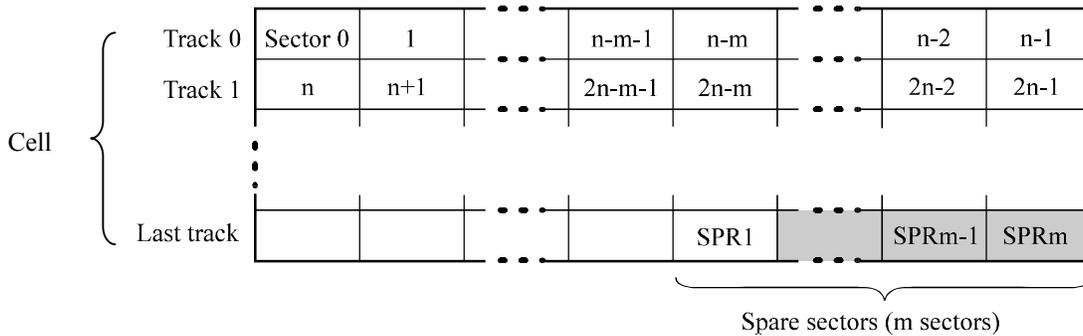
Note: This drive manages alternate spare areas for each cell, which is a set of cylinders. One cell consists of 27 cylinders.

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.
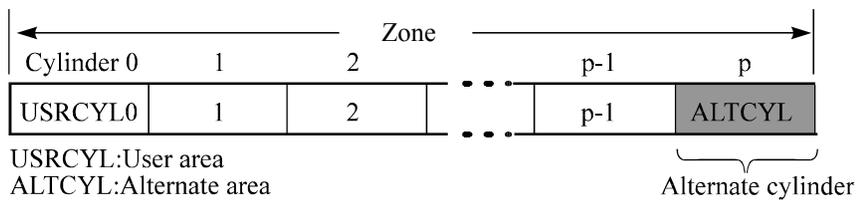
Note: The number of alternate cylinders cannot be changed.

Figure 3.3   Alternate cylinder

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 the HDD internal free running clock 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.
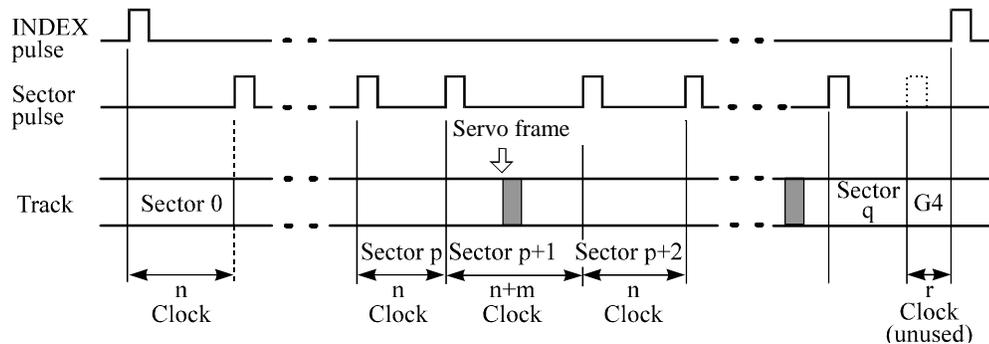
Figure 3.4   Track format

(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 cylinder switching location in a head, 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 head switching location, like the cylinder switching location, the first logical data block in a head is allocated at the sector position which locates the head skew behind the last logical sector position in the preceding head. The last logical sector in the cell is allocated when formatting, and is an unused spare sector.
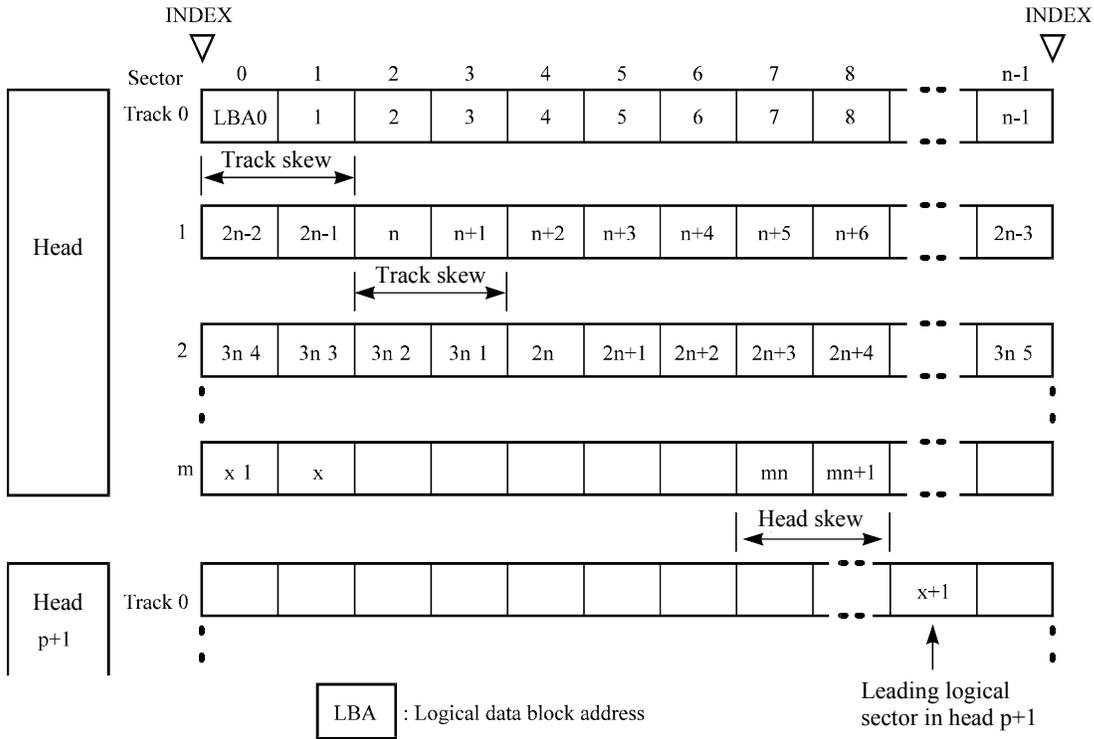
Figure 3.5   Track skew/head skew

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 HDD 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.
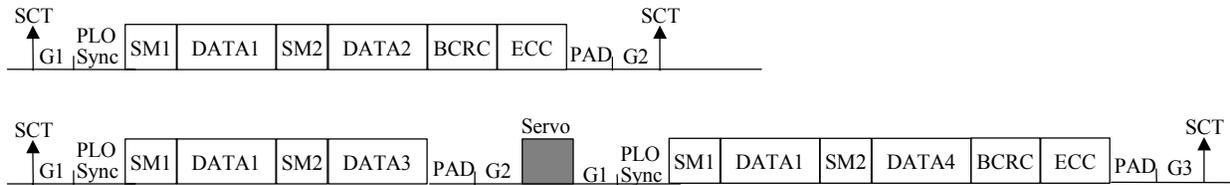
Figure 3.6   Sector format

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 54-byte code that allows detection and correction of errors in the data field, which is capable of correcting the single burst error up to 216 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 HDD (format capacity) varies according to the logical data block or the size of the spare sector area. Table 3.1 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.

[Number of sectors of each zone] = [number of sectors per track × number of tracks per cell – number of alternate spare sectors per cell] × [number of cells in the zone]

[Formatted capacity] = [total of sectors of all zones] ÷ [number of physical sectors in logical block] × [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.

[Format capacity] = [logical data block length] × [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 3.1   Format capacity

Model	Data block length	User blocks	Format capacity (GB)
MAX3147FC		287,277,984	147.0 (*)
MAX3073FC	512	143,638,992	73.5 (*)
MAX3036FC		71,819,496	36.7 (*)

(*) 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 HDD adopts the logical data block addressing as a data access method on the disk medium. The HDD 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 initiator 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 hexadecimal numbers 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 HDD 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 in ascending order of track number in the same 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) and 2).

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 the HDD 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 HDD 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 initiator 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 initiator 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 initiator, information on defective logical data blocks assigned alternate blocks by means of the HDD 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 initiator 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 HDD.

The initiator 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 "alternate cylinders". See Subsection 3.1.2 for details.

The initiator 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 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 Chapter 4 "Command Specifications" and Subsection 5.3.2 "Auto alternate block allocation processing" of the Fibre Channel Interface 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 HDD 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.

Example 1

0	1	X	3	4	5	6	7
8	9	10	11	12	X	14	15
16	17	18	19	20	21	22	23
X	25	26	27	S	S	S	S

Sector slip

0	1	X	2	3	4	5	6
7	8	9	10	11	X	12	13
14	15	16	17	18	19	20	21
X	22	23	24	25	26	27	S

Example 2

0	1	X	3	4	5	6	7
X	9	10	11	12	X	14	15
16	17	18	X	20	21	22	23
X	25	26	27	S	S	S	S

Sector slip

0	1	X	2	3	4	5	6
X	7	8	9	10	X	11	12
13	14	15	X	16	17	18	19
X	21	22	23	24	25	26	27

Alternate cylinder

Alternate sector

| 20 | S | S | S |

0	1	X	2	3	4	5	6
X	7	8	9	10	X	11	12
13	14	15	X	16	17	18	19
X	21	22	23	24	25	26	27

Alternate cylinder

| n | : n represents a logical data block number |

| X | : Defective sector |

| S | : Unused spare sector |

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 HDD 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 HDD 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. The alternate block is allocated to unused spare sectors in the alternate cylinder.

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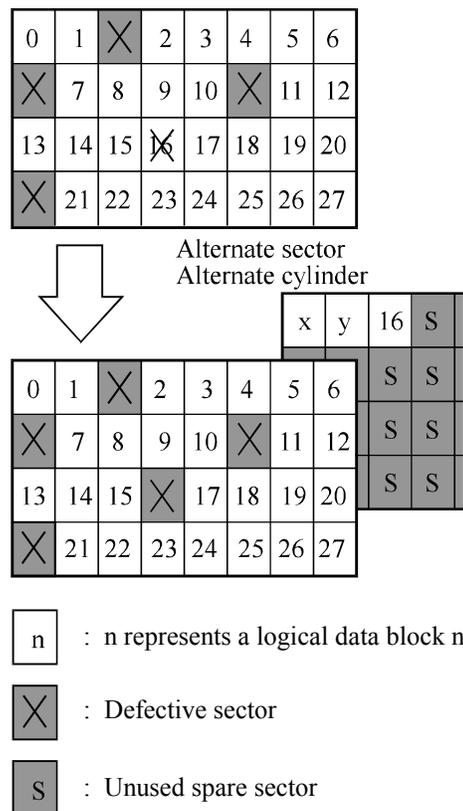
Figure 3.8   Alternate block allocation by REASSIGN BLOCKS command

(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 HDD 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 HDD 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.

Type 2 (Reassignment of write fail sector)

1) Commands to be applied
    -   WRITE
    -   WRITE EXTENDED
    -   FORMAT UNIT
    -   WRITE at executing WRITE AND VERIFY

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 up to the following quantities during the execution of one command:

> *ARRE = Twice*
>
> *AWRE (Type 1) = Eight times*
>
> *AWRE (Type 2) = Maximum number which can be processed within the recovery time limit*

If more than the above mentioned 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.

CHAPTER 4   Installation Requirements

4.1   Mounting Requirements

4.2   Power Supply Requirements

4.3   Connection Requirements

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 HDD and the location of the holes for the HDD mounting screws.

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

[Unit: mm]

Figure 4.1   Dimensions

4.1.2 Mounting orientations

The permissible orientations of the HDD are shown in Figure 4.2, and the tolerance of the angle is ±5° from the horizontal plane.

(a) Horizontal –1

(b) Horizontal –2

(c) Vertical –1

(d) Vertical –2

(e) Upright mounting –1

(f) Upright mounting –2

Direction of gravity
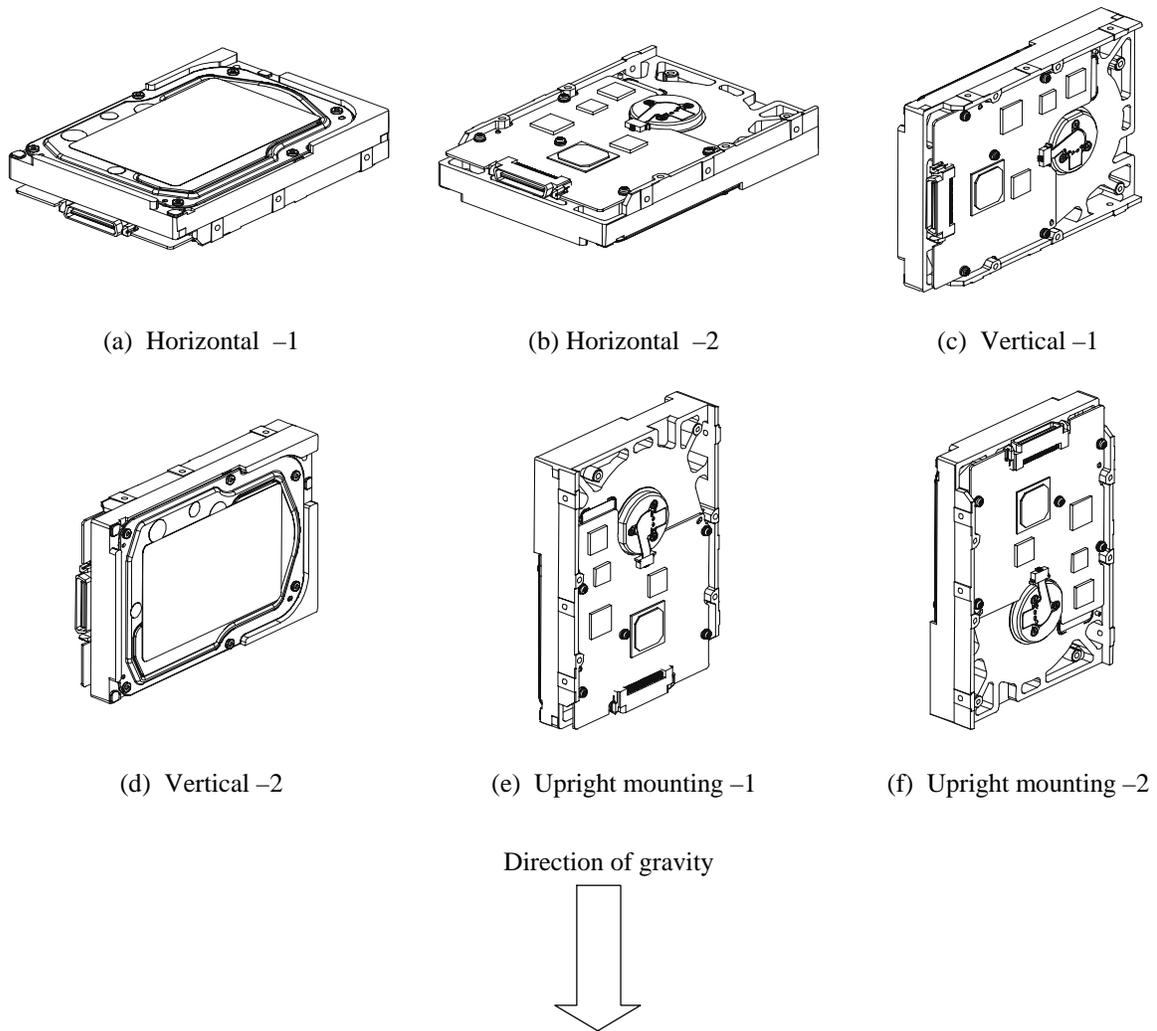
Figure 4.2   HDD orientations

4.1.3   Notes on mounting

⚠CAUTION

Damage

Never remove any labels from the drive or deface them in any way.

(1)   Mounting screw

Use #6-32UNC.

(2)   Mounting frame structure

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

a)   Use the frame with an embossed structure, or the like. Mount the HDD with making a gap of 2.5 mm or more between the HDD and the frame of the system.

b)   As shown in Figure 4.3, the inward projection of the screw from the HDD frame wall at the corner must be 5.0 mm or less.

c)   Tightening torque of screw must be secured with 0.59N·m (6kgf·cm) ±12%.

d)   Impact caused by the electric screwdriver must be within the device specifications.

e)   Must be handled on an anti-static mat.
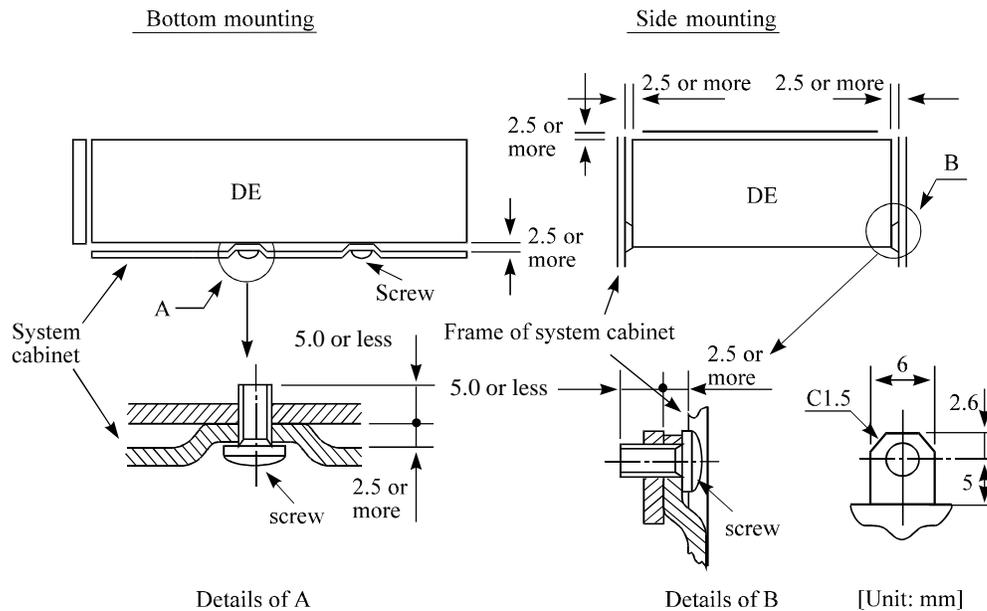
Figure 4.3   Mounting frame structure

(3)   Limitation of side-mounting

Use the four 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 two holes on both ends. (Total six screws for six holes enclosed)
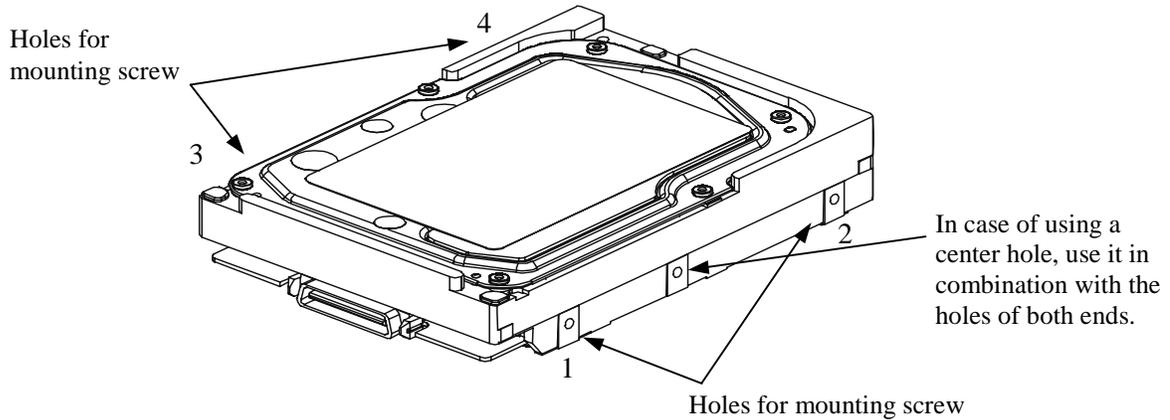
Use four holes (No.1 to No.4) to mount.

Figure 4.4   Limitation of side-mounting

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

(5)   Environmental temperature

Temperature condition at installed in a cabinet is indicated with ambient temperature measured 30 mm from the disk drive. At designing the system cabinet, consider following points.

- Make a suitable air flow so that the DE surface temperature never exceed 60°C.

- Cool the PCA side especially with air circulation inside the cabinet. Confirm the cooling effect by measuring the surface temperature of specific ICs and the DE. These measurement results must satisfy the temperature condition 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 0.8 m/s.

Table 4.1   Surface temperature check point

No.	Measurement point	Max. temperature on package
1	DE surface	60°C
2	Read channel LSI	80°C
3	VCM/SPM Driver	92°C
4	HDC	90°C
5	MPU	90°C
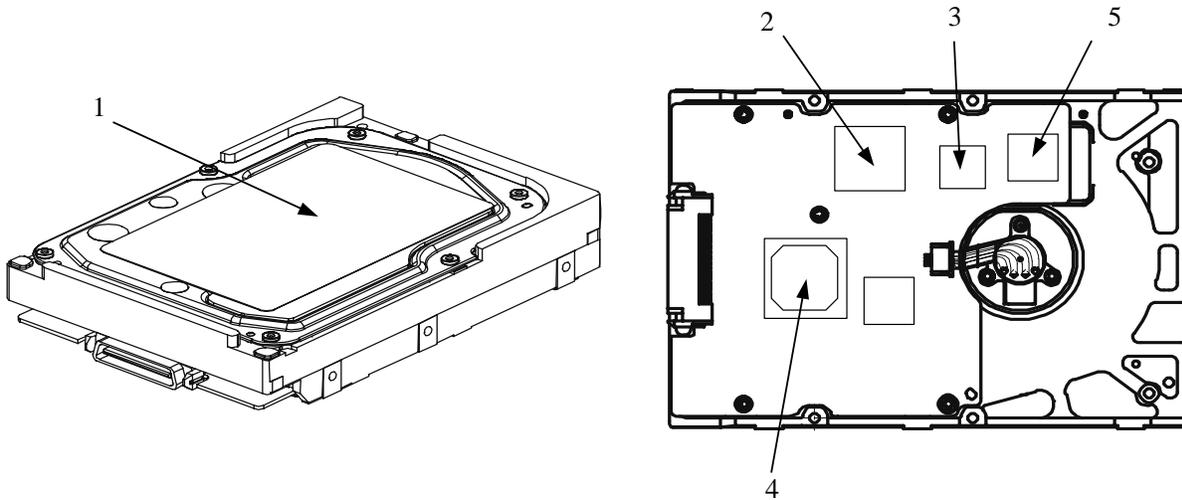
Figure 4.5   Surface temperature measurement points

(6)   Service clearance area

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

[Surface R]
• Hole for mounting screw

[Surface P]
• Cable connection

[Surface Q]
• Hole for mounting screw
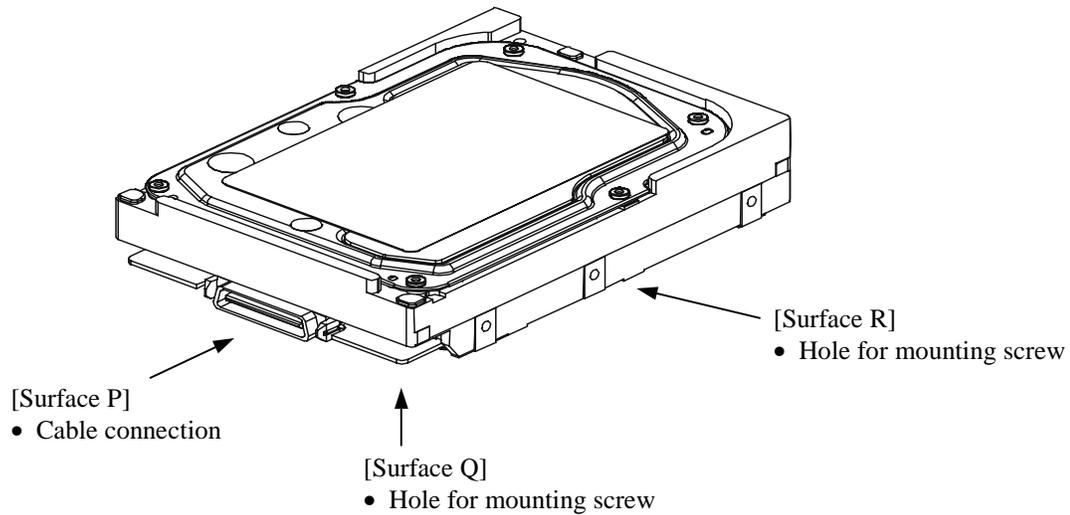
Figure 4.6   Service clearance area

(7)   Environmental magnetic field

Do not install the HDD in the vicinity of equipment giving off strong magnetic fields, such as monitors, televisions, or loudspeakers.

(8)   Leakage magnetic flux

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

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 HDD (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.
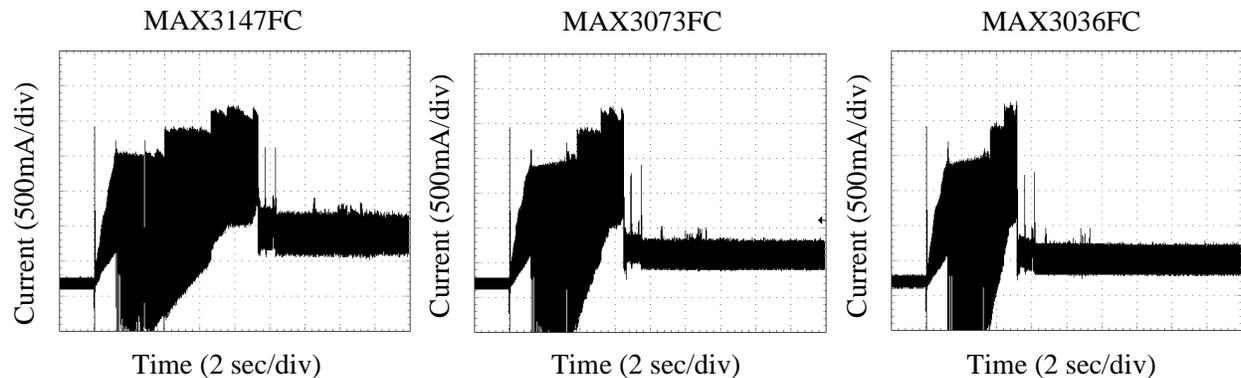
Figure 4.7   Current waveform (+12 VDC)

(3)   Power on/off sequence

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

(4)   Sequential starting of spindle motors

After power is turned on to the HDD, a large amount of current flows in the +12 VDC line when the spindle motor rotation starts. Therefore, if more than one HDD 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 12-second intervals or more 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 HDD 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.
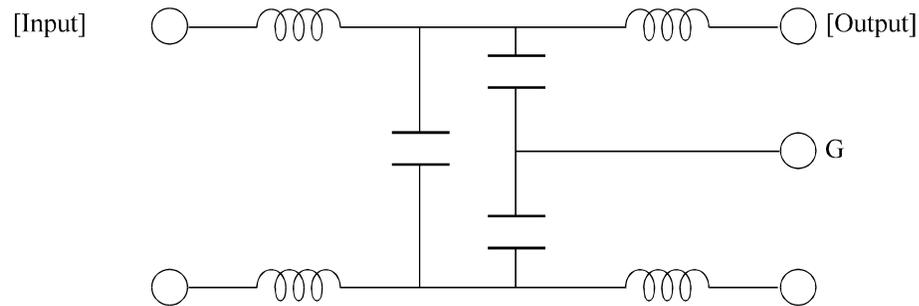
Figure 4.8   AC noise filter (recommended)

4.3   Connection Requirements

4.3.1   Connector

Figure 4.9 shows the location of interface connector.

Interface connector (CN1)
(including power supply)
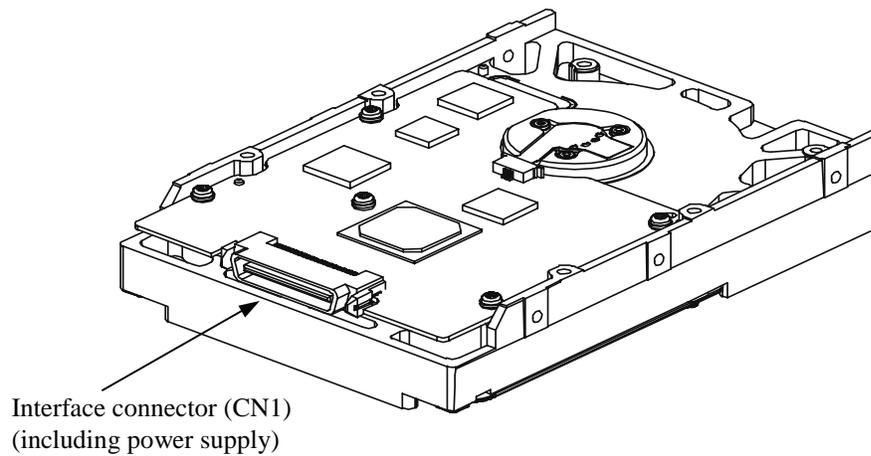
Figure 4.9   Connector location

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 Section 1.3 "Physical Requirements, Electrical Requirements" of the Fibre Channel Interface Specifications.
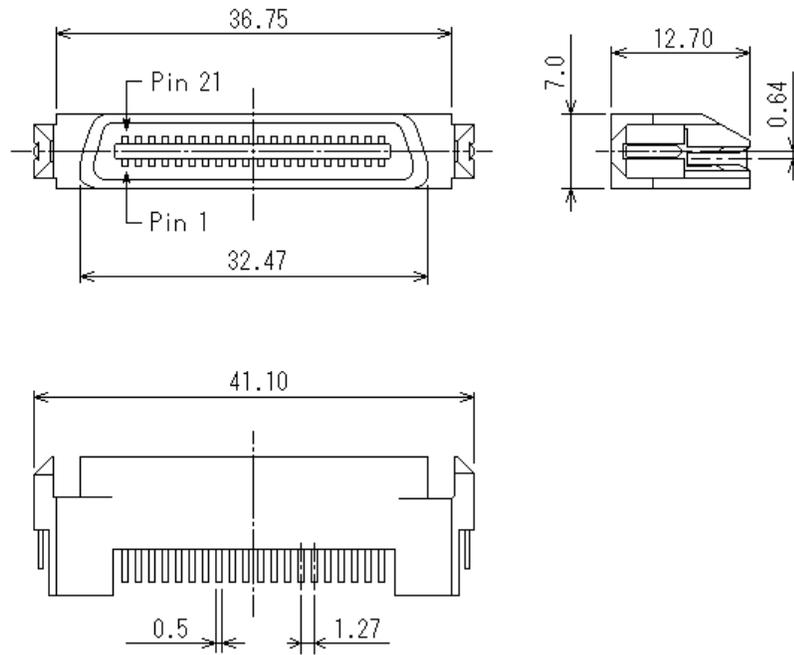
Figure 4.10   SCA2 type connector

CHAPTER 5   Installation

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 specifications 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 damaged 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.

⚠CAUTION

Hot temperature
To prevent injury, never touch the drive while it is hot. 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 PCA and interface connector when removing the drive from the Fcell.

    d)   Never remove any labels from the drive. Never open the disk enclosure for any reason.

(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 case (Fcell).

    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.

(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.

(6)   Storage

    a)   Provide moistureproof 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 HDD 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 pin	CN1-09 pin	
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 drive 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 HDD.

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: 3×2, bottom: 4). Fix the drive by using four mounting holes of both sides of the drive or the bottom. (See Figure 4.4)

- Use mounting screws of which 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 PCA.

3) Confirm the DE is not touching the frame on the system side excluding the screw installing part 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 using an electric screwdriver, use an electric screwdriver that does not apply a force on the drive that would exceed the drive's specifications.

5.4   Checking Operation after Installation and Preparing the HDD for Use

5.4.1   Checking initial operation

This section explains how to check operation after power is turned on. Since the initial operation of an HDD 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 HDD starts the initial self-diagnosis.

   b)   If the initial self-diagnosis detects a problem, the HDD 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 HDD is in idle mode, the Active LED remains lit. (When the initiator accesses the HDD, 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 HDD starts the initial self-diagnosis.

   b)   If the initial self-diagnosis detects a problem, the HDD 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 5.4.2 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 HDD 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 HDD.)

   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 REQEUST SENSE command from the initiator (host system). Sense data is information required for troubleshooting.

IMPORTANT

The Active LED goes off while the HDD 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.

5.4.2 Checking connection

When the initial operation is checked normally after power is turned on, check that the HDD 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 d) correspond to a) to d) in Figures 5.1 and 5.2.

a)   Issue the TEST UNIT READY command and check that the HDD 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 HDD 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
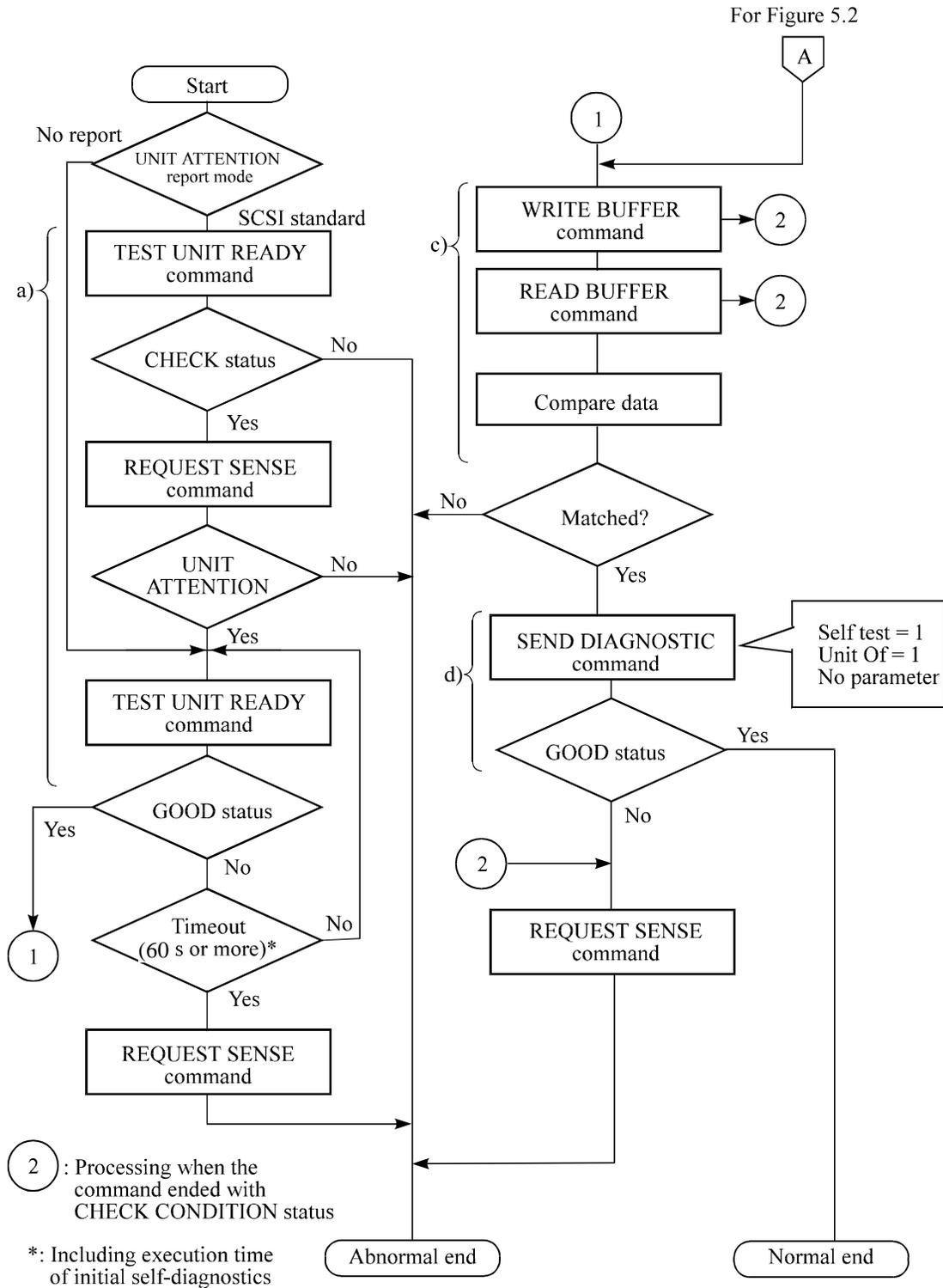
For Figure 5.2

Figure 5.1   Checking the HDD connection (A)

Motor starts by START/STOP command
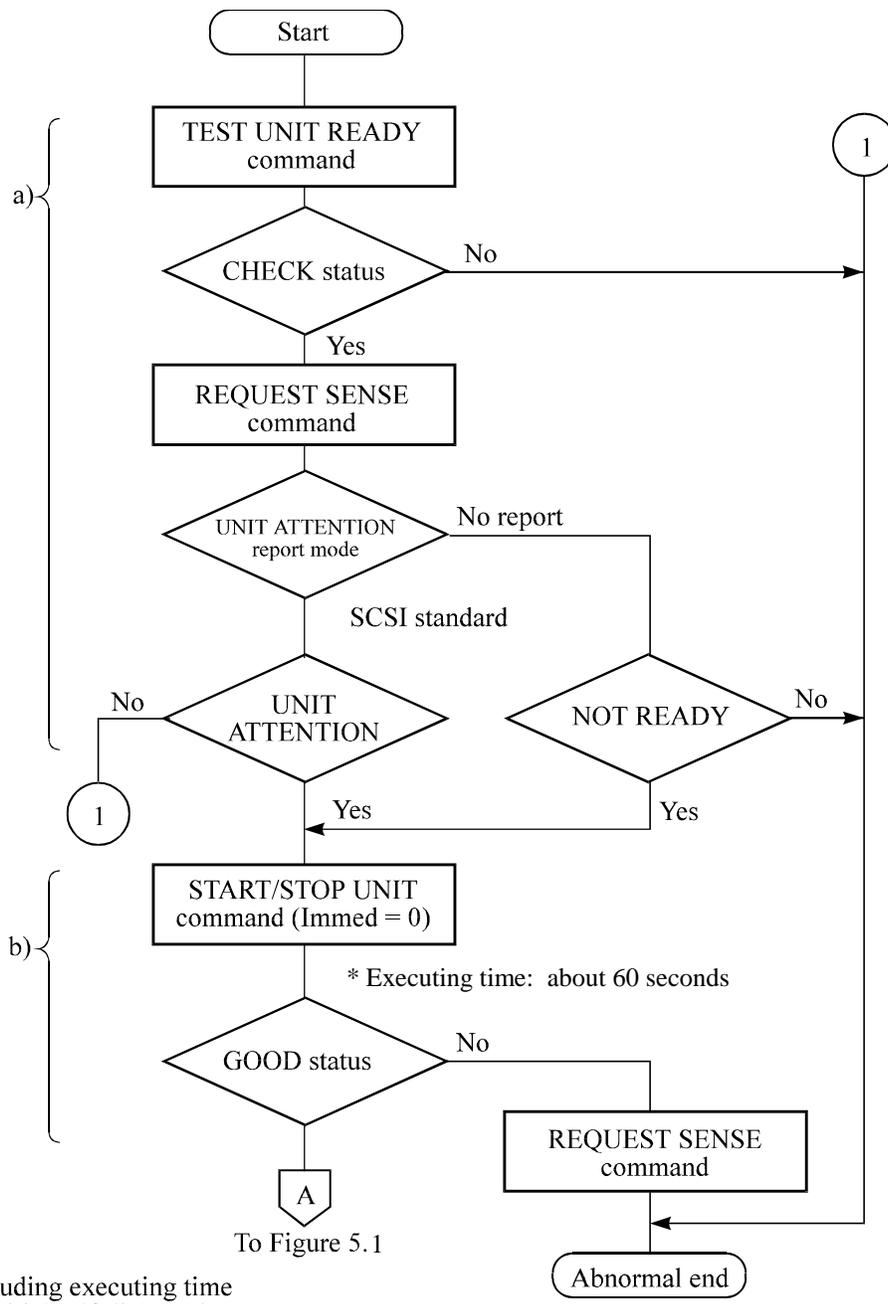
Figure 5.2   Checking the HDD connection (B)

(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 "Sense Data and Error Recovery Method" of the 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.

5.4.3   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 recording surface 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 in the user space
*   Alternate spare area size

This section outlines the formatting at installation. Refer to Subsection 4.1.4 "MODE SELECT (15)", 4.1.5 "MODE SELECT EXTENDED (55)" of the 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. It is recommended not to specify values smaller than the HDD default value in this field.

(2)   FORMAT UNIT command

Initialize entire recording surface of the disk with the FORMAT UNIT command. The FORMAT UNIT command initializes entire surface 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.

5.4.4   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
- Fibre channel control 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 HDD to operate by using the parameter value set by the user when power is turned on again. When the system has more than one initiator, different parameter value can be set for each initiator.

When the parameters are not set or saved with the MODE SELECT or MODE SELECT EXTENDED command, the HDD sets the default values for parameters and operates when power is turned on or after reset. Although the HDD 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 Subsection 4.1.4 "MODE SELECT (15)", 4.1.5 "MODE SELECT EXTENDED (55)" of the 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 HDD, the saving operation for the MODE SELECT parameter is not executed. So, if the user does not set parameters, the HDD 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 mult-initiator System, parameter setting cannot be changed for each initiator.*

3. *Once parameters are saved, the saved value is effective as long as next saving operation is executed from the initiator. 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 HDD, to which the saving operation has been executed on a system, is connected to another system, the user must pay attention to that the HDD 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 initiator 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 the HDD 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 initiator	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 3 "Data Buffer Management" of the 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 3 "Data Buffer Management" of the 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 the HDD Read-Ahead caching operations under the system environments. Refer to Chapter 3 "Data Buffer Management" of the 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)   Fibre channel control parameters

Refer to Subsection 4.1.4 "MODE SELECT (15)" of the Fibre Channel Interface Specifications for details.

Parameter	Default value
• DTOLI (Disable Target Original Loop Initialization)	0 (An Initializing LIP is issued when the HDD enters the Loop.)
• DTIPE (Disable Target Initiated Port Enable)	0 (The HDD does not have the Loop Port Enable primitive, so it enters the loop port.)
• ALWLI (Allow Login Without Loop Initialization)	0 (The HDD carries out confirmation of the address in the Loop Initialization process.)
• RHA (Require Hard Address)	0 (In the Loop Initialization process, try fixing a soft address.)
• DLM (Disable Loop Master)	0 (The HDD itself is permitted to become the Loop Master.)
• DDIS (Disable DIScovery)	0 (Before the INIT restarts task processing, it must wait for Address Discovery or Port Discovery.)
• PLPB (Prevent Loop Port Bypass)	0 (Receiving Loop Port bypass (LBP)/Loop Port Enable(LPE) Primitive, it controls Port Bypass circuit according to the received Primitive.)
• DTFD (Disable Target Fabric Discovery)	0 (Fabric connection is enabled.)

Note:
It is prohibited that "1" is specified in DTIPE and PLPB simultaneously.
If DTIPE=PLPB=1 is specified, it responds with CHECK CONDITION (ILLEGAL REQUEST, VALID FIELD IN THE PARAMETER LIST.)

5.5   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.

⚠CAUTION

Damage
1. *When dismounting the drive which is mounted on the system while power is supplied to it.*
    - *The drive to be dismounted must be disconnected from the loop. Dismounting the drive which is not disconnected from the loop may cause an unexpected error.*
    - *If the drive is not disconnected 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 dismounted 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 case (Fcell). (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 case (Fcell). (Shown in Section 5.1).*

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

6.1 Diagnostics
6.2 Maintenance Information
6.3 Operation Check
6.4 Troubleshooting Procedures

This chapter describes diagnostics and maintenance information.

6.1 Diagnostics

6.1.1 Self-diagnostics

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

- 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 HDD 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 regarded as success when the seek operation to the target cylinder is completed.

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 HDD 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 HDD sends the Fault LED Out signal to the interface connector. In this status, the HDD 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 initiator 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 HDD 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 HDD executes the initial self-diagnosis again.

The HDD does not reply to the loop for up to 2 seconds after the initial self-diagnostics is started. After that, the HDD 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 HDD 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 HDD 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 2.4 "Command Queuing Function" and Subsection 2.7.4 "Command processing in the not ready state" of the Fibre Channel Interface Specifications.

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

The initiator can make the HDD execute self-diagnostics by issuing the SEND DIAGNOSTIC command.

The initiator 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 UnitOfl bit.

When the UnitOfl bit on the CDB is set to 0, the HDD executes the hardware function test only once. When UnitOfl bit is set to 1, the HDD 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 HDD performs the error recovery according to the MODE SELECT parameter value (read/write error recovery parameter, additional error recovery parameter) which the initiator 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 HDD posts the GOOD status for the SEND DIAGNOSTIC command.

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

The initiator 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 HDD 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 initiator, the error information (sense data) is cleared.

b) When an error is detected in the hardware function test, the HDD 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 HDD executes the initial self-diagnostics again (see item (1)).

Refer to Subsection 4.4.1 "SEND DIAGNOSTIC (1D)" of the Fibre Channel Interface Specifications for further details of the command specifications.

⚠CAUTION

Data loss
When the SEND DIAGNOSTIC command terminates with the CHECK CONDITION status, the initiator 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 HDD 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 HDD functions generally.

(1)   Interface (loop) test

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

(2)   Basic operation test

The basic operations of the HDD 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:

⚠CAUTION

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 is not required.

(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) HDD 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

⚠CAUTION

Data loss
Save data stored on the disk drive to other media 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 label attached on the HDD. Figure 6.1 shows an example of the label.

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 O (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.

At shipment

```
+12V 1.20A === +5V 1.60A ===
DATE 2005-06  DE.REV.A
MADE IN PHILIPPINES
REV.NO.  A 0 1 2 3 4 5 6 7 8 9
         B 0 1 2 3 4 5 6 7 8 9
SER. NO.DA60P5400001
```
⇨ Rev. A2

Revising at field

```
+12V 1.20A === +5V 1.60A ===
DATE 2005-06  DE.REV.A
MADE IN PHILIPPINES
REV.NO.  A 0 1 2 ③ 4 5 6 7 8 9
         B 0 1 2 3 4 5 6 7 8 9
SER. NO.DA60P5400001
```
⇨ Rev. A3
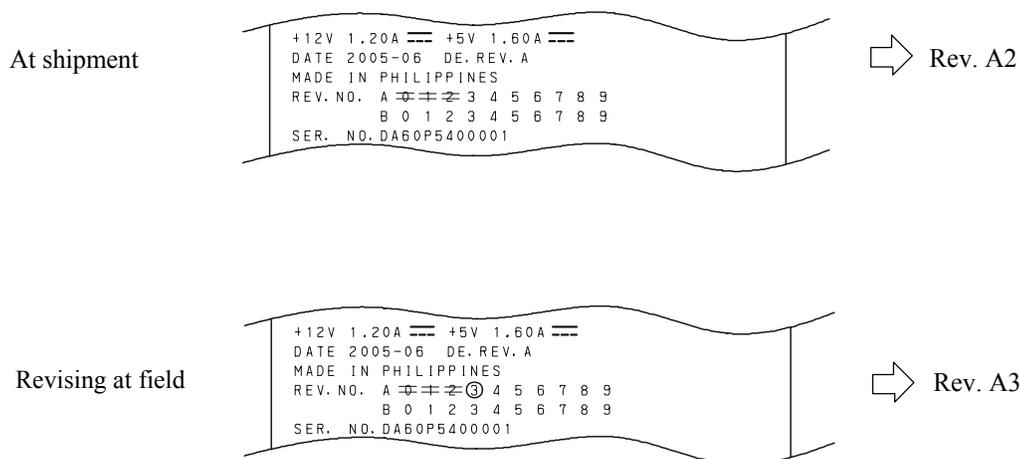
Figure 6.2   Indicating revision numbers

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.

```
                 ┌──────────────┐
                 (    Start     )
                 └──────┬───────┘
                        │
         ┌──────────────▼──────────────┐
         │ Start self-test by          │
         │ turning the power on         │
         └──────────────┬──────────────┘
                        │
                        ▼         No
                   ╱Test results╲──────────►┌────────────────────┐
                   ╲  OK?       ╱           │ Check host system  │
                        │                   │ (Table 6.2)        │
                       Yes                  └─────────┬──────────┘
                        │                             │
         ┌──────────────▼──────────────┐              ▼          No
         │ Execute an operation         │        ╱Host system╲──────►┌────────────────────┐
         │ test using a host            │        ╲ normal?   ╱        │ Analyze system-    │
         │ computer or test             │             │               │ related error      │
         │ equipment                    │            Yes              └────────────────────┘
         └──────────────┬──────────────┘             │
                        │                  ┌──────────▼──────────┐
                        ▼         No       │ Replaced or repair  │
                   ╱Test results╲────────  │ disk drive          │
                   ╲  OK?       ╱          └──────────┬──────────┘
                        │                             │
                       Yes                            ▼          No
                        │                        ╱Disk drive ╲──────────────┐
         ┌──────────────▼──────────────┐         ╲ normal?   ╱              │
         │ Continue operation           │             │                     │
         └──────────────────────────────┘            Yes                    │
                                           ┌──────────▼──────────┐          │
                                           │ Execute diagnostic  │          │
                                           │ test using a host   │          │
                                           │ computer or test    │          │
                                           │ equipment           │          │
                                           └──────────┬──────────┘          │
                                                      │                     │
                                                      ▼          No         │
                                                 ╱Test results╲─────────────┤
                                                 ╲  OK?       ╱             │
                                                      │                     │
                                                     Yes                    │
                                           ┌──────────▼──────────┐          │
                                           │ Test using voltage  │          │
                                           │ or temperature stress│         │
                                           └──────────┬──────────┘          │
                                                      │                     │
                                                      ▼          No ┌───────▼────────────┐
                                                 ╱Test results╲─────►│ Analyze disk drive │
                                                 ╲  OK?       ╱      │ error (Table 6.3)  │
                                                      │              └────────────────────┘
                                                     Yes
                                           ┌──────────▼──────────┐
                                           │ Normal              │
                                           └─────────────────────┘
```

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 spindle motor of the disk drive stops, and then the disk drive becomes unusable.

For an explanation of the operation check before the initial seek, refer to the Section 5.4.

6.3.2 **Operation test**

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

When receiving the CHECK CONDITION status, the initiator issues a REQUEST SENSE command to collect detailed information about the error. The initiator then issues a REZERO UNIT command to return the read/write head to track 00. In normal processing, the HDD itself or initiator 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 the 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	Check that the DC voltage is within the specified range (±5%).
	For +5 VDC, measure the voltage between pin 20 (+5V) of the interface connector and the nearest PCA mounting screw (GND) from the interface connector, and confirm the value is from 4.75 to 5.25 VDC.
	For +12 VDC, measure the voltage between pin 2 (+12V) of the interface connector and the nearest PCA mounting screw (GND) from the interface connector, and confirm the value is from 11.4 to 12.6 VDC.
Electrical noise	Make sure the maximum ripple peak-to-peak value of +5 VDC is within 250 mV and +12 VDC is within 250 mV.
	Make sure the high frequency noise (over 20 MHz) is less than 100 mVp-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	Check the AC voltage from the power supply. Check the DC voltage level at the power connector for the disk drive.
	If the AC voltage level is abnormal or there is a lot of electrical noise, notify the user of the error.
	If the DC voltage level is unstable, replace the power supply unit.
	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.

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 HDD 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 the 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 the disk drive returned to the factory.

⚠CAUTION

Damage
1. *Never remove any labels from the drive.*
2. *Never open the disk enclosure for any reason.*
    Doing so will void any warranties.

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.

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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, additional sense code, and additional sense code qualifier, 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 an additional sense code, and the rightmost x is an additional sense code qualifier.

7.1   Error Analysis Information Collection

7.1.1   Sense data

When the HDD 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 HDD generates sense data about the command-issuing initiator. The initiator can read the sense data by reading the sense data added to the response frame of the command where an error occurred (Auto Sense function), or 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 initiator receives part of the sense data, but the remaining part of the sense data is lost.

For details of the Auto Sense function, refer to Section 2.6 "Sense Data Hold State" of the Fibre Channel Interface Specifications.

For details of the REQUEST SENSE command, refer to Subsection 4.1.14 "REQUEST SENSE (15)" of the Fibre Channel Interface Specifications.

7.1.2   Sense key, additional sense code, and additional sense code qualifier

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, additional sense code, and additional sense code qualifier.

	Bit 7	6	5	4	3	2	1	0
Byte 0	Valid	X'70' or X'71' (error code)						
1	X'00'							
2	0	0	ILI	0	Sense key			
3	[MSB]							
4		Information						
5								
6								[LSB]
7	X'28' (additional sense data length)							
8	[MSB]							
9								
10		Command-specific information						
11								[LSB]
12	Additional sense code							
13	Additional sense code qualifier							
14	X'00'							
15	SKSV							
16		Sense key-specific information						
17								
18	0	0	0	Port	0	Link Rate		
19	CDB operation code							
20		Detail information						
47								

Left bracket labels: Basic information (Byte 0–17), Additional information (18–47)

ILI: Incorrect Length Indicator
MSB: Most Significant Byte
LSB: Least Significant Byte
SKSV: Sense Key Specific Valid

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. For details of the following sense data, refer to Chapter 5 "Sense Data Error Recovery Methods" of the Fibre Channel Interface Specifications.

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	Additional sense code	Additional sense code qualifier	
00	00	00	Operation was normal.
3	0C	03	A write to a disk terminated abnormally.
4	32	01	Failed to update the defect list due to a disk medium write error, etc.
	40	xx	An error occurred in power-on self-diagnosis.
	C4	xx	A drive error occurred.
1	1x	xx	A disk read error occurred.
3	1x	xx	A disk read error occurred.
E	1D	00	Data discrepancy found by VERIFY command byte check.
5	2x	xx	A SCSI error, such as an invalid operation code, occurred.
4 or B	44	xx	A hardware error occurred inside the HDD.
B	47	00	A CRC error occurred in the fibre channel loop.
	49	00	An unmounted or inappropriate message was received.
	4E	00	An overlap command was issued.

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

Sense data (3-0C-03), (4-40-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 drive error occurred.

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

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 Subsection 4.3.2 "REASSIGN BLOCKS (07)" of the Fibre Channel Interface Specifications.

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

7.2.4   Sense data (4-44-xx), (5-2x-xx), (B-44-xx), (B-47-xx), (B-49-00) and (B-4E-00): fibre channel interface error

Sense data (4-44-xx), (5-2x-xx), (B-47-xx), (B-49-00) and (B-4E-00) indicates one of the following symptoms:

- An invalid or unsupported command was issued, or invalid or unsupported parameters were specified.

- An FC error occurred.

- A hardware error occurred inside HDD.

- A CRC error occurred in the fibre channel loop.

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

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

Additional Sense Code

> This is a 1-byte code displayed in the sense data and is information which specifies the type of error that was detected.

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.

Device

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

Initiator

> This is a device which initiates input and output operations on the fibre channel loop.

SCSI

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

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. In this manual, target is abbreviated "TARG."

Acronyms and Abbreviations

A

ACK   ACKnowledge
AEN   Asynchoronous Event Notification
ALT   ALTernated (block)
ARRE   Automatic Read Reallocation Enabled
ASCII   American Standard Code for Information Interchange
ASG   ASiGned block
ATN   ATTeNtion
AWG   American Wire Gauge
AWRE   Automatic Write Reallocation Enabled

B

bpi   bits per inch
BSY   BuSY
BytChk   Byte Check

C

C list   Target Certification list
C/D   Control/data
CCS   Common command set
CDB   Common descriptor block
CE   Customer Engineer
CmpLst   Complete List
CRC   Cyclic Redundancy Check
CSS   Contact Start Stop
CYL   CYLinder

D

D   Depth
D list   Data Defect List
DBD   Disable Block Descriptor
DC   Direct Current
DCR   Disable Correction
DCRT   Disable CeRtificaTion
DE   Disk Enclosure
DEF   DEFective block
DevOfl   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

FC   Fibre Channel
FG   Frame Ground
FIFO   First In First Out
FmtData   Format Data
FOV   Format Options Valid
FUA   Force Unit Access

G

G   Gap
G list   Grown defect list

H

H   Height
HDD   Hard Disk Drive
HSEC   Hard SECtor

I

I/O   Input/Output
ID   IDentifier
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

O

OEM	Original Equipment Manufacturer

P

P list	Primary defect list
P/N	Parts/Number
PBdata	Physical Block data
PC board	Printed Circuit board
PCA	Printed Circuit Assembly
PER	Post ERror
PF	Page Format
PLOSync	Phase Lock Oscillator Syncronous
PMI	Partial Medium Indicator
PR4ML	Partial Response class 4 Maximum Likelihood

R

RC	Read Continuous
RCD	Read Cache Disable
REQ	Request
RH	Relative Humidity
RMB	ReMovaBle
RST	ReSeT
RSV	ReSerVed

S

S/N	Serial/Number
SBd	Synchronized Byte data area
SBi	Synchronized Byte identifier area
SCSI	Small Computer System Interface
SCT	SeCTor
SEL	SELect
SelfTest	Self Test
SG	Signal Ground
SP	Save Page
SPR	SPaRe block
SR	Servo
SSEC	Soft SECtor
STPF	SToP Format
SURF	SURFace

T

TB	Transfer Block
TPI	Tracks Per Inch
TRM	TeRMinator

U

UnitOfl	Unit Offline

V

VCM	Voice Coil Motor
VPD	Vital Product Data
VU	Vendor Unique

W

W	Width
WCE	Write Cache Enable
WP	Write Protect

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Comment Form

We would appreciate your comments and suggestions regarding this manual.

Manual code	C141-E234-01EN
Manual name	MAX3147FC, MAX3073FC, MAX3036FC HARD DISK DRIVES PRODUCT/MAINTENANCE MANUAL

Please mark each item: E(Excellent), G(Good), F(Fair), P(Poor).

General appearance	( )	Illustration	( )	
Technical level	( )	Glossary	( )	
Organization	( )	Acronyms & Abbreviations	( )	
Clarity	( )	Index	( )	
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