FUJITSU

M2622S/SA/SB
M2623S/SA/SB
M2624S/SA/SB

INTELLIGENT DISK DRIVES

CE MANUAL

41FH6868E-01

REVISION RECORD

Edition	Date published	Revised contents
01	Jul., 1991	

Specification No.: 41FH6868E

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PREFACE

This manual describes the 3.5-inch type SCSI controller embeded disk drive, M2622Sx, M2623Sx, M2624sx.

It contains detailed information on the disk drive configuration, trouble analysis, parts replacement, confirm and adjust operation, and concept of hardware operation. It is assumed that the reader has an experience of the disk drive operation, and has a thorough knowledge on the disk drive environment at the user system.

The manual configuration and its description scope on the disk drive are indicated in the "Manual Configuration" later. It is assumed that the reader has thoroughly covered the "OEM Manual" (SPECIFICATIONS & INSTALLATION, SCSI PHYSICAL SPECIFICATION, SCSI LOGICAL SPECIFICATION)

Contents of this manual are summarized as follows.

CHAPTER 1 SPECIFICATIONS AND UNIT CONFIGURATION

This chapter describes the specifications, basic configuration, interface connector, and specification switch and plug of the M2622Sx/M2623Sx/M2624Sx intelligent disk drive (IDD).

CHAPTER 2 DIAGNOSTICS AND MAINTENANCE

This chapter describes the basic elements of maintenance, diagnostics for operation confirmation, and basic items of troubleshooting of the M2266Sx/M2266Hx intelligent disk drive.

CHAPTER 3 TROUBLESHOOTING AND FAULT ISOLATION

This chapter contains detailed information on data collection method for troubleshooting and fault analysis of the collected data.

CHAPTER 4 REMOVAL AND REPLACEMENT PROCEDURES

This chapter describes how the spare parts are removed and replaced in the field.

CHAPTER 5 SIGNAL CONFIRMATION AND ADJUSTMENT PROCEDURES

This chapter describes the check terminal for signals required for operation confirmation and its method, and adjustment method after parts are being replaced.

CHAPTER 6 THEORY OF OPERATION

This chapter describes the hardware configuration and its operation of the M2622Sx/M2623sx/M2624Sx intelligent disk drive.

CHAPTER 7 PCA LAYOUT AND SCHEMATICS

This chapter indicates the circuit diagrams, which were valid when this manual was issued, and parts mounting diagram on the PCA. Note that these diagrams are reference only.

Model names of the IDD can be categorized by a suffix attached according to the electrical condition of SCSI, which connects host system and the IDD, and the data format at shipment, e. g., M2264S, M2264SA, M2624SB. Except when a specific model name should be indicated, M2622, M2623, or M2624 will be used to represent all relevant drive names. Also, these intelligent disk drives will be noted as 'IDD', 'drive', or 'device'.

CONVENTIONS

This manual uses the following conventions :

Danger: Danger indicates that the user is in danger of personal injuries if operation is not correctly performed.

Warning: Warning indicates that a critical damage will be done to the disk drive if operation is not correctly performed.

Note: Note indicates that some damage will be done to the disk drive or inconvenience such as data loss is likely to occur if operation is not correctly performed.
Also, it indicates the information should be noted.

DISCLAIMER

Failure of the M2266S/H intelligent disk drive is defined as a failure requiring adjustments, repairs, or replacement. Fujitsu is not responsible for drive failures caused by misuse by the user, poor environmental conditions, power trouble, host problems, cable failures, or any failure not caused by the drive itself.

MANUAL ORGANIZATION

OEM MANUAL Specifications & Installation	1. General Description 2. Specifications 3. Data Format 4. Installation Prerequisites 5. Installation 6. Diagnosis and Maintenance
OEM MANUAL SCSI Physical Specification	1. SCSI Bus 2. SCSI Message 3. SCSI Bus Error Recovery Procedure
OEM MANUAL SCSI Logical Specification	1. Command Processing 2. Data Buffer Management 3. Command Specification 4. Sense Data and Error Recovery Procedure 5. Disk Manegement
CE MANUAL (This manual)	1. Specifications and Unit Configuration 2. Diagnosis and Maintenance 3. Troubleshooting and Fault isolation 4. Removal and Replacement Procedures 5. Theory of Operation

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FIGURES

TABLES

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GLOSSARY

Actuator: Head positioning assembly actuator comprises a voice coil motor, which is used for positioning read/write head, a head arm, and a servo head.

Bus condition: Asynchronous condition for causing SCSI bus status transition. There are two types of bus conditions, ATTENTION and RESET.

Bus phase: Name of an SCSI bus state. The SCSI bus is in one of the following phases: BUS FREE, ARBITRATION, SELECTION, RESELECTION, or INFORMATION TRANSFER. The INFORMATION TRANSFER phase is divided into DATA IN, DATA OUT, COMMAND, STATUS, MESSAGE IN, and MESSAGE OUT phases depending on the type of information being transferred.

CCS (Common Command Set):
Common Command Set which is the standard SCSI logical specification stipulated by a working committee of ANSI. Functions necessary for direct access devices are defined.

CDB (Command Descriptor Block):
Command Descriptor Block–a group of data that describes the command for I/O and is transferred from an initiator to a target.

Command: Issued to a target to direct an input/output operation and written as CDB.

DE: Disk enclosure, which contains fixed disk, spindle motor, actuator, head, and air filter. Encloses these to protect from dust.
Sometimes called HDA (head/disk assembly).

Disconnect: Operation performed by the target to free itself from the SCSI bus and the initiator temporarily when SCSI bus operation becomes unnecessary during command processing.

HDA: Head/disk assembly. Sometimes called DE (disk enclosure).

Initiator (INIT): SCSI device that has initiated an input/output operation on the SCSI device. This can be abbreviated as INIT.

Logical unit: Simple unit of equipment that can be directed to perform one I/O operation on the SCSI bus.

LUN (Logical Unit Number):
Logical unit number used to identify a logical unit.

Message: Information that controls a series of bus phases and I/O sequence between the initiator and the target on the SCSI bus.

MTBF (Mean-time-between-failure):
Total length of time in life (total length of power on time)/total number of disk drive failures

MTTR (Mean-time-to-repair):
The average time required for corrective maintenance by service engineer.

Positioning time: Duration of time required to move a head from the current track to the track requested next. Excludes the average rotation wait time.

Ready LED: Green LED at the from of the disk drive. Indicates either disk drive ready status or disk drive select specification.

Reconnect: Operation performed by the target to reconnect itself with the initiator when operation on the SCSI bus becomes necessary after disconnection.

Rotation wait time:
Duration of time required for 1 disk rotation. Average wait time is duration of time required for 1/2 disk rotation, which is the average time required to reach a sector after head is positioned on a track.

SCSI device: General term for device (Input/outpur device, I/O controller, and host adapter, etc.) connected to on SCSI bus.

SCSI ID: Physical device address used to identify an SCSI device on the SCSI bus. This number is specific to each SCSI device. SCSI IDs are #0 to #7, each corresponding to one bit on the data bus.

SCSI (Small Computer System Interface):
Small computer system interface which an input/output interface standardized by American National Standard Institute (ANSI). [Standard number: ANSI X3.131-1986]

Seek time: Positioning time + average rotation wait time.

Sense code: One-byte of code attached to sense data identify the type of the detected error.

Sense data: Detailed information created by the target when any error is involved in the command termination status. This information is transferred to report the error.

Sense key: Four-bit code attached to sense data to identify the class of the detected error.

Status: One byte of information that is transferred from a target to an initiator on termination of each command to indicate the command termination status.

Target (TARG): SCSI device which performs I/O initiated by an initiator. It can be abbreviated as TARG.

VCM (Voice coil motor):
Motor anticipated by more than 1 magnet. M2266S/H uses VCM for faster and more precise head positioning.

REFERENCED STANDARDS

Item	Number	Name	Organization
1	ANSI X3.131-1986	American National Standard for Information Systems — Small Computer System Interface (SCSI)	American National Standards Institute (ANSI)
2	X3T9.2/85-52 Rev 4.B	COMMON COMMAND SET (CCS) of the Small Computer System Interface (SCSI)	American National Standards Institute (ANSI)
3	X3T9.2/86-109 Rev 10C	Draft proposed American National Standard for Information systems — Small Computer System Interface-2 (SCSI-2)	American National Standards Institute (ANSI)

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CHAPTER 1 SPECIFICATIONS AND UNIT CONFIGURATION

This chapter describes the specification and configuration of the intelligent disk drives.

The M2622/M2623/M2624 intelligent disk drives (IDDs) are high performance large capacity 3.5 - inch fixed disk drives with an embedded SCSI controller.

The interface between the IDD and host system is based on SCSI (Small Computer System Interface) standard (ANSI X3.131 - 1986).

1.1 Model Specifications

1.1.1 Model name and part number

Each model has a different data format, front panels, and mounting screw types when shipped. Table 2.1 shows the IDD model name and part number. Data format can be changed by reinitializing with the user's system.

Table 1.1 IDD model/part number table (1 of 2)

Model	Block length	Storage capacity	Front panel	Mounting screws	Part number	Remarks
M2622S	256 B	292.76 MB	Provided	M3	B03B-7195-B004A	
			None	M3	B03B-7195-B004A#P	
			Provided	#6-32UNC	B03B-7195-B004A#N	
			None	#6-32UNC	B03B-7195-B004A#NP	

Table 1.1 IDD model/part number table (2 of 2)

Model	Block length	Storage capacity	Front panel	Mounting screws	Part number	Remarks
M2622SA	512 B	330.17 MB	Provided	M3	B03B-7195-B014A	
			None	M3	B03B-7195-B014A#P	
			Provided	#6-32UNC	B03B-7195-B014A#N	
			None	#6-32UNC	B03B-7195-B014A#NP	
M2622SB	1,024 B	346.52 MB	Provided	M3	B03B-7195-B024A	
			None	M3	B03B-7195-B024A#P	
			Provided	#6-32UNC	B03B-7195-B024A#N	
			None	#6-32UNC	B03B-7195-B024A#NP	
M2623S	256 B	376.72 MB	Provided	M3	B03B-7195-B005A	
			None	M3	B03B-7195-B005A#P	
			Provided	#6-32UNC	B03B-7195-B005A#N	
			None	#6-32UNC	B03B-7195-B005A#NP	
M2623SA	512 B	425.13 MB	Provided	M3	B03B-7195-B015A	
			None	M3	B03B-7195-B015A#P	
			Provided	#6-32UNC	B03B-7195-B015A#N	
			None	#6-32UNC	B03B-7195-B015A#NP	
M2623SB	1,024 B	446.77 MB	Provided	M3	B03B-7195-B025A	
			None	M3	B03B-7195-B025A#P	
			Provided	#6-32UNC	B03B-7195-B025A#N	
			None	#6-32UNC	B03B-7195-B025A#NP	
M2624S	256 B	460.69 MB	Provided	M3	B03B-7195-B006A	
			None	M3	B03B-7195-B006A#P	
			Provided	#6-32UNC	B03B-7195-B006A#N	
			None	#6-32UNC	B03B-7195-B006A#NP	
M2624SA	512 B	520.10 MB	Provided	M3	B03B-7195-B016A	
			None	M3	B03B-7195-B016A#P	
			Provided	#6-32UNC	B03B-7195-B016A#N	
			None	#6-32UNC	B03B-7195-B016A#NP	
M2624SB	1,024 B	547.03 MB	Provided	M3	B03B-7195-B026A	
			None	M3	B03B-7195-B026A#P	
			Provided	#6-32UNC	B03B-7195-B026A#N	
			None	#6-32UNC	B03B-7195-B026A#NP	

1.1.2 Function specifications

Table 1.2 shows the function specifications of the IDD.

Table 1.2 Function specifications (1 of 2)

Item				Specification		
				M2622	M2623	M2624
Unformatted capacity / drive (* 1)				387.41 MB	498.10 MB	608.79 MB
Number of disks				4	5	6
Number of heads (data + servo) (* 2)				7 + 1	9 + 1	11 + 1
Number of cylinders (user + CE + SA) (* 1)				1,429 + 1 + 5		
Unformatted capacity / track						
Rotational speed				4,400 ± 0.5 % rpm		
Average latency time				6.82 ms		
Positioning time (* 3)			Minimum	3 ms		
			Average	12 ms		
			Maximum	25 ms		
Start / Stop time (* 4)			Start time	15 s		
			Stop time	30 s		
Recording code				1 / 7 RLL		
Recording density				46,383		
Track density				1,751 TPI		
Dimension (W × H × D)				101.6 mm × 41.3 mm × 146.0 mm with front panel : 104.1 mm × 43.8 mm × 151.3 mm		
Weight				Approx. 1.2 kg		
Power consumption				11 W typ.		
Interface				Single-Ended type SCSI Cable length : 6 m max.		
Data transfer rate	Disk drive			3.05 MB / s max.		
	SCSI (*5)	Async mode		3.00 MB / s max.		
		Sync mode		4.80 MB / s max.		
Logical data block length (*1)				256 bytes to 4.096 bytes (fixed block length programable by every 2-byte at formatting)		

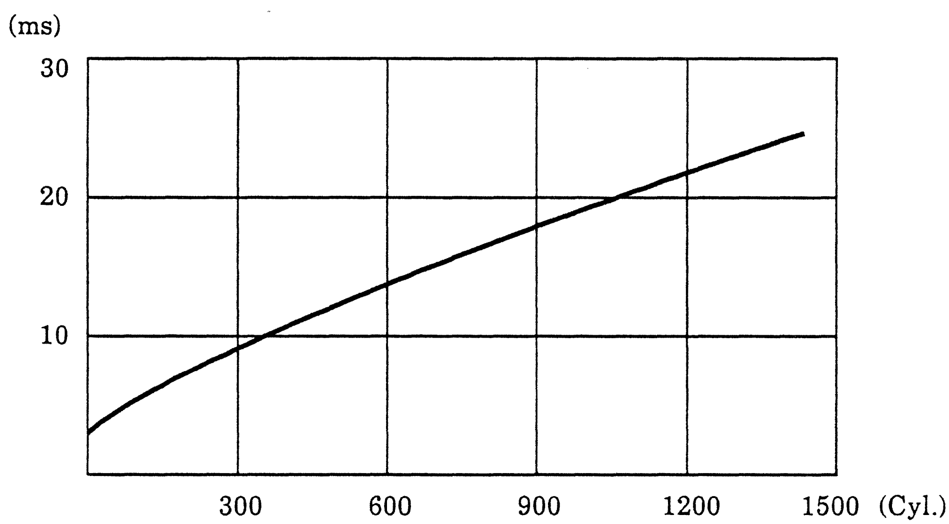
Table 1.2 Function specifications (2 of 2)

Item	Specification
SCSI command specification	ANSI X3.131 - 1986 and CCS (Rev. 4 B) Supports a part of SCSI-2 command FUJITSU unique command
Data buffer	60 KB × 4 FIFO ring buffer Read-Ahead cache feature provided

(*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.

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

(*3) The positioning time is as follows:



(*4) The start time (is the time from power on or start command to when the IDD is ready), and stop time (is the time for disks to completely stop from power off or stop command.

(*5) The maximum data transfer rate may be restricted to the response speed of initiator and by transmission characteristics.

(*6) The terminator power pin (SCSI connector) which supplies power to other terminators is not used (See section 4.3).

1.1.3 Environmental specifications

Table 1.3 lists environmental and power requirements.

Table 1.3 Environmental/power requirements

Items		Specifications
Temperature (*1)	Environment at operating	5 to 45°C (41 to 113°F)
	Environment at non-operating	−40 to 60°C (−40 to 140°F)
	DE surface at operating	
	DE surface at non-operating	
	Gradient	15°C / hr (59°F / hr) or less
Relative humidity	Operating	20 to 80%RH
	Non-operating	5 to 95%RH
	Max. wet bulb	29°C (No condensing)
Vibration	Operating	Less than 0.5G (5 to 250 Hz)
	Non-operating (*2)	Less than 2.0G (5 to 250 Hz)
Shock	Operating	Less than 5G (10 ms max.)
	Non-operating	Less than 50G (10 ms max.)
Altitude (above sea level)	Operating	0 to 3,000 m
	Non-operating	0 to 12,000 m
Power requirements	Input voltages (*3)	+ 12VDC ± 5% 0.5 A (Average) 2.5 A (Peak) + 5VDC ± 5% 1.0 A (Average) (*5)
	Ripple (*4)	+ 5 V 50 mVp-p, + 12 V 100 mVp-p

(*1) For detail condition, see Section 4.1 in OEM Manual Specifications and Installation.

(*2) At power-off state after installation

(*3) Input voltages are specified at the connector.

(*4) High frequency noise is less than 100 mVp-p.

(*5) The terminator power pin (SCSI connector) which supplies power to other terminators is not used (See Section 1.3).

1.1.4 Error rate

Errors detected during initialization and replaced by alternate block assignments are not included in the error rate.

(1) Recoverable error rate

Recoverable errors are errors which can be read correctly within 18 retries and ECC correction, should not exceed 10 per 10^{10} bits. (*)

(2) Unrecoverable error rate

Errors which cannot be recovered within 16 retries and ECC correction should not exceed 10 per 10^{15} bits. (*)

(3) Positioning error rate

Positioning errors which cannot be recovered by one retry should be 10 or less per 10^7 seeks.

(4) Media defects

The number of allowable media defects are as follows. The maximum defect length is 8 bytes.

- M2622: 160 or less
- M2623: 210 or less
- M2624: 260 or less

(*) Retries at read errors are controlled by error recovery procedure of the IDD, which includes retries with head offset.

1.1.5 Reliability

(1) Mean Time Between Failures (MTBF)

The estimated MTBF of the IDD during its life time is 200,000 power-on hours after an initial 3-month period.

Note:

The MTBF is defined as:

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

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

Overhaul of the drive is not required for the first five years or 20,000 hours if handled correctly.

(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 was being performed. The above does not applied to formatting disks or assigning alternate blocks.

1.2 Mounting Requirement

1.2.1 Exterior dimensions

Figures 1.1 to 1.2 show the exterior dimensions of the IDD and the positions of the holes for the IDD mounting screws.

Notes:

1. Dimensions are in mm.

2. The depth does not include the dimension of the hook for mounting the cable on the interface connector.

(*) Between mounting screw holes on the bottom.

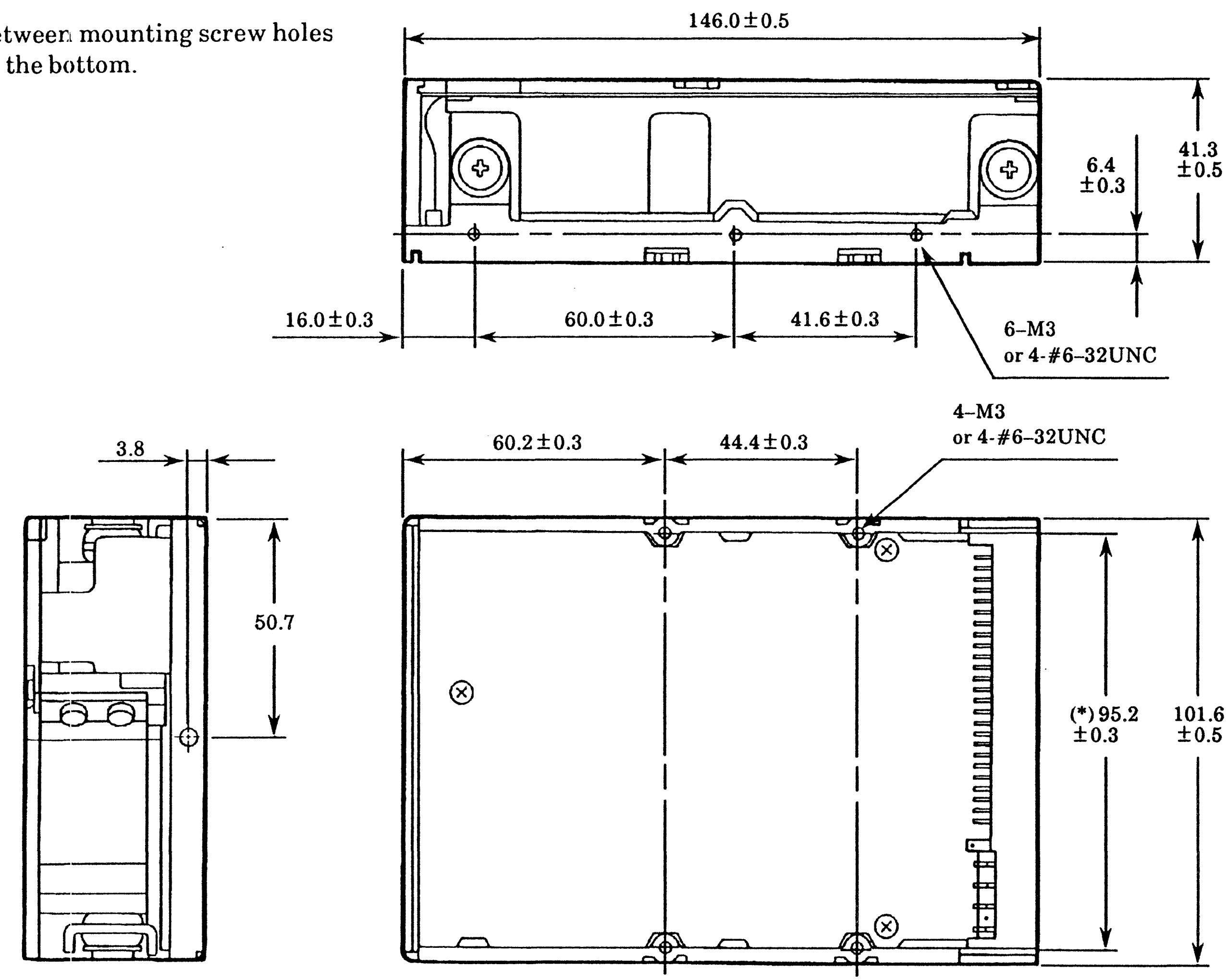


Figure 1.1 Exterior dimensions (M2624S without front panel)

(*) Between mounting screw holes on the bottom.

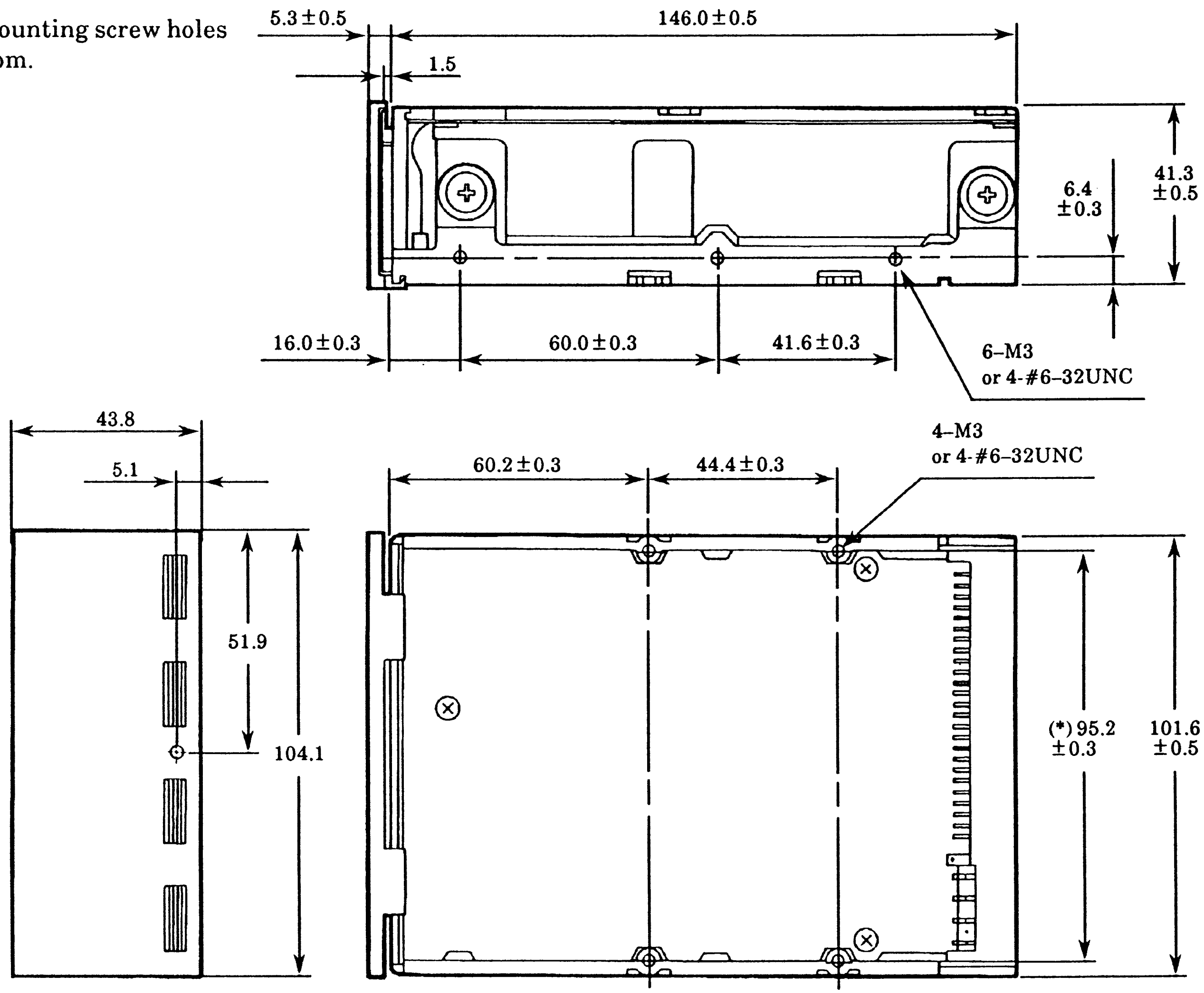


Figure 1.2 Exterior dimensions (M2624S with front panel)

1.2.2 Mounting

The permissible orientations of the IDD are shown in Figure 1.3, and the tolerance of the angle is ±5° from the horizontal plane.

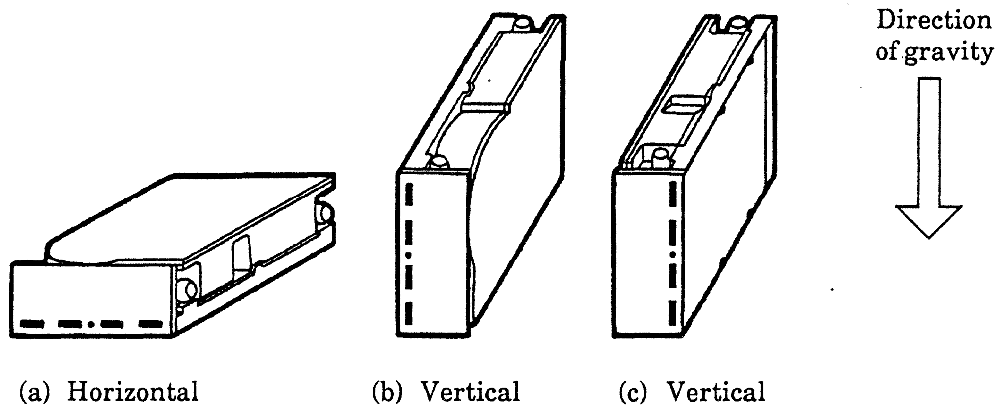


Figure 1.3 IDD orientation

1.2.3 Notes on mounting

(1) Mounting frame structure

The disk enclosure (DE) of the IDD serves as a signal ground (SG) and is insulated from the mounting frame (frame ground: FG). As this insulation is maintained after the IDD is mounted in the system, the following precautions must be followed.

Note:

Generally, SG and FG are connected at one point in the system enclosure. Therefore, use following procedure to maintain the insulation when mounting the IDD:

(a) Use the frame with an embossed structure or the like to avoid contact between the DE base and FG.

(b) As shown in Figure 1.4, the inward projection of the screw from the IDD frame wall at the corner must be 4 mm or less.

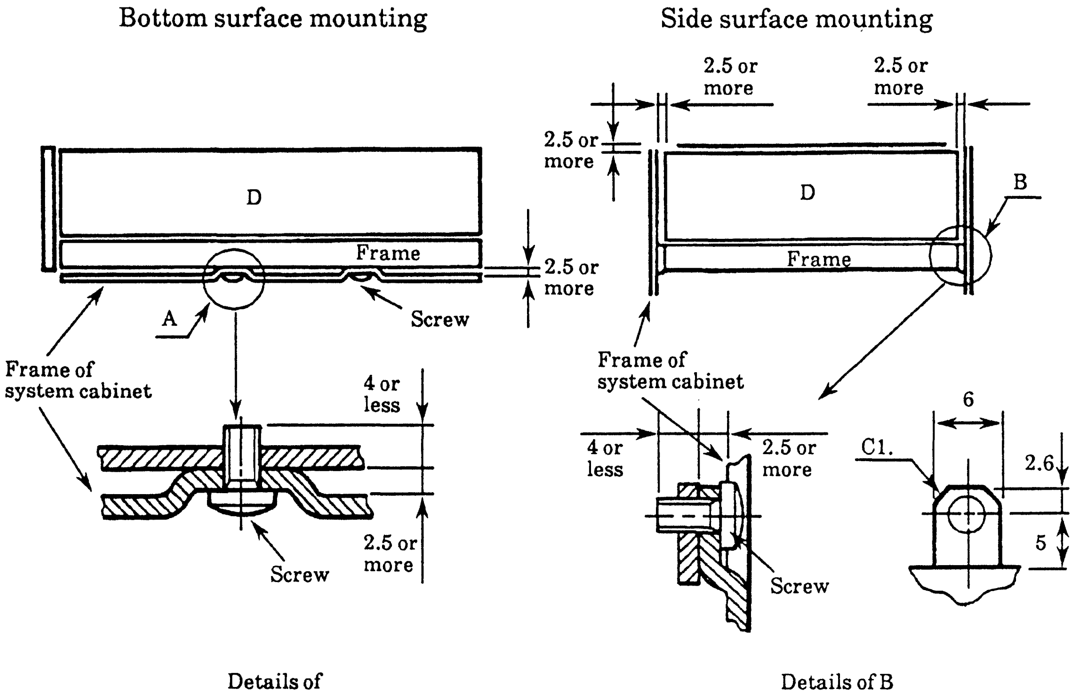


Figure 1.4 Mounting frame structure

(2) Ambient temperature

The operating temperature range for the IDD in a cabinet is specified at a distance of 3 cm from the IDD. Design the air flow in the cabinet to keep the maximum ambient temperature within 60°C.

The air circulation in the cabinet must be designed so that the PCA side of the IDD is particularly cooled. The cooling effort should be confirmed in measuring the surface temperature of the specific IC and the DE. These surface temperature should be within the specific value in the Table 1.4 in spite of any ambient temperature.

Table 1.4 Surface temperature specification

No.	Measuring point	Temperature
1	Center of DE cover	60°C
2	Heat sink for VCM driver	70°C
3	TEC 200 (SCSI controller)	70°C
4	SSI 547 (pulse decoder)	70°C
5	SSI 537 (encoder/decoder)	75°C
6	Servo demodulator	80°C

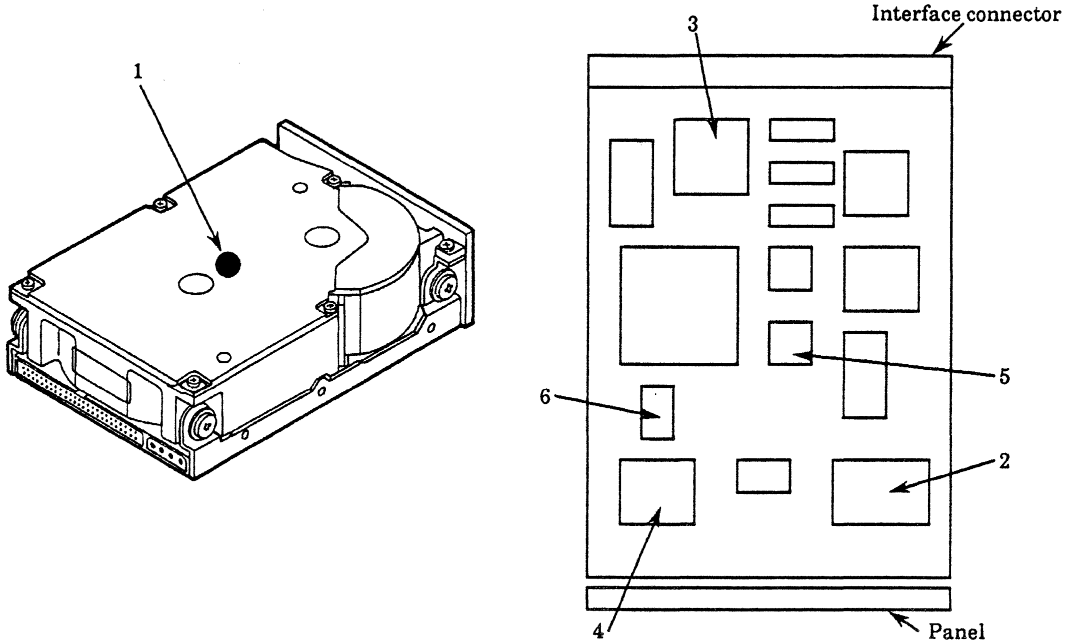


Figure 1.5 Surface temperature measuring point

(3) Service clearance area

The service clearance area, or the sides which must allow access to the IDD for installation or maintenance, is shown in Figure 1.6.

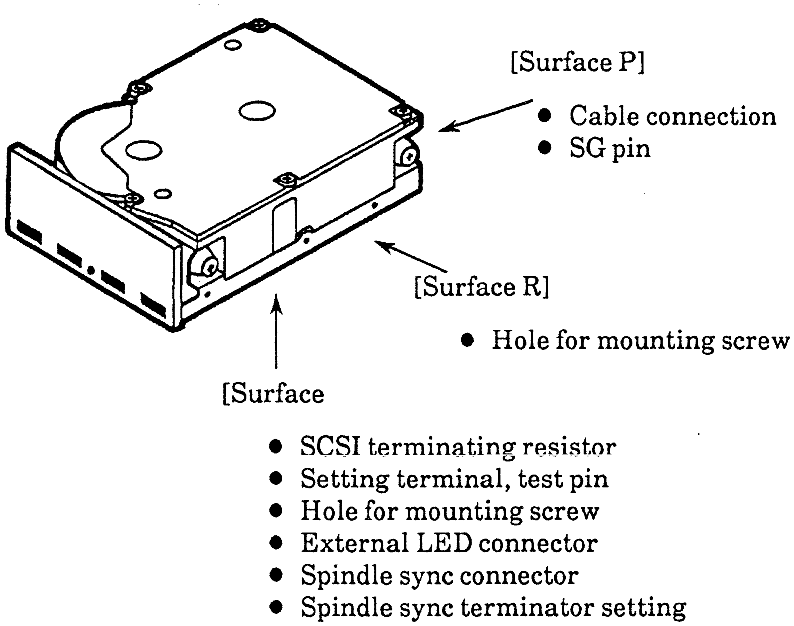


Figure 1.6 Service clearance area

(4) External magnetic force

Installation must be done away from the powerful magnetic entity such as a speaker to avoid being effect by the external magnetic force.

1.3 Power Supply Requirement

(1) Allowable input voltage and current

The power supply input voltage measured at the power supply connector pin of the IDD (receiving end) must satisfy the requirement given in Subsection 1.1.3. (For other requirements, see Items (4) and (5) below.)

(2) Current waveform (reference)

Figure 1.7 shows the waveform of +12 VDC.

(a) At start of spindle motor rotation

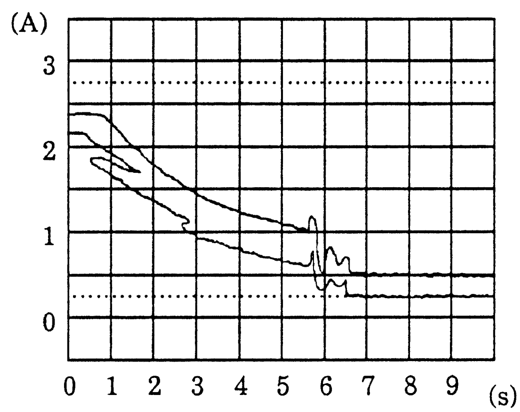


Figure 1.7 Current waveform (+12 VDC)

(3) Power on/off sequence

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

(b) In a system which uses the terminating resistor power supply signal (TERMPWR) on the SCSI bus, the requirements for +5 VDC given in Figure 1.8 must be satisfied between the IDD and at least one of the SCSI devices supplying power to that signal.

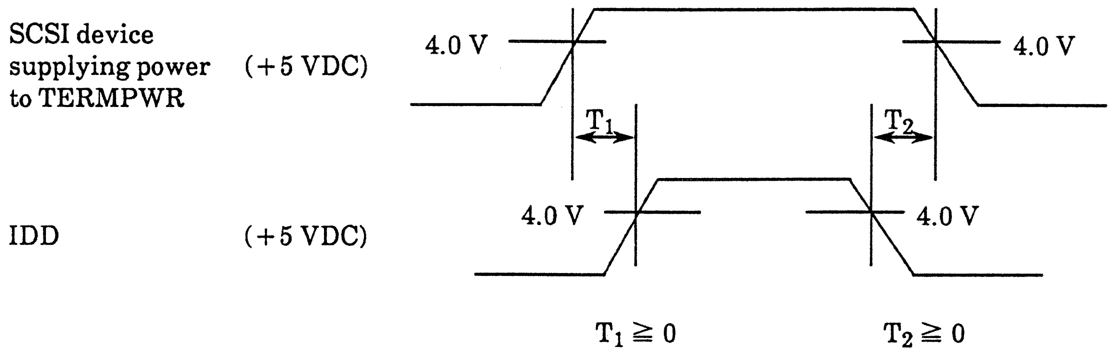


Figure 1.8 Power on/off sequence (1)

(c) In a system which does not use the terminating resistor power supply signal (TERMPWR) on the SCSI bus, the requirements for +5 VDC given in Figure 1.9 must be satisfied between the IDD and the SCSI device with the terminating resistor circuit.

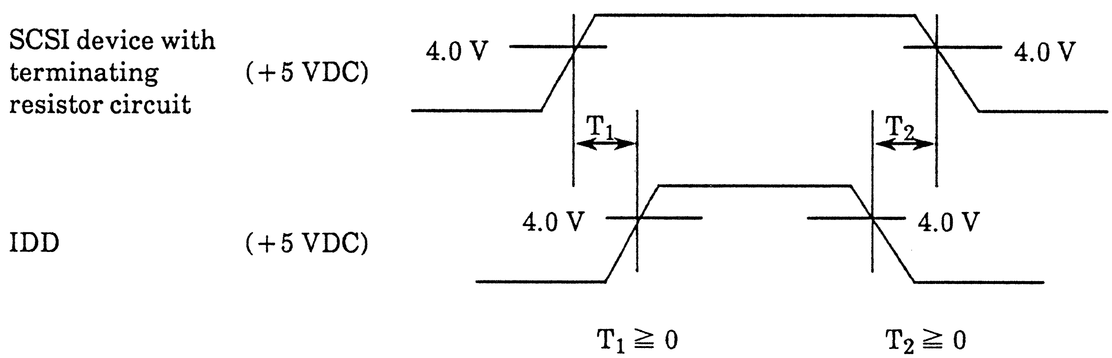


Figure 1.9 Power on/off sequence (2)

(d) Between the IDD and other SCSI devices on the SCSI bus, the +5 VDC power on/off sequence is as follows:

- In a system with its all SCSI devices designed to prevent noise from leaking to the SCSI bus when power is turned on or off, the power sequence does not matter if the requirement in (b) or (c) is satisfied.

- In a system containing an SCSI device which is not designed to prevent noise from leaking to the SCSI bus, the requirement given in Figure 1.10 must be satisfied between that SCSI device and the IDD.

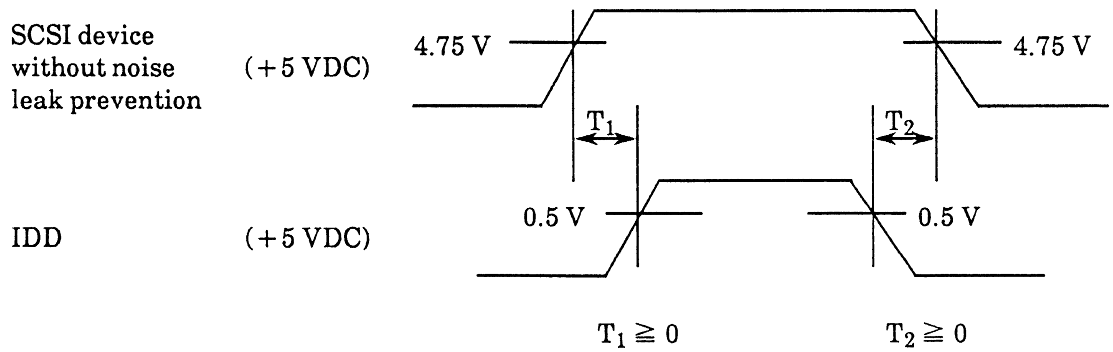


Figure 1.10 Power on/off sequence (3)

(4) Sequential starting of spindle motors

After power is turned on to the IDD, a large amount of current flows in the +12 VDC line when the spindle motor rotation starts. Therefore, if more than one IDD is used, the spindle motors should be started sequentially using one of the following procedures to prevent overload of the power supply unit. For how to set a spindle motor start control mode, see Subsection 1.5.1.

a. Issue START and STOP commands at 20-second intervals to start the spindle motors. For details of this command specification, refer to chapter 3 in OEM Manual SCSI Logical Specifications.

b. Turn on the +12 VDC power in the power supply unit at 20-second intervals to start the spindle motors sequentially.

(5) Power supply to SCSI terminating resistor

If power for the terminating resistor is supplied from the IDD to other SCSI devices through the SCSI bus, the current-carrying capacity of the +5 VDC power supply line to the IDD must be designed with considering of an increase of up to 900 mA.

A method of power supply to the terminating resistor is selected with a setting terminal on the IDD. See Subsection 1.5.1 for this selection.

For the electrical condition of supplying power to the terminating resistor, refer to Subsection 1.4.2 in OEM Manual SCSI Physical Specifications.

(6) Noise filter

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

- Attenuation: 40 dB or more at 10 MHz
- Circuit construction: A T-configuration as shown in Figure 1.11 is recommended.

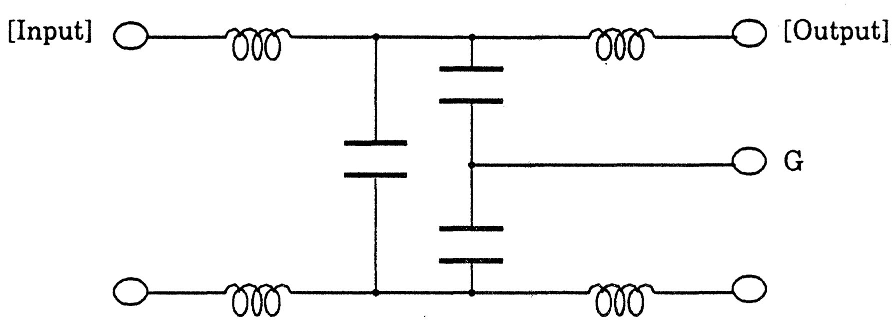


Figure 1.11 AC noise filter (recommended)

1.4 Connection Requirement

1.4.1 Connectors

Connectors and terminals for connection to the outside are installed on the IDD. Their positions are shown in Figure 1.12 .

- Power supply connector
- SCSI connector
- SG terminal
- Connector for external LED
- Connector for spindle synchronization function

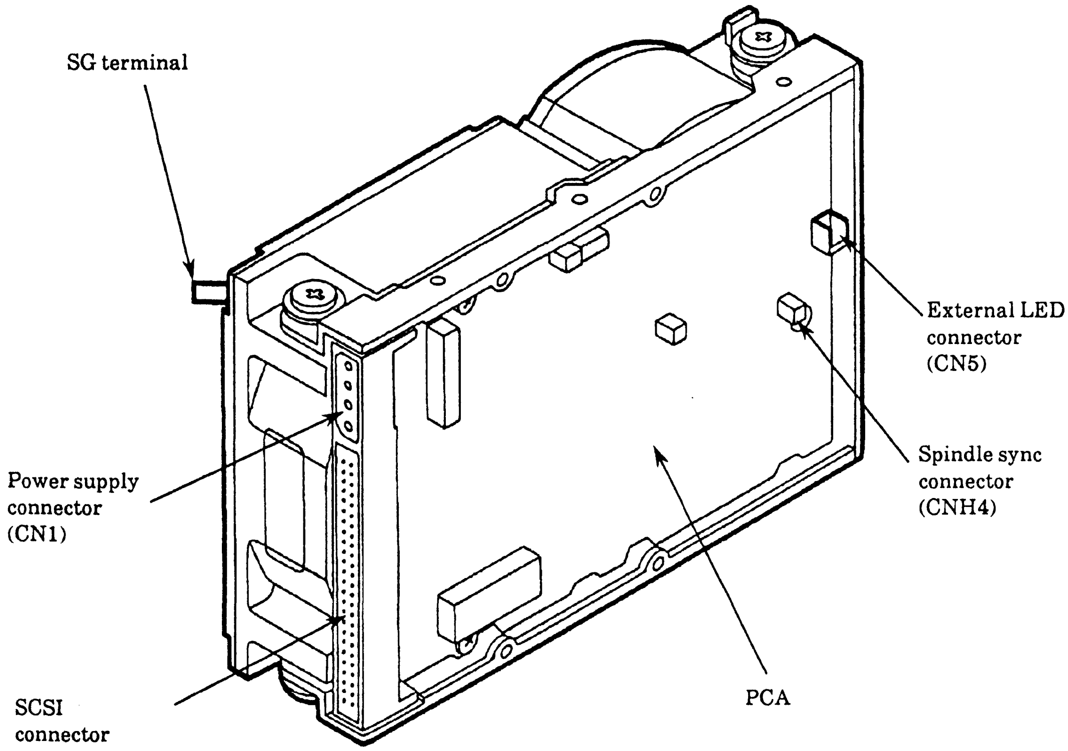
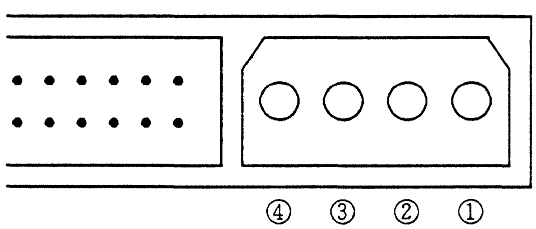


Figure 1.12 Positions of connectors

(1) Power supply connector

The shape and pin configuration of the DC power supply connector are shown in Figure 1.13.



①	+12 VDC
②	+12 VDC Return (GND)
③	+5 VDC Return (GND)
④	+5 VDC

Figure 1.13 Power supply connector

(2) SCSI connector

The connector for the SCSI bus is an unshielded standard connector which has two rows of 25-pin spaced 2.54 mm (0.1 inch) apart. Figure 1.14 shows the signal assignment on the connector.

For details information on the physical/electrical requirements of the interface signals, refer to Sections 1.3 and 1.4 in OEM Manual SCSI Physical Specifications.

Pin number	Signal	Signal	Pin number
01	GND	–DB0	02
03	GND	–DB1	04
05	GND	–DB2	06
07	GND	–DB3	08
09	GND	–DB4	10
11	GND	–DB5	12
13	GND	–DB6	14
15	GND	–DB7	16
17	GND	–DBP	18
19	GND	GND	20
21	GND	GND	22
23	Open	Open	24
25	Open	TERMPWR (*1)	26
27	Open	Open	28
29	GND	GND	30
31	GND	–ATN	32
33	GND	GND	34
35	GND	–BSY	36
37	GND	–ACK	38
39	GND	–RST	40
41	GND	–MSG	42
43	GND	–SEL	44
45	GND	–C/D	46
47	GND	–REQ	48
49	GND	–I/O	50

*1 Terminating resistor power supply (jumper setup for input only, both input and output, or open)

Figure 1.14 Signal assignment on SCSI connector

(3) SG terminal

For DC ground, an SG terminal (Fastin-Faston tab) is mounted as shown in Figure 1.15.

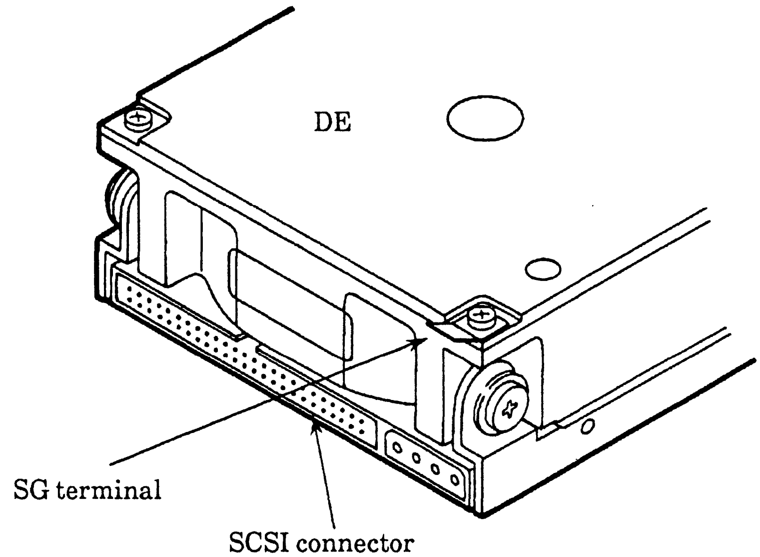
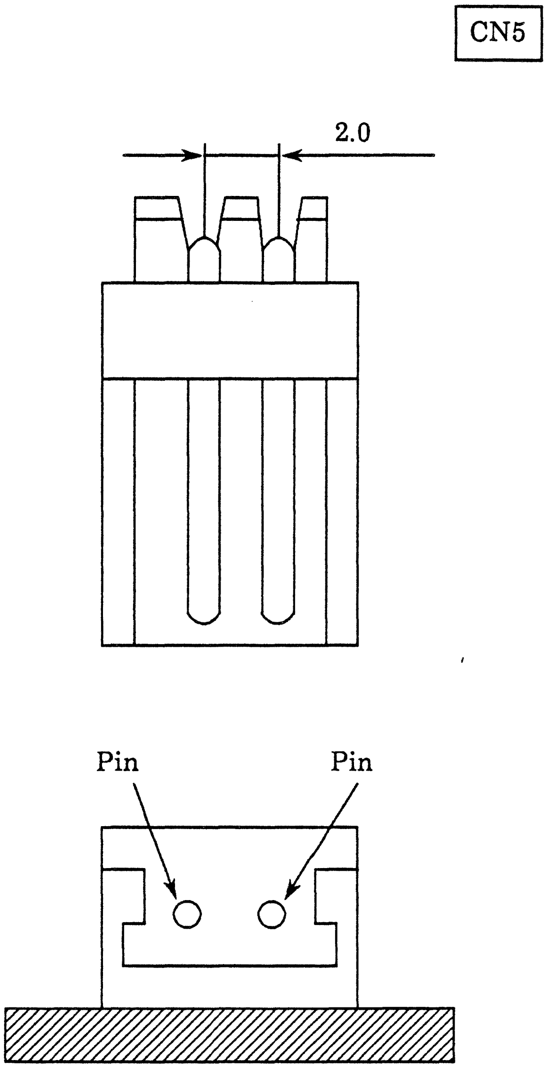


Figure 1.15 SG terminal

(4) Connector for external LED

A connector for the external LED is provided on the IDD as shown in Figure 1.16. It allows connection of an LED on the front panel.

For the electrical requirement and the recommended circuit for the external LED, refer to Section 4.4 in OEM Manual Specifications & Installation. However, the external operator panel is required to be made by the user according to the system requirement, as it is not supplied as an option product.



Pin	Signal
01	LED (V)
02	–LED

Figure 1.16 External LED connector

1.4.2 Cable connection requirements

The requirements for cable connection between the IDD, host system, and power supply unit are given in Figure 1.17. Recommended components for connection are listed in Table 1.5.

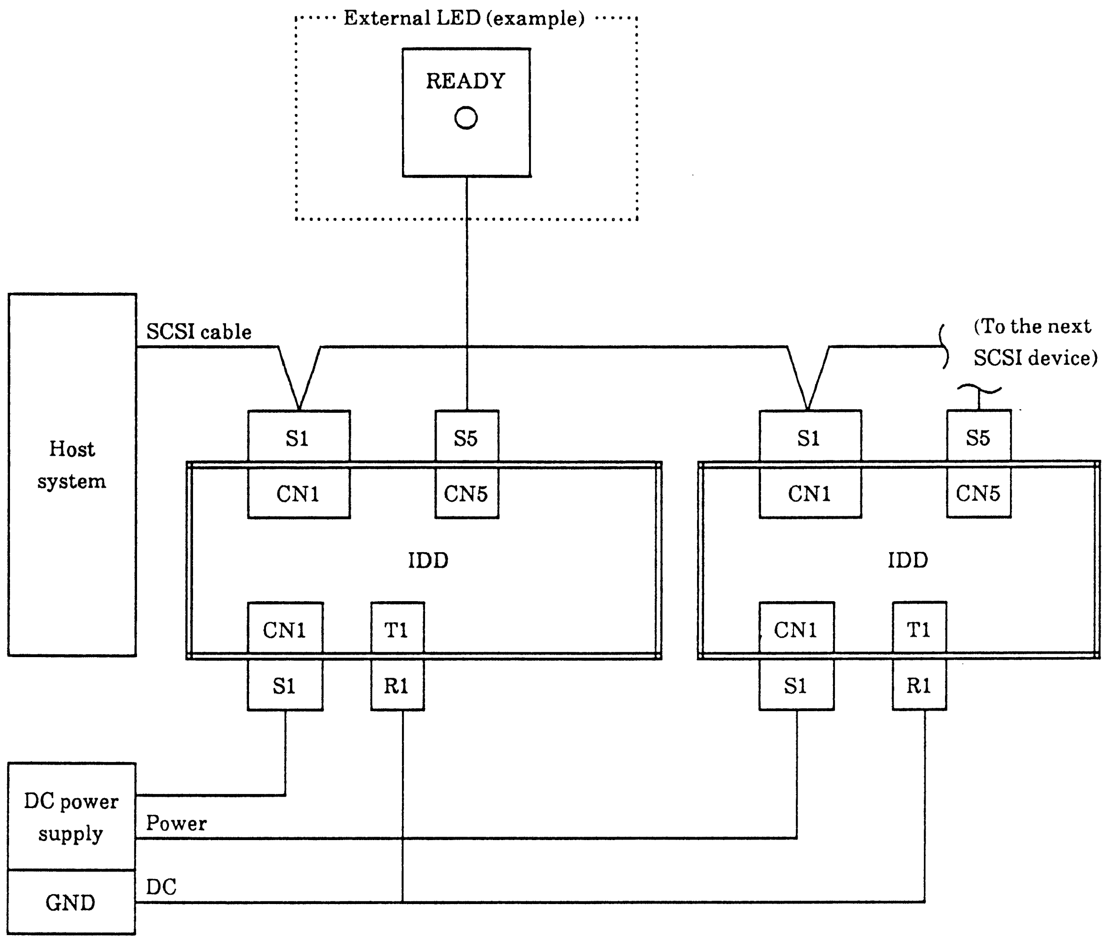


Figure 1.17 Cable connection

Table 1.5 Recommended components for connection

Category	Name	Model	Manufacturer	Symbol in Figure 4.19
SCSI cable	Cable socket (closed-end type)	FCN-707B050-AU/B	Fujitsu Ltd.	S1
	Cable socket (through-end type)	FCN-707B050-AU/O	Fujitsu Ltd.	
	Signal cable	UL20184-LT25PX28AWG	Hitachi Cable, Ltd.	
		455-248-50	SPECTRA-STRIP	
Power supply cable	Housing for cable socket	1-480424-0	AMP	S2
	Contact	170121-4	AMP	
	Cable	AWG18 ~ 24		
DC ground	Fastin-Faston receptacle	62187-1	AMP	R1
	Cable	AWG20		
External LED	Housing for cable socket	608283302815000	ELCO	S5
	Contact	608283052330808 (AWG24 ~ 30)	ELCO	
		608283252330808 (AWG32)		

(1) SCSI cable

All SCSI devices on one bus are daisy-chained with an SCSI cable. A terminating resistor must be mounted in the SCSI device at each end of the SCSI cable.

Since an SCSI terminating resistor module is mounted in the IDD on shipment, it must be removed when the IDD is not connected at either end of the SCSI cable. Also, a method for power supply to the terminating resistor must be selected with the setting terminal on the IDD. For further details, see Subsections 1.4.3 and 1.5.1.

The maximum number of SCSI devices that can be connected to the SCSI bus is 8, including the host adapter, IDD, and other SCSI equipment.

The connector (socket) for the SCSI cable must be an unshielded 50-contact socket which has two rows of 25 contacts spaced at 2.54 mm (0.1 inch) apart. It should also have a key way to prevent insertion in the wrong direction (bump type connector).

The maximum length of the SCSI cable is as follows. If more than one SCSI device is connected, the total cable length must not exceed 6 m.

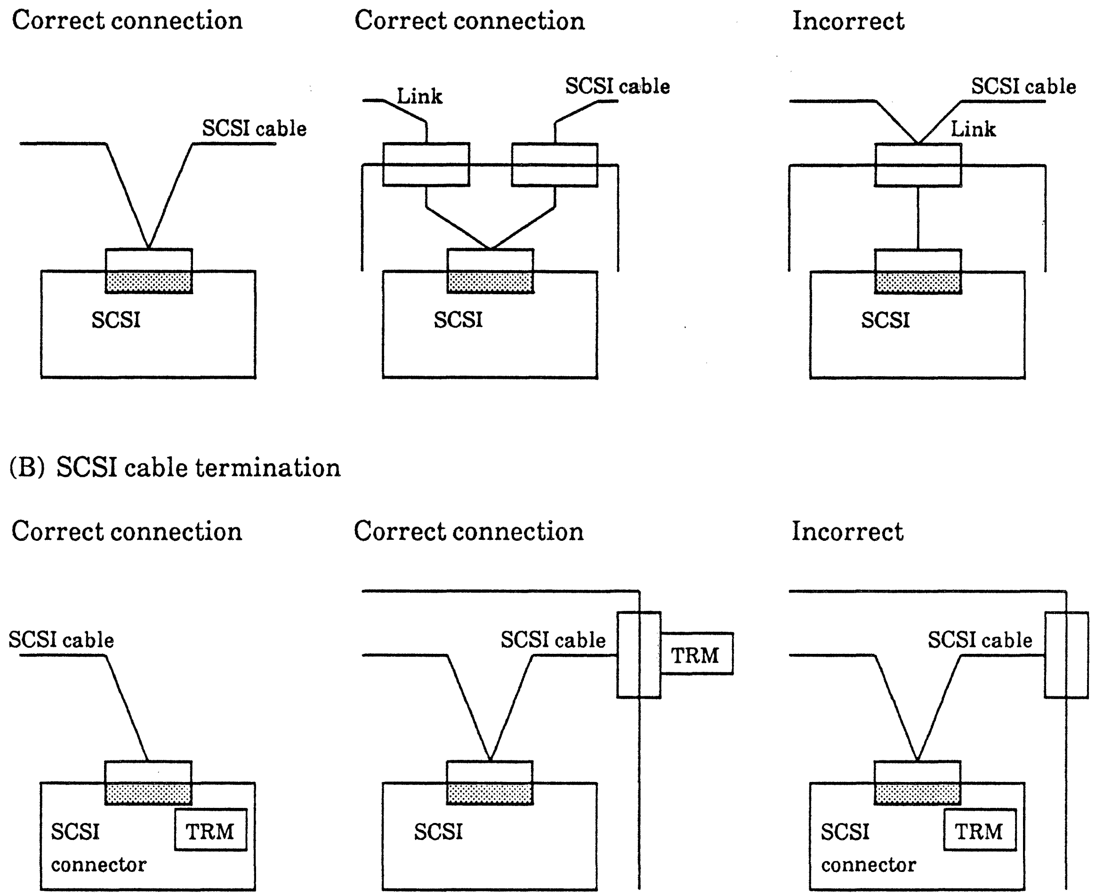
The use of a 25-pair twisted cable satisfying the following requirements is recommended.

① Conductor size: 28 AWG (American wire gauge) or bigger
② Characteristics impedance: 100 to 132 Ω

Each pair of wires in the 25-pair twisted cable must be connected to pins n and n + 1 (where n is an odd number) on the interface connector. Cables having an identical impedance must be used on the same SCSI bus to reduce signal reflection and maintain transmission characteristics.

When an SCSI device is connected to the SCSI cable except at either end of the cable, connection to the SCSI connector must be at a branchpoint of the cable. If an SCSI device is connected to one end of the SCSI bus, no cable should be connected after the last SCSI device except when the cable has a terminating resistor. (See Figure 1.18)

(A) Connection to a middle point of the cable



TRM: SCSI terminating

Figure 1.18 Connection of SCSI cable

(2) Power cable

IDDs must be star-connected to the DC power supply (one to one connection) to reduce the influence of load variations.

(3) DC ground

A DC ground cable may or may not be installed depending on the system requirements (system installation environment, cabinet structure, power supply system). This cable is generally connected to the ground of the power supply unit. Connection between more than one IDD may be in a daisy chain.

(4) External LED

The external LED is installed only when required for the system. If it is unnecessary, pins 01 and 02 of CN5: connector for the external LED on the IDD must be opened.

1.4.3 SCSI terminating resistor

The SCSI terminating resistor module is installed in the IDD when the IDD is shipped from the factory. See Figure 1.12 for installation positions. The terminating resistor module is mounted in a socket and must be processed in one of followings.

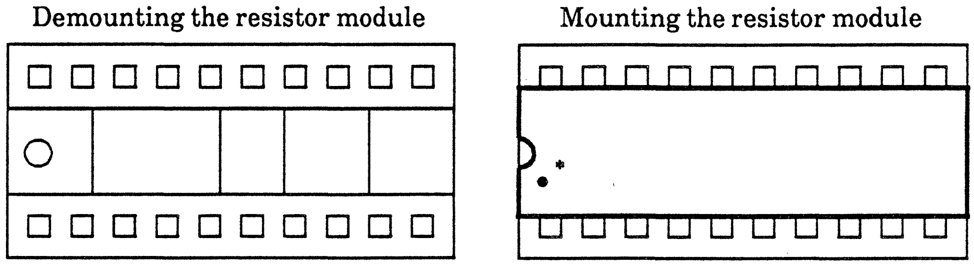
① When connecting the IDD to either end of the SCSI cable, do not demount the terminating resistor module.

② When connecting the IDD to a position other than both ends of the SCSI cable, demount terminating resistor modules.

Notes:

1. When demounting the terminating resistor module, be careful not to damage the resistor module pins, mount socket, and contiguous parts.

2. When mounting the terminating resistor module, check the mounting direction and whether the module is fixed (see Figure 1.19).



*1 ● shows pin No. 1 of the resistor module.

Figure 1.19 SCSI terminating resistor module

1.5 Settings

1.5.1 Setting terminals

The user must set the following terminals and SCSI terminating resistor before installing the IDD in the system.

- Setting terminal: CNH1, CNH2, CNH7
- Setting terminal: CNH3
- SCSI terminating resistor (see Subsection 1.4.3)

Figure 1.20 shows the setting terminal and the position of the SCSI terminating resistor module.

For the detailed information of the function set by the setting terminals and notes on the setting, refer to Section 5.3 in OEM Manual Specifications & Installation.

Notes:

1. The user must not change the setting of terminals not described in this section. Do not change setting statuses set at factory shipment.

2. Do not change the setting of terminals except CNH1 (offline self-diagnostics) / CNH7 (write protect) or do not connect or disconnect the SCSI terminating resistor module when power is turning on.

3. To short the setting terminal, use the short plug attached when the device is shipped from the factory.

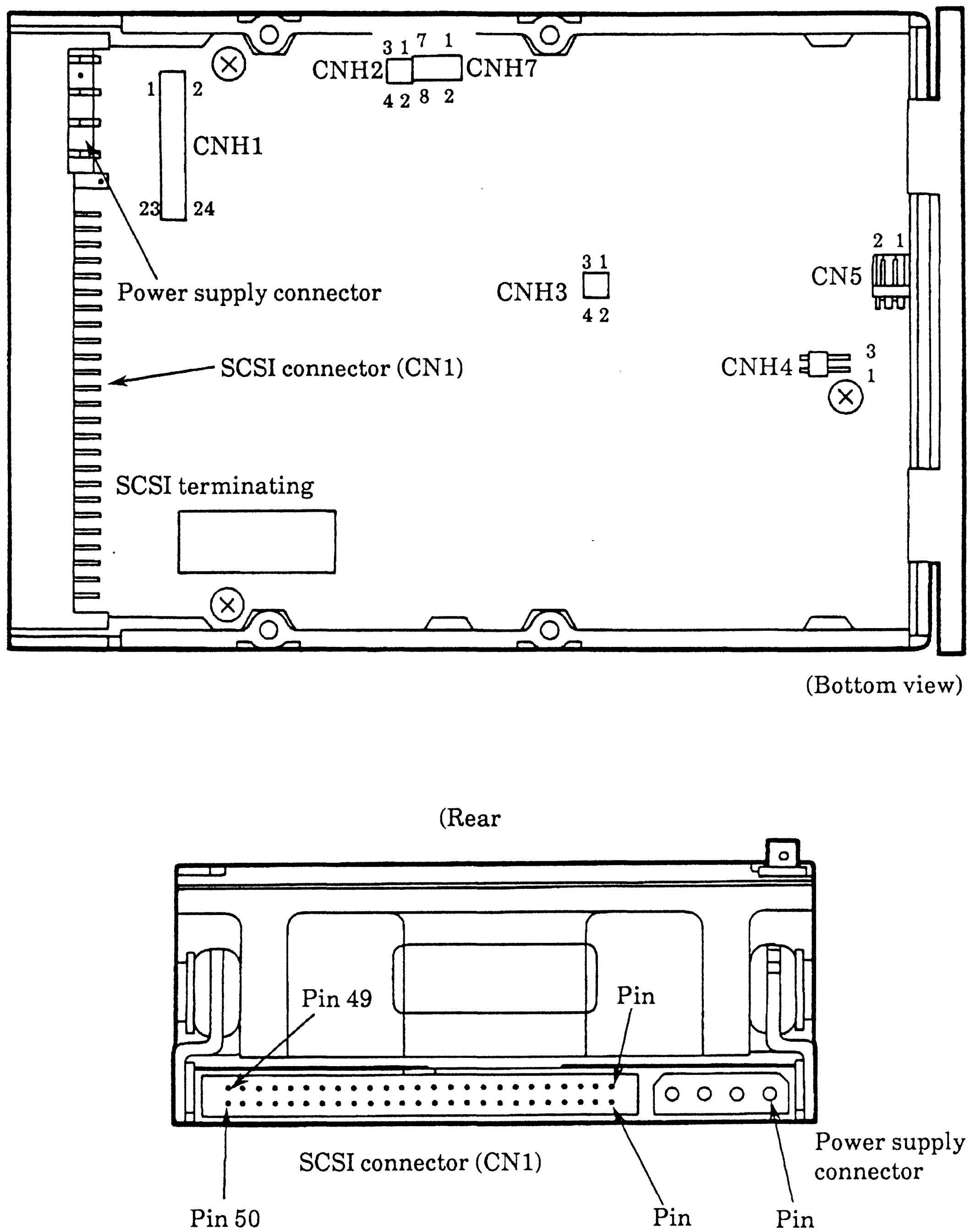


Figure 1.20 Positions of connectors, pins, and terminating resistor

(1) Setting terminals (CNH7)

Figure 1.21 shows the setting terminals and its setting at factory shipment and Table 1.5 lists the setting functions.

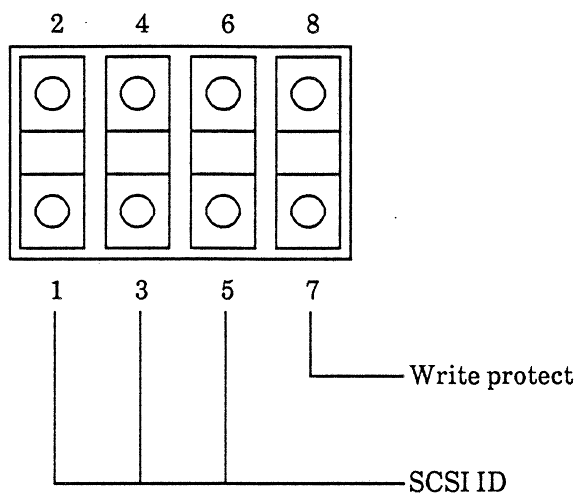


Figure 1.21 Setting terminals (CNH7)

Note:

"Short" and "Open" in the explanation of this section have following meaning.

Short: The short plug is mounted between specified pins.
Open: The short plug is removed from between specified pins.

Table 1.6 Setting terminal: CNH7

Setting item	Pin position			Setting contents
	9-10	11-12	13-14	SCSI ID
SCSI ID	Open	Open	Open	0
	Open	Open	Short	1
	Open	Short	Open	2
	Open	Short	Short	3
	Short	Open	Open	4
	Short	Open	Short	5
	Short	Short	Open	6
	Short	Short	Short	7 (*)
Write protect	7-8		Open	Disable write operation
			Short	Enable write operation (*)

* Setting at factry shipment.

(2) Setting terminals (CNH1, CNH2)

Figure 1.22 shows the plug types and setting at factory shipment and Tables 1.7 and 1.8 list the setting functions.

Note:

"Short" and "open" of the setting terminal are used with the meanings below in the explanations that follow:

Short: A short plug is set between specified pins.
Open: A short plug is removed from specified pins.

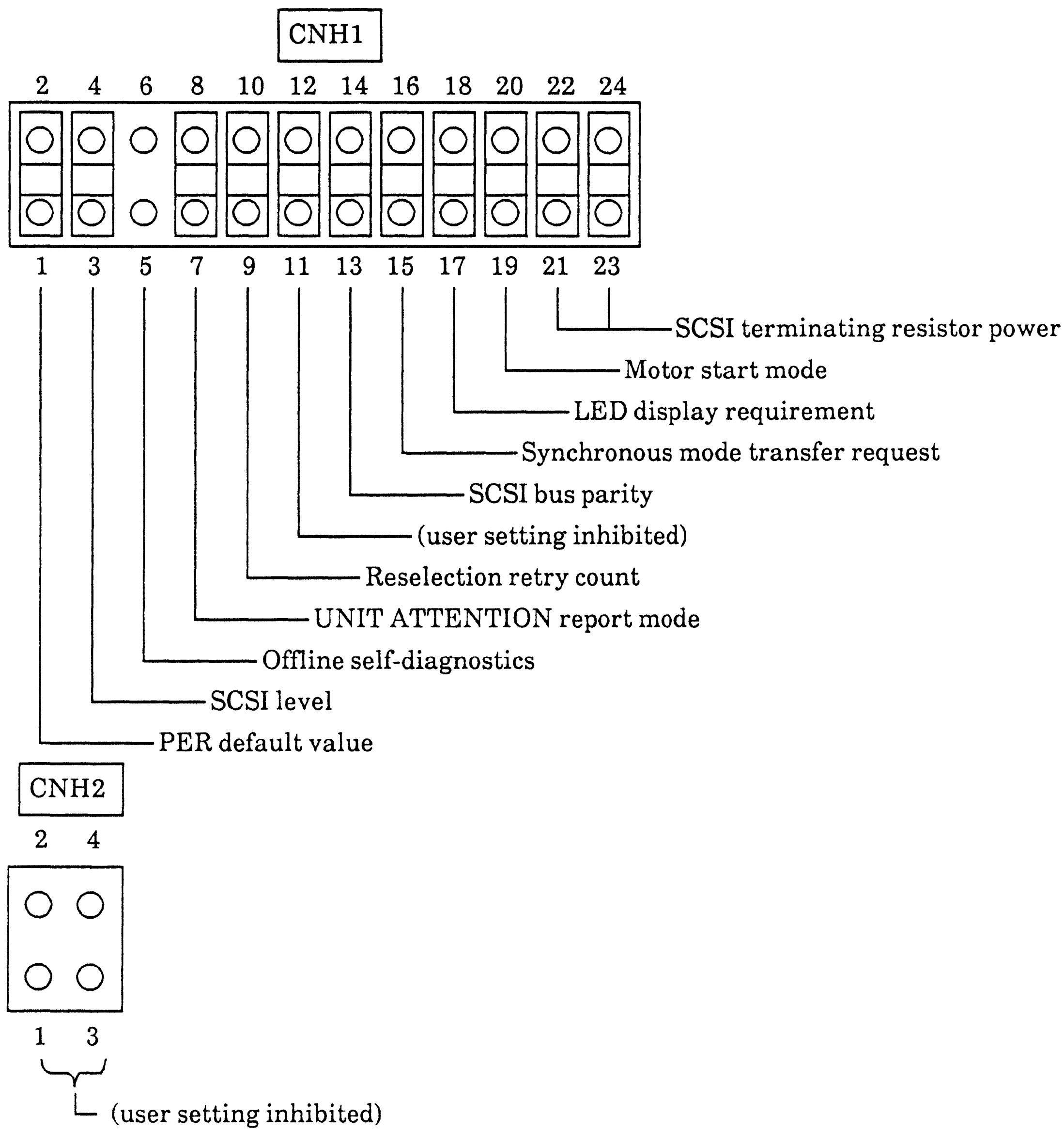


Figure 1.22 Setting terminals (CNH1, CNH2)

Table 1.7 Setting terminal: CNH1

Setting item	Pin position		Setting contents			
PER default value	1-2	Short	"0"			(*)
		Open	"1"			
SCSI level	3-4	Short	SCSI-1/CCS mode			(*)
		Open	SCSI-2 mode			
Offline self-diagnostics	5-6	Open	Stopped (normal operation mode)			(*)
		Short	Executed (diagnostic mode)			
UNIT ATTENTION report mode	7-8	Short	Reports the CHECK CONDITION status.			(*)
		Open	Not report the CHECK CONDITION status.			
Reselection retry	9-10	Short	Retry count = unlimited			(*)
		Open	Retry count = 10			
—	11-12	Short	(Reserved)			(*)
		Open				
SCSI bus parity	13-14	Short	Executed			(*)
		Open	No executed			
Synchronous mode transfer request	15-16	Short	Enabled from TARG			(*)
		Open	Disabled from TARG			
LED display requirement	17-18	Short	Lights during operating			(*)
		Open	Lights during not operating			
Motor start mode	19-20	Short	Started by power-on			(*)
		Open	Started by the START/STOP UNIT command			
SCSI terminating resistor power	21-22	23-24	Connecting TERMPWR pin and terminating resistor	Connicting power to TERMPER pin	Connecting power to IDD terminating resistor	
	Short	Short	Yes	Yes	Yes	(*)
	Short	Open	No	No	Yes	
	Open	Short	Yes	No	No	

* Setting at factory shipment

Table 1.8 Setting terminal: CNH2

Setting item	Pin position		Setting contents
For testing at factory	1-2 3-4	Open Open	User change disabled

Note:

The user must not be change CNH2 setting. (The IDD does not operate correctly when shorted)

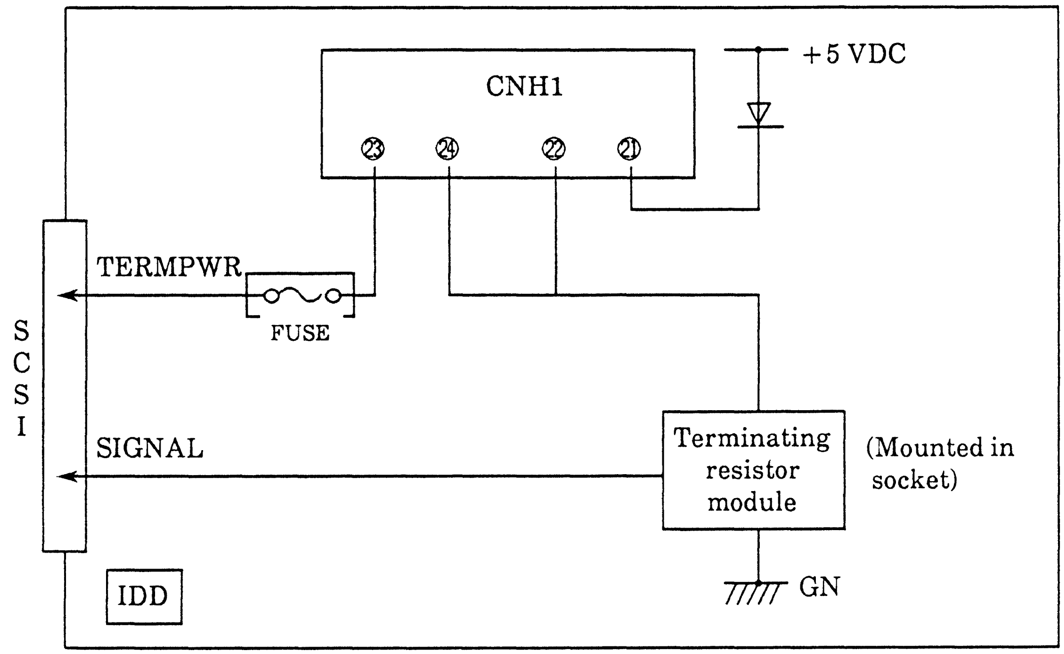


Figure 1.23 Configuration of SCSI terminating resistor circuit

1.5.2 Setting parameters

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

- Error recovery parameter
- Disconnection/re-connection parameter
- Read caching parameter

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

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

This section outlines the parameter setting procedures. Refer to Chapter 3 of <u>OEM Manual SCSI Logical Specifications</u> for further details of the MODE SELECT command and specifying the parameters.

Notes:

1. At factory shipment of the IDD, the saving operation for the MODE SELECT parameter is not executed. So, if the user does not set parameters, the IDD operates according to the default value of each parameter.

2. The MODE SELECT parameter is saved for each SCSI ID of the INIT. When the SCSI ID of the INIT needs to be changed for system requirements, paremters must be set again. Also in the multi-INIT system, parameters must be set for each INIT.

3. Once parameters are saved, the saved value is effective unitl next saving operation is executed by the INIT having a same SCSI ID. For example, even if the initialization of the disk is performed by the FORMAT UNIT command, the saved value of parameters described in this section is not affected.

4. When the IDD, to which the saving operation has been executed on a system, is connected to another system, the user must pay attention to that the IDD operates according to the saved parameter value if the saving operation is not executed at installation.

5. The saved value of the MODE SELECT parameter is assumed as the initial value of each parameter after the power-on, the RESET condition, or the BUS DEVICE RESET message. The INIT can change the parameter value temporary (actively) at any timing by issuing the MODE SELECT command with specifying "0" to the SP bit in the CDB.

(1) Error recovery parameter

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

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

Parameter	Default value
• AWRE: Automatic alternate block allocation at write operation	0 (disabled)
• ARRE: Automatic alternate block allocation at read operation	0 (disabled)
• TB: Uncorrectable data transfer to the INIT	1 (enabled)
• EER: Immediate correction of correctable error	1 (enabled)
• PER: Report of recovered error	0 (disabled) or 1 (enabled) Can be selected with the terminal.
• 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 read operation	18
• Retry count at write operation	18

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) or 1 (enabled) Can be selected with the terminal.
• 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	18

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

Parameter		Default value
• DCED:	Disable delay in the command execution start for IDD internal processing	0 (enabled)
• PSER:	Report of recovered error on SCSI bus	0 (disabled)
• RPR:	Report of parameter rounding at MODE SELECT command	0 (disabled)
• Retry count at seek error		2

Notes:

1. The user can arbitrarily specify the following parameters according to the system requirements:

    - AWRE
    - ARRE
    - TB
    - PER
    - DTE
    - PSER

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

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

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

Parameter	Default value
● Buffer full ratio	Length of a logical data block
● Buffer empty ratio	28 KB

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 data transfer rate of the SCSI bus
   - Average amount of processing data specified with a command

   Refer to Chapter 2 of OEM Manual SCSI Logical 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 them in an operation status under the average system load requirements.

(3) Caching parameters

The following parameters are used to optimize IDD Read-Ahead caching operations under the system environments. Refer to Chapter 2 of OEM Manual SCSI Logical Specifications for further details.

a. Read caching parameters

Parameter	Default value
• RCD: Disabling Read-Ahead caching operations	0 (enabled)
• MS: Specifying the multipliers of "minimum prefetch" and "maximum prefetch" parameters	0 (specifying absolute value)
• Number of blocks for which prefetch is suppressed	X'FFFF'
• Minimum prefetch	X'0000'
• Maximum prefetch	X'0XXX' (equivalent to 60 KB)
• Number of blocks with maximum	X'FFFF'

Notes:

1. When Read-Ahead caching operations are disabled by the caching parameter, these parameter settings have no meaning.

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. If access is mostly random access, generally, it is recommended to disable the Read-Ahead caching.

1.6 Dismounting Drives

Since dismounting the drive to check the setting terminals, change the setting, or change the drive depends on the structure of the system cabinet, the work procedures must be determined in consideration of the requirements specific to the system. This section describes the general procedures and notes on dismounting the drive.

CAUTIONS

1. *Dismount the drive after disconnecting system power. Do not remove mounting screws holding the cables and drive while power is on.*

2. *Do not move the drive until it completely stops (15 seconds after spindle motor is stopped with START/STOP UNIT command or after power is turned off).*

① Remove the power cable.

② Remove the SCSI cable.

③ When the external operator panel is mounted, remove the cable. If it is difficult to access the connector position, the cable may be removed after step ⑤.

④ Remove the DC ground cable.

⑤ Remove the four mounting screws securing the drive, then remove the drive from the system cabinet.

⑥ To store or transport the drive, keep it in an antistatic bag and provide packing (see Section 5.1 in OEM Manual Specifications & Installation).

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CHAPTER 2 DIAGNOSTICS AND MAINTENANCE

This chapter contains information on the maintenance, diagnostics, operation confirmation, and troubleshooting of the IDD, and the followings are described.

- Danger and warning on the normal maintenance and troubleshooting
- Maintenance level definition (field and factory)
- Displaying of machine revision number and changing revision number at field
- Tools and test device required for each maintenance level
- General test procedure at each maintenance level
- Recommended troubleshooting and trouble separation procedure

2.1 Maintenance Requirements

2.1.1 Danger and warning

The following safety precautions must always be observed to avoid personal injury during troubleshooting or maintenance.

Danger

1. *To avoid electric shock, do not remove/fix the PCA, or connect/remove cables/connector plugs under when the power is on.*

2. *To avoid injuries, do not approach to the unit assembly when the drive is activated.*

3. *Do not use harmful abluent when cleaning drive.*

The following warnings must always be observed to avoid any damages to the drive during troubleshooting or maintenance.

Warning

1. *To protect the PCA from electrical damage, touch the frame ground before touching the PCA to discharge the static electricity.*

2. *To protect drive from electrical damage, do not remove/fix the PCA or connect/disconnect cables/connector plugs when the power is on.*

3. *To prevent unexpected or implicit operation, do not power on when removing PCA.*

4. *Do not use abluent which may cause electrical short when cleaning an assembly.*

5. *To avoid over-heating electrical circuit, leave all ventilators open, and do not close them.*

6. *Confirm that the mark on a ribbon shape cable is always positioned at the pin 1 of a cable connector.*

2.1.2 Maintenance requirements

(1) Preventive maintenance

Preventive maintenance such as replacing air filter is totally unnecessary.

Warning

The DE is completely enclosed and do not open the DE at field.

(2) Service life

Overwhole is unnecessary within 5 years from the installation under the pertinent environment and correct operation.

(3) Field replacing parts

No parts (including PCA and DE) can be replaced at the field. Whole drive must be replaced at the field.

(4) Service system and repair

Fujitsu offers the service system and repair facility for the disk drive. User is requested to contact Fujitsu and give the information necessary to replace or repair the disk drive. The information generally includes the followings.

① Device model, part number (P/N), machine revision number, serial number (S/N), and production date of the disk drive

② Error condition

- Date of trouble occurred
- System configuration
- Environment condition (power voltage, temperature, and humidity etc.)

③ Past maintenance record

④ Trouble description

- Outline of trouble data
- Issued command and specified parameter
- Sense data
- Other analysis data

Warning

When maintenance is requested, the data stored in the disk drive must be saved. Fujitsu Ltd. is exempted from any responsibilities on data loss during service/repair.

Refer to Section 5.1 for information on precautions on handling and packing disk drive when returning.

2.1.3 Maintenance level

It is advisable to replace whole disk drive for its compact size and unique repair requirements. 2 maintenance levels are described here.

(1) Field maintenance (replacing disk drive)

- Replaced at user field
- Replaced using general tools
- Replaced normally by user, retail dealer, vendor, or OEM vendor

(2) Factory maintenance (replacing parts)

- Replaced by Fujitsu engineer at this maintenance level.
- Includes support for maintenance training and other OEM vendors. OEM vendors usually support retail dealer and vendors.
- Tools and test equipments at production level are used, including repairing or replacing recommended spare parts or other parts.

2.1.4 Machine revision number

The maching revision number of the disk drive is expressed in 1 column of alphabet followed by 1 column of numerics, and is indicated on the revision number label on the DE. Figure 2.1 shows the drive revision number label format.

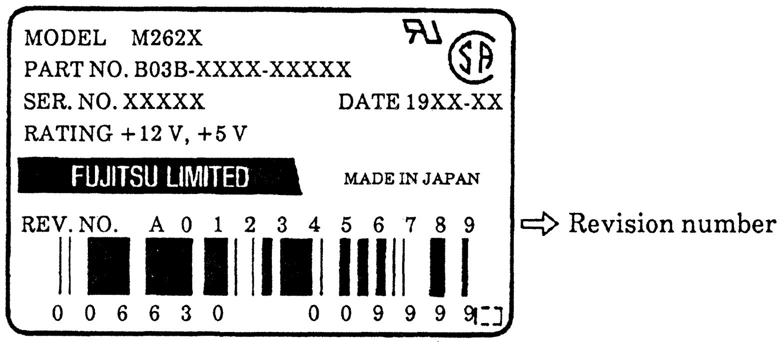

Figure 2.1 Machine revision number label

(1) Revision number indication at shipment

The revision number of the disk drive at shipment is indicated by erasing relevant alphanumerics with = (see Figure 2.2).

(2) Revision number change at field

When changing drive revision number at field due to parts replacement or other revisions applied, the applied level is indicated by marking relevant alphanumerics with = (see Figure 2.2).

Note:

At change of revision number after shipment, "Engineering Change Request/Notice" is issued by Fujitsu, and the changed machine revision number is explicitly indicated. When the change is applied at user end, a revision number label should be updated after the change is applied according to the procedure described before.

Revision number indication at factory shipment

Revision number change at field

Figure 2.2 Machine revision number indication

2.1.5 Tool and test equipments

At field maintenance level, general hand tools only are required for troubleshooting or repair, and special tools and test equipment are not necessary.

This manual does not cover the tools and test equipments at factory maintenance level.

2.1.6 Self-diagnostic function

The IDD has the self-diagnostic function as described below. This function confirms whether the basic operation of the IDD is normally executed or not.

- Initial self-diagnostics
- Off-line self-diagnostics (setting terminal)
- Off-line self-diagnostics (SEND DIAGNOSTIC command)

For more detailed information on each self-diagnostics function, refer to Chapter 6 in OEM Manual Specifications & Installation.

2.1.7 Test

Testing for disk drives is categorized into the following 3 levels.

- Initial seek operation confirmation (see Subsection 2.2.1)
- Operation test (see Subsection 2.2.2)
- Diagnostic test (see Subsection 2.2.3)

Figure 2.3 shows the relationship between the test level and troubleshooting.

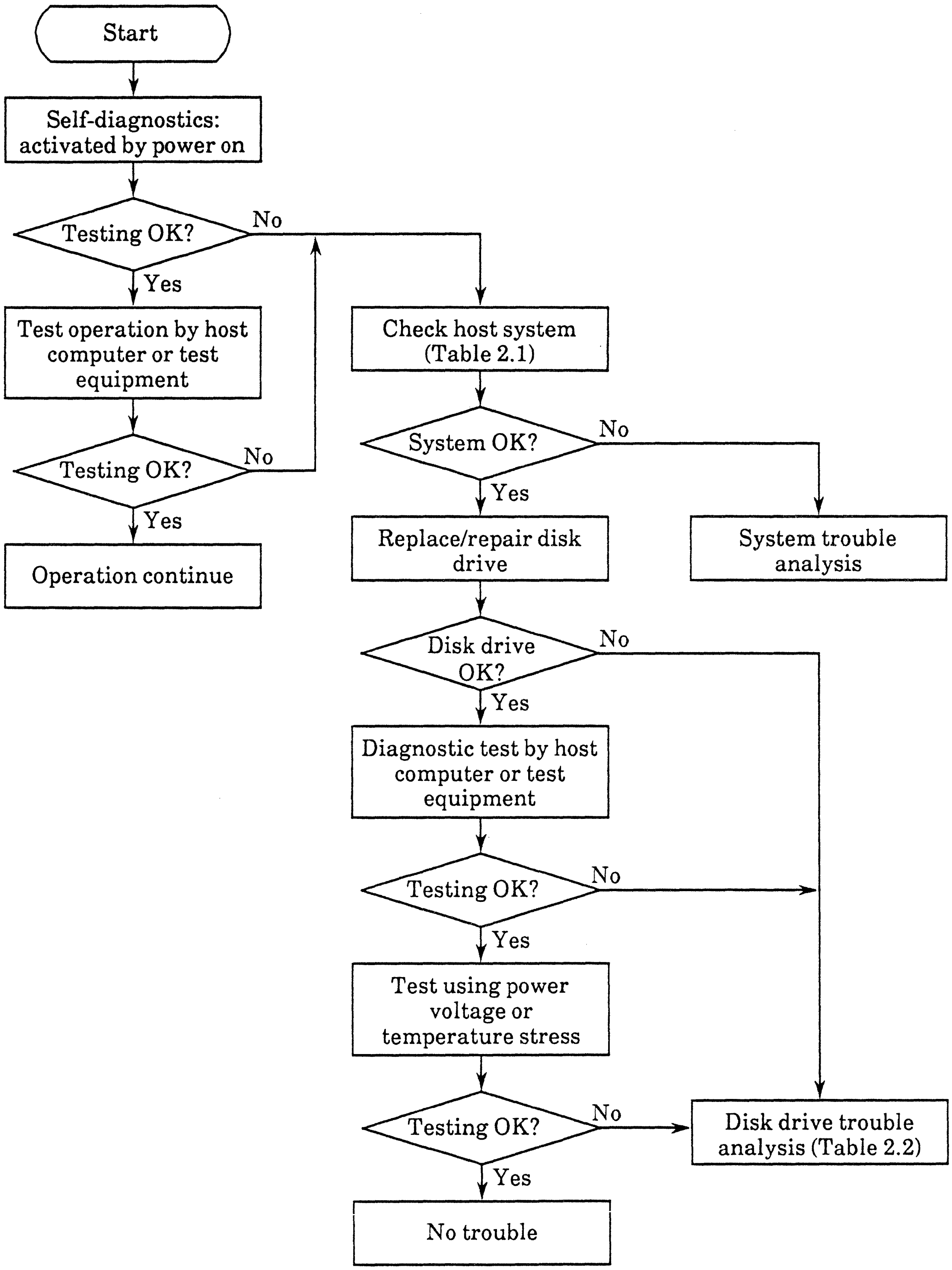

Figure 2.3 Test flow chart

2.2 Operation Confirmation

2.2.1 Initial seek operation confirmation

When an error is detected during the initialization, i.e., initial seek operation confirmation routine, at the power on, LED on the front panel blinks and the spindle motor of the disk drive stops, resulting in complete halt of disk drive operation.

For more detailed information on the operation confirmation before initial seek, refer to Chapter 5 in OEM Manual Specifications & Installation.

2.2.2 Operation test

While the host computer executes data a processing, the IDD observes disk drive operation errors including data, command, and seek errors. An error detected by the IDD is reported to the INIT, and the result is reported to user.

Also, user is sometimes reported of indefinite errors, such as abnormal noise, offensive smell, excessive duration of time for a specific operation, and so on.

Errors reported by the operation test requires further investigation. A disk drive can be replaced to confirm whether the trouble reported was the direct cause.

Errors reported by the operation test often are caused by other elements of host system. For example, insufficient margin of power supply, loose cable connection, insufficient margin of timing and mechanism, or problems related to other system.

When the operation error is detected by the error detect circuit of disk drive, interruption occurs and error information is sent to the MPU on the control PCA. The MPU interrupts a command in execution, and generates the CHECK CONDITION status to report an error to the INIT.

When the INIT receives the CHECK CONDITION status, it normally obtains the detailed information of an error by the REQUEST SENSE command. Further more, it issues the REZERO UNIT command to return read/write head to track 00. Under the normal operation condition, the IDD or INIT handles the detected error process (retry or abort).

When troubleshooting an error reported at this test level, a CE normally re-realizes the condition under which an error has occurred correctly, and separates an error to other section of the IDD host system by replacing the disk drive.

2.2.3 Diagnostic test

The diagnostic test is used to breakdown a confirmed disk drive trouble into subassembly in the disk drive and to confirm the performance level of the disk drive. At this level, a test generally includes concentrated execution of specific disk drive functions or a group of functions. A test is generally done by engineers at repair center or factory, and takes place outside the environment where a trouble has occurred using other host computer or test equipments.

When troubleshooting a disk drive error by the diagnostic test, an engineer re-realizes the condition under which an error has occurred, and breakdown the error location into subassembly of the disk drive or parts level.

At this level, the test procedure depend heavily on the test equipment system, and is not covered in this manual.

2.3 Troubleshooting Procedure

2.3.1 Troubleshooting procedure

This section explains the troubleshooting procedure of the disk drive.

Troubleshooting is done according to the maintenance level to breakdown a reported trouble into the disk drive, recommended spare parts, or disk drive parts.

Troubleshooting is normally required only when the cause of a trouble is uncertain or doubtful. When the cause of a trouble is clear, for example, abnormal noise in the DE or burnt parts on the PCA, level of troubleshooting becomes low.

2.3.2 Disk drive replacement at field troubleshooting

At the field troubleshooting, it is recommended to replace whole disk drive. When the replaced disk drive does not shown any sign of trouble, the removed disk drive is returned to a repair center for a test or repair. When the replaced disk drive causes the trouble as that of the removed disk drive, the cause of a trouble remains in other section of the system.

Troubleshooting at system level (see Table 2.1) is done at field (customer site) to separate whether a reported error relies on the disk drive or system.

Table 2.1 System level/troubleshooting at customer site

Item	Recommended
DC power cable	Check whether the power cable is correctly connected to the disk drive and power supply section.
AC and DC power voltage level	Check that the DC power voltage is within the regulated value of ±5%. +5 VDC must be 4.75 to 5.25 VDC which is measured by pin 3 and 4 of the power connector. +12 VDC must be 11.4 to 12.6 VDC which is measured by pin 1 and 2 of the disk drive power connector.
Electrical noise	Check that the maximum ripple at +5 and +12 VDC is smaller than 50 mV at peak-to-peak.
Interface cable connection	Check that the SCSI interface cable is correctly connected to the disk drive and control unit.
Terminator	Check that the terminating resistor is correctly mounted on the last drive in daisy chain connection and on all drives in radial connection.
Drive select address	Check the setting so that the disk select address operates in the host system correctly.
Plug setting	Check the jumper setting on the control PCA so that the set contents operates in the host system correctly. Refer to Section 1.5.
System cable	Check that cables are correctly connected in the system.
System diagnostic test	If possible, execute the diagnostic routine of the system described in the manual for host computer to separate an error.
Uncertain or intermittent error	Check the AC power voltage level at the power supply section, and re-check the DC power voltage level at the disk drive power connector. Report to user when the AC power voltage level is wrong or the electrical noise is too loud. Replace the power supply section if DC power voltage level is unstable. If possible, replace the disk drive. When a trouble occurs continuously, the cause does not remain in the disk drive. Refer to the hardware and software manuals attached to the system for more information which may help to separate a trouble.
Spindle sync cable	Check that the spindle sync cable is certainly connected between drives.

2.3.3 Troubleshooting at repair center

At the repair center maintenance, it is recommended to do an additional test of the disk drive and to confirm a signal.

A sense data reported from the IDD eases the troubleshooting and helps to separate functional, mechanical and electrical trouble. Chapter 3 describes each trouble indicated by the sense data, and gives an additional information on the trouble separation.

Table 2.2 shows the separation procedure of a trouble to disk drive subassembly. It is prerequisite that the host computer or disk drive test equipment can be used to set the condition under which the trouble has occurred in the disk drive.

Even when the trouble is not re-realized under the normal test procedure, some load can be added in the repair center maintenance so that the trouble is re-realized by changing the surround termperature or DC voltage level.

If the trouble is not realized after the load is added, the disk drive is normal. When the disk drive is tested and no trouble is found, report to customer and obtain further information on the disk drive environment.

Table 2.2 Trouble separation of disk drive

Item	Recommended
Multiple or repetitive seek error	Collect sense data and see Chapter 3. Replace the disk drive and check the test procedure. If the trouble continues, it is thought that the trouble is not caused by the disk drive, but is caused by the test procedure.
Multiple or repetitive data error	Collect sense data and see Chapter 3. Replace the disk drive and check the test procedure. If the trouble continues, it is thought that the trouble is not caused by the disk drive, but is caused by the test procedure.
Uncertain or intermittent error	Replace the disk drive and check the test procedure. If the trouble continues, it is thought that the trouble is not caused by the disk drive, but is caused by the test procedure. To check the performance, perform the load test of the disk drive by changing the power voltage ahd temperature.

When it is confirmed that the disk drive is failed by the troubleshooting, return the whole disk drive with a media defect list to the factory for repair.

When the trouble is separated to the DE by troubleshooting, or the explicit trouble in the DE (for example, bad servo track information, loud noise) exists, return the whole disk drive with a media defect list to the factory for repair.

Warning

The DE (disk enclosure) cannot be opened at the field. Opening the DE may cause a trouble which cannot be repaired.

2.3.4 Parts replacement at factory troubleshooting

This manual does not cover the troubleshooting at factory.

2.3.5 Trouble separation

Trouble separation at the field (customer site) is described in Subsection 2.3.2.

At repair center maintenance level, it is desirable that the CE follow the trouble separation procedure as shown in Table 2.2.

This manual does not cover the trouble separation at the factory.

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CHAPTER 3 FAULT ISOLATION

This chapter describes the detailed information on how the sense data obtained from the disk drive is used for trouble separation. These sense data indicate the trouble detected by the disk drive and ease the troubleshooting and trouble separation.

Sense key, sense code, and sub sense code among the sense data are used often. This chapter describes how these three codes are used to separate trouble. Sense data implies the above three codes as long as particularly mentioned. Also, the sense data (X-XX-XX) indicates sense key, sense code, and sub sense code from the left.

3.1 Collecting Trouble Analysis Data

3.1.1 Sense data

When the IDD reports the CHECK CONDITION status or some critical errors related to SCSI bus is detected, the IDD generates the sense data to the INIT that issued the command at clearing the command being executed or stacked. The INIT can read sense data by issuing the REQUEST SENSE command.

The REQUEST SENSE command execution is normally ternimated even when the "transfer byte" length which is shorter than the sense data provided by the target device is specified. In such case, it must be noted that only a part of the sense data is received and the remaining information will be lost.

Refer to Chapter 3 in OEM Manual SCSI Logical Specifications for more detailed information of the REQUEST SENSE command.

3.1.2 Sense key, sense code, and sub sense code

Every trouble detected by the disk drive will be indicated in the sense data obtained from the disk drive. Figure 3.1 shows the position of sense key, sense code, and sub sense code.

	Byte	Bit 7	6	5	4	3	2	1	0
Basic data	BYTE 0	Valid	X '70' or X '71' (error code)						
	1	X '00'							
	2	0	0	ILI	0	Sense key			
	3	[MSB] Information							
	4								
	5								
	6	[LSB]							
	7	X '28' (additional sense data length)							
	8	[MSB] Command unique information							
	9								
	10								
	11	[LSB]							
	12	Sense code							
	13	Sub sense code							
	14	X '00'							
	15	SKSV	Information unique to sense key						
	16								
	17								
	18	0	SCSI ID				LUN		
	19	CDB operation code							
Additional data	20	Detailed information							
	⟆								
	47								

Figure 3.1 Extended sense data format

3.2 Analyzing Sense Data

3.2.1 Trouble information by sense data

Subsections 3.2.2 through 3.2.7 show the flowchart of trouble separation by the each sense data which determine the cause of a trouble.

Table 3.1 defines the sense data of the error status. Also, refer to Chapter 4 in OEM Manual SCSI Logical Specification for more detailed information on the sense data.

Table 3.1 Relation between sense data and error status

Sense data			Definition
Sense Key	Sense Code	Sub Sense Code	
0	00	00	Normal operation
4	01	00	Target sector cannot be detected by sector counter.
	02	00	Seek timeout
	03	xx	Write operation to the medium is terminated with an error.
	40	xx	Error occurs at power-on self-diagnostics.
	44	xx	Hardware error occurs in the IDD.
	C4	04	Overcurrent of spindle motor is detected.
	C4	09	Hardware error occurs in the DSP.
	C4	0A	Error occurs during calibration seek.
1	1x	xx	Medium read error (such as SB in the ID field is not detected) occurs.
3	1x	xx	Medium read error (such as SB in the ID field is not detected) occurs.
5	2x	xx	SCSI error such as invalid operation code occurs.
	3D	00	"1" is set to the reserve bit in the IDENTIFY message.
	90	00	RESERVE UNIT, RELEASE UNIT, or PRIORITY RESERVE command cannot be executed because the SCSI ID of INIT is not reported in the SELECTION phase.
1	47	xx	Parity error occurs at SCSI data bus.
3	47	xx	Parity error occurs at SCSI data bus.
4	C4	03	Error occurs at START command for spindle motor.
4	C4	05	Power voltage is less than rated value.
6	5C	02	spindle synchronization is broken.

3.2.2 Sense data (4-01-00), (4-02-00), (4-03-xx), (4-40-xx), (4-44-xx), (4-C4-04), (4-C4-09), and (4-C4-0A)

Cause of these sense data is one of followings.

- The target sector cannot be detected by the sector counter.
- A seek timeout occurs.
- A write operation to the medium is terminated with an error.
- An error occurs at the power-on self-diagnostics.
- A hardware error occurs in the IDD.
- An overcurrent of the spindle motor is detected.
- A hardware error occurs in the DSP.
- An error occurs during the calibration seek.

It is thought to be caused by a failure of the PCA or DE. See Figure 3.2.

For the details of these sense data, refer to Chapter 4 in OEM Manual SCSI Logical Specification.

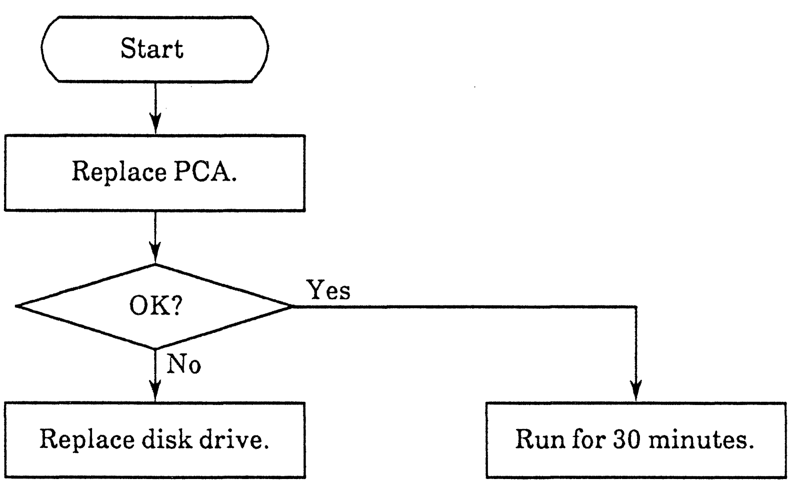

Figure 3.2 Sense data (4-01-00), (4-02-00), (4-03-xx), (4-40-xx), (4-44-xx), (4-C4-04), (4-C4-09), and (4-C4-0A)

3.2.3 Sense data (1-1x-xx), (3-1x-xx): Medium read error

These sense data indicate the media defect which was not recorded on the media defect list when they occur repetitively in specific blocks. In such case, the blocks where an error occurs repetitively should be assigned to the alternate blocks by the REASSIGN BLOCKS command. Refer to chapter 3 and Section 5.4 in OEM Manual SCSI Logical specification for more detailed information on the REASSIGN BLOCKS command.

When the above error occurs in the different block, the cause of error is thought as a defective PCA or DE. see Figure 3.3.

For the details of these sense data, refer to Chapter 4 in OEM Manual SCSI Logical Specification.

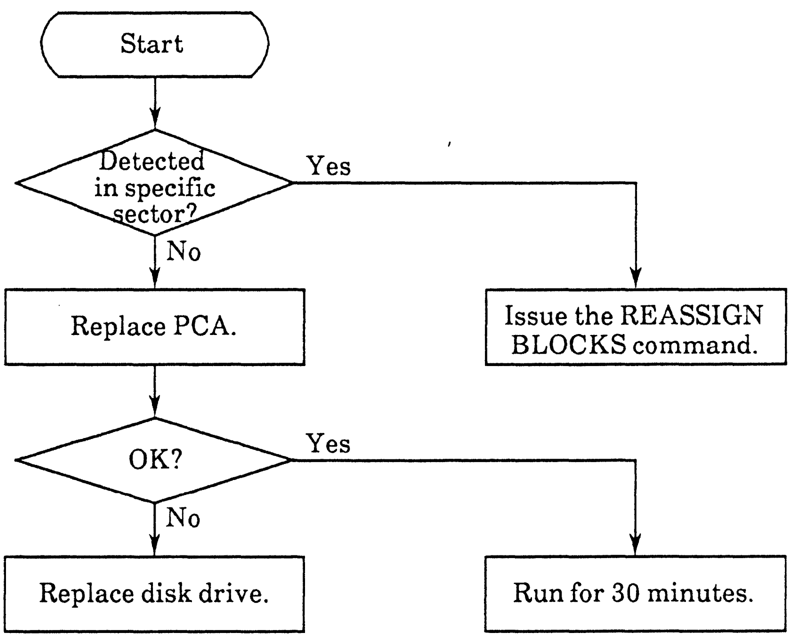

Figure 3.3 Medium read error

3.2.4 Sense data (5-2x-xx), (5-3D-00), 5-90-00), (1-47-xx), and (3-47-xx): SCSI interface failure

The cause of these sense data is one of followings.

- An invalid or unsupported command (parameter) is issued.
- SCSI interface failure
- An parity error occurs at the SCSI bus.

These sense data is thought to be caused by the defective PCA or SCSI interface cable. See Figure 3.4.

For details of these sense data, refer to Chapter 4 in OEM Manual SCSI Logical Specification.

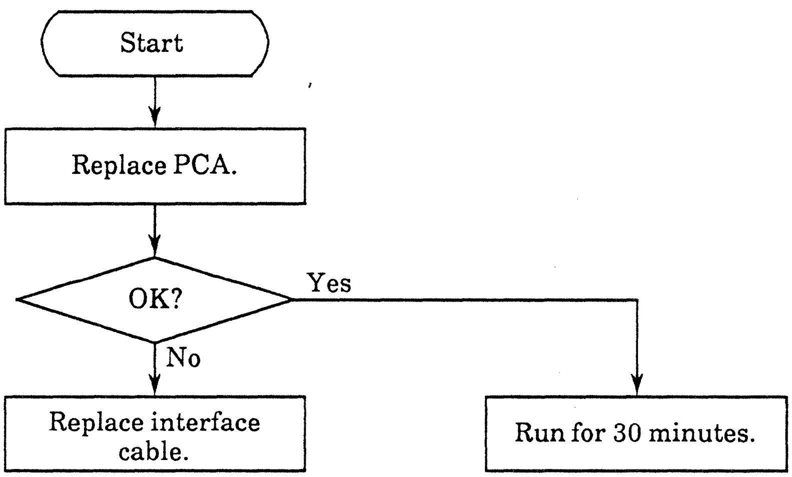

Figure 3.4 SCSI interface failure

3.2.5 Sense data (4-C4-03): Spindle motor timeout

This sense data indicates the rotation speed of the spindle motor is not reached the rated speed within 30 seconds after power on or receiving a spindle motor activate command from the control unit. It is thought to be caused by the defective PCA or DE. See Figure 3.5.

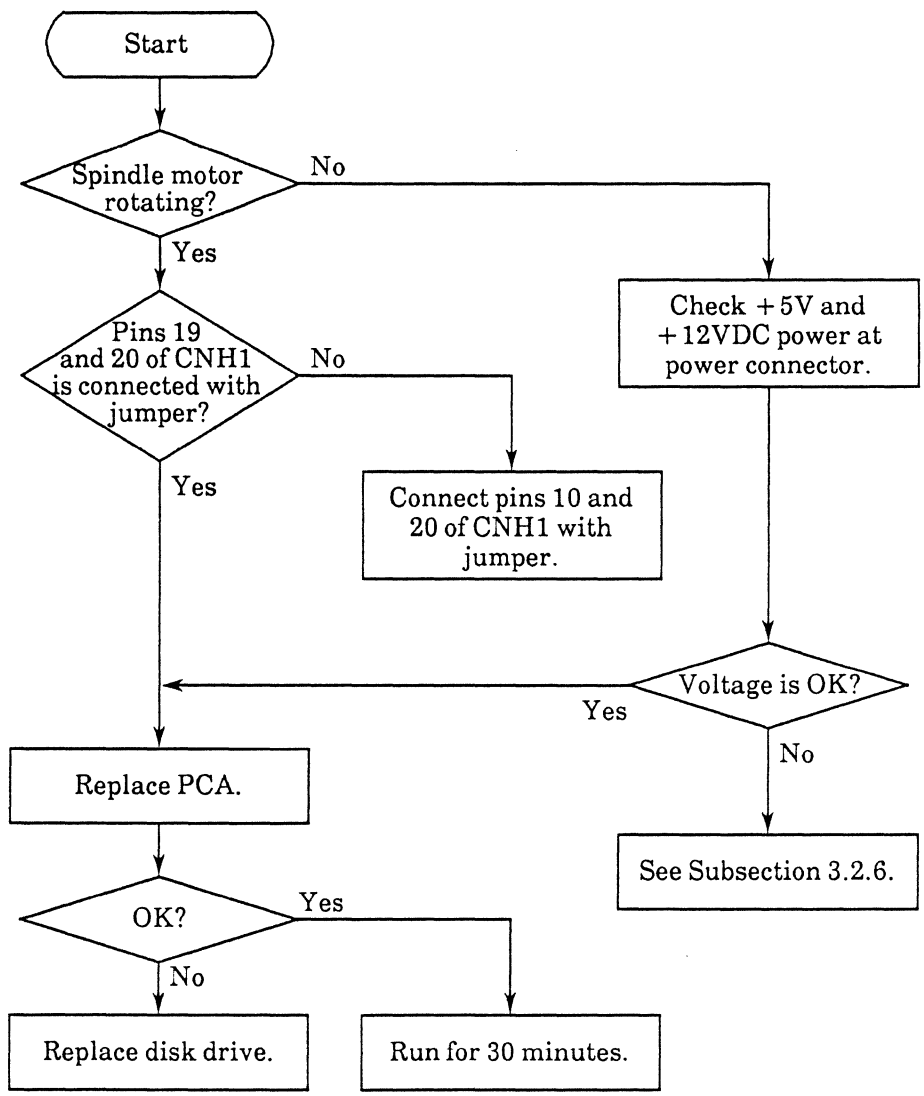

Figure 3.5 Spindle motor timeout

3.2.6 Sense data (4-C4-05): Low power voltage

This sense data indicates that either +12VDC or +5VDC power was less than 80% of the rated value. It is thought to be caused by a defective power supply, power cable, PCA, or DE. See Figure 3.6.

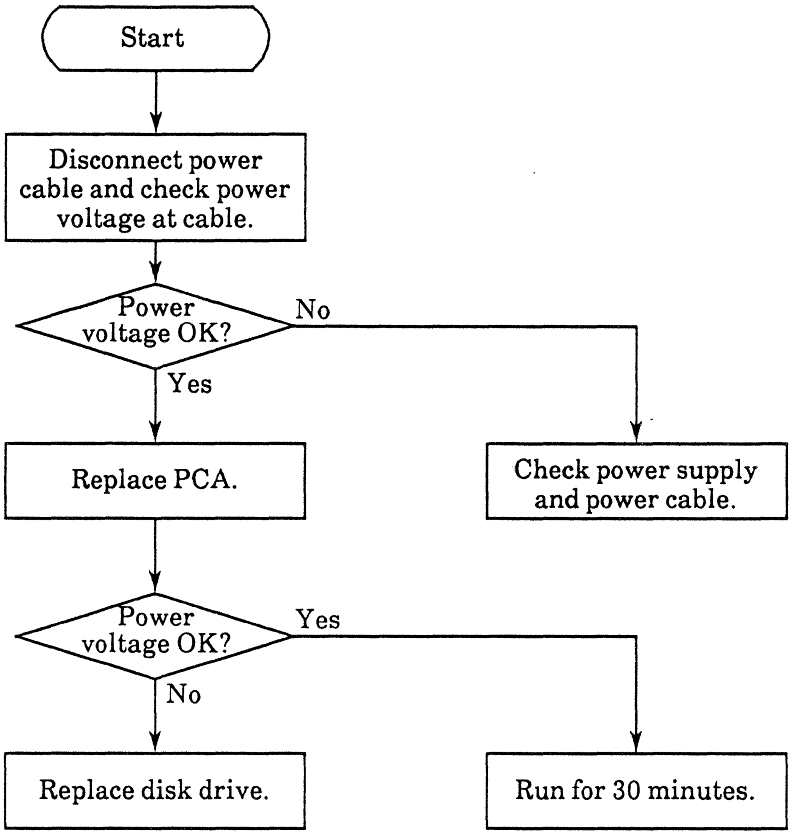

Figure 3.6 Low power voltage

3.2.7 Sense data (6-5C-02): Spindle synchronization is broken

This sense data indicates that the spindle synchronization could not be performed or was broken. It is thought to be caused by a defective spindle sync cable, PCA, or DE. See Figure 3.7.

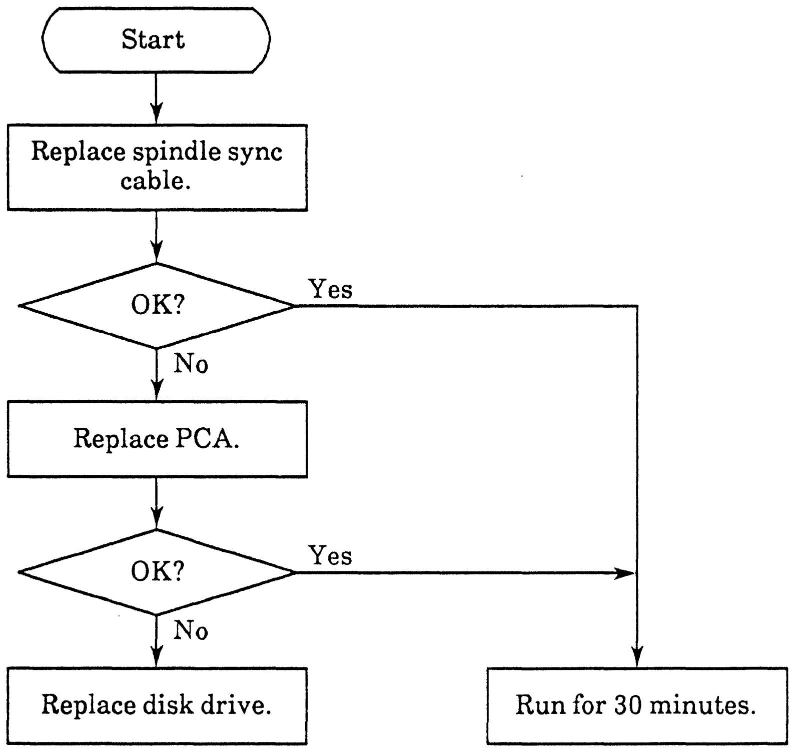

Figure 3.7 Spindle synchronization is broken

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CHAPTER 4 REMOVAL AND REPLACEMENT PROCEDURES

This chapter describes how to remove and replace the disk drive. Reader is assumed to have thorough knowledge on replacing whole disk drive, or on replacing interface cable, or power cable.

The followings should be noted when executing these procedures.

- The disk drive must be removed from the host system.
- All power cable and signal cable connected to the disk drive must be disconnected.
- Reference to the previous procedure is indicated in ( ).
- Mounting procedure is the reverse procedure of removal.

The followings should be noted for correct maintenance.

- Keep all record of maintenance work.
- Screws must be fixed positively, but not too tightly.
- Before contacting the PCA, contact the frame ground to discharge the static electricity from the engineer's body for protecting the PCA from the electric damage.

4.1 Spare Parts

This section explains the part number for ordering the spare disk drive and other related information.

4.1.1 Disk drive model and part number

See Table 1.1 for information on model and part number required for ordering disk drive for replacement.

4.2 Disk Drive Removal

The removal procedure of the disk drive depends on the system cabinet configuration. The actual removal procedure should be defined with adding a system unique requirement. The following procedure is the general removal procedure and notes.

① Disconnect the power cable.

② Disconnect the SCSI cable.

③ When the external LED is mounted, disconnect the cable for the external operator panel. If access to the connector section is difficult, it can be disconnected after step ⑤.

④ Disconnect the DC ground cable.

⑤ Remove screws which fix the drive to the system cabinet, and take out the drive.

⑥ When storing or transporting the disk drive, put it in the antistatic bag and then pack.

Warning

1. *Turn off the power of the system before removing. Do not remove screws which fix cables and disk drive under the power on status.*

2. *Do not move the disk drive until the drive stops completely (approximately 30 seconds from the START/STOP UNIT command issued to stop the spindle motor, or approximately 30 seconds after turning off the power of the drive).*

Note:

To avoid the damage of the drive and to prevent personal injuries, observe the items in Subsection 2.1.1.

CHAPTER 5 THEORY OF OPERATION

This chapter explains basic design concepts of the disk drive. Also, this chapter explains subassemblies of the disk drive, each sequence, servo control, and electrical circuit blocks.

5.1 Outline

This chapter consists of two parts. First part (Section 5.2) explains mechanical assemblies of the disk drive. Second part (Sections 5.3 through 5.7) explains a servo information recorded in the disk drive and drive control method.

5.2 Subassemblies

The disk drive consists of a disk enclosure (DE) and printed circuit assembly (PCA).

The DE contains all movable parts in the disk drive, including the disk, spindle, actuator, read/write head, and air filter. For details, see Subsections 5.2.1 to 5.2.5.

The PCA contains the electrical circuits for the disk drive. The M262x disk drive has one PCA for drive control and read/write. For details, see Sections 5.3.

5.2.1 Disk

The DE contains a Winchester type disk with an outer diameter of 95 mm and an inner diameter of 25 mm. The M2622 has 4 disks, the M2623 has 5 disks, and the M2624 has 6 disks.

The head contacts the disk each time the disk rotation stops; the life of the disk is 10,000 contacts or more. Servo data is recorded on top disk.

Servo data recorded at the production line is read by a special servo head. For details, see Section 5.7.

5.2.2 Head

Figure 5.1 shows the read/write and servo head structures. The M2622 has 7 read/write heads, the M2623 has 9, and the M2624 has 11. These heads are raised from the disk surface as the spindle motor approaches the rated rotation speed.

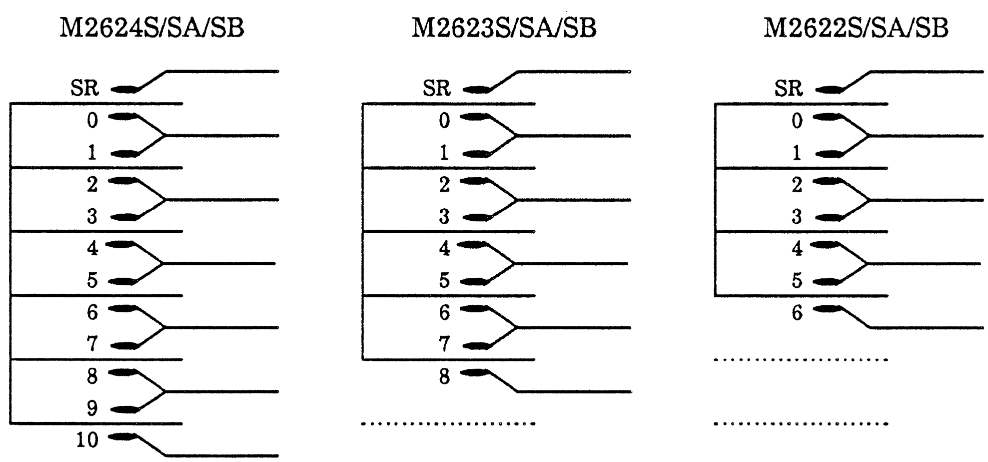


Figure 5.1 Head structure

5.2.3 Spindle

The spindle consists of a disk stack assembly and spindle motor. The disk stack assembly is activated by the direct drive DC spindle motor, which has a speed of 4,400 rpm $\pm 0.2\%$. The rotation speed is maintained by comparing the output frequency of the Hall element in the spindle and the standard frequency of the crystal oscillator.

5.2.4 Actuator

The actuator consists of a voice coil motor (VCM) and a head carriage. The VCM moves the head carriage along the inner or outer edge of the disk. The head carriage position is controlled by feeding back the servo information read by the servo head.

5.2.5 Air filter

There are two types of air filters: a breather filter and a circulation filter.

The breather filter makes an air in and out of the DE to prevent unnecessary pressure around the spindle when the disk starts or stops rotating. When disk drives are transported under conditions where the air pressure changes a lot, filtered air is circulated in the DE.

The circulation filter cleans out dust and dirt from inside the DE. The M2266S/H drive cycles air continuously through the circulation filter through an enclosed loop air cycle system operated by a blower on the rotating disk.

5.3 Circuit Configuration

Figure 5.2 shows the intellighent disk drive (IDD) circuit configuration.

(1) Read/write circuit

In the read/write function, LSI chips and head ICs are used to prevent external noise from causing errors and to improve data reliability. The read/write circuit contains a VFO and a 1/7 RLL code modulator/demodulator. The read/write circuit also contains a synthesizer to record data in the constant density recording format.

(2) Servo circuit

The position and speed of the voice coil motor are controlled by 2 closed-loop servo using the servo information recorded on the servo side. The servo information is an analog signal converted to digital for processeing by a digital signal processor (DSP) and then reconverted to an analog signal for control of the voice coil motor. The DSP adds the servo data on the data side to that on the servo side, to position each head tracks.

(3) Spindle motor driver circuit

The DSP makes the spindle motor driver circuit compare the frequency output from the Hall element of the motor with the frequency obtained by dividing the crystal oscillator frequency and control the motor speed by pulse-width modulation (PWM).

(4) Controller circuit

Major functions are listed below.

- Data buffer (four-segment buffer, 60 KB/segment)
- SCSI protocol control and data transfer control
- Sector format control
- ID registration
- SERDES
- ECC
- Error recovery and self-diagnosis

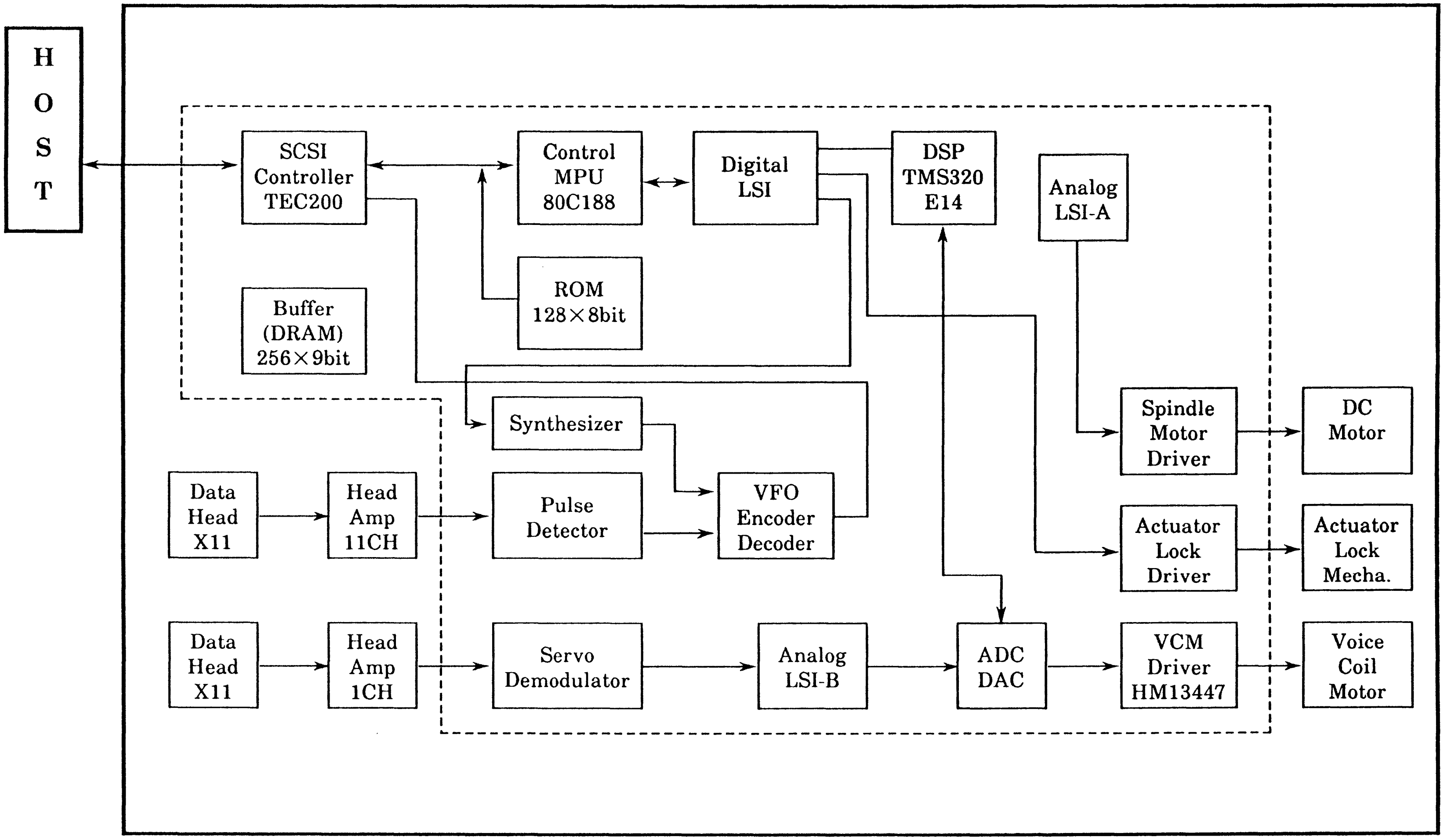


Figure 5.2 Circuit configuration

5.4 Power-on Sequence

Figure 5.3 describes the operation sequence of the IDD at power-on. The outline is described below.

① After the power is turned on, the IDD executes the MPU bus test, internal register read/write test, and work RAM read/write test. If self-diagnosis terminates normally, ② is followed.

② If the motor start-mode setup pin of the IDD is jumpered (default setting), the IDD starts the spindle motor immediately. If the setup pin is open, the IDD starts the spindle motor when the host issues the START UNIT command.

③ The IDD executes self-diagnosis (data buffer read/write test) after enabling response to the SCSI bus.

④ After confirming that the spindle motor has reached rated speed, the IDD releases the heads by applying current to the solenoid of the actuator lock mechanism. This unlocks the heads which are parked at the inner circumference of the disks.

⑤ The IDD positions the heads onto the innermost reference cylinder (cylinder 1436).

⑥ The IDD executes self-calibration. This collects data for calibrating off-tracks and mechanical external forces applied to the actuator.

⑦ The drive becomes ready. The host can issue commands.

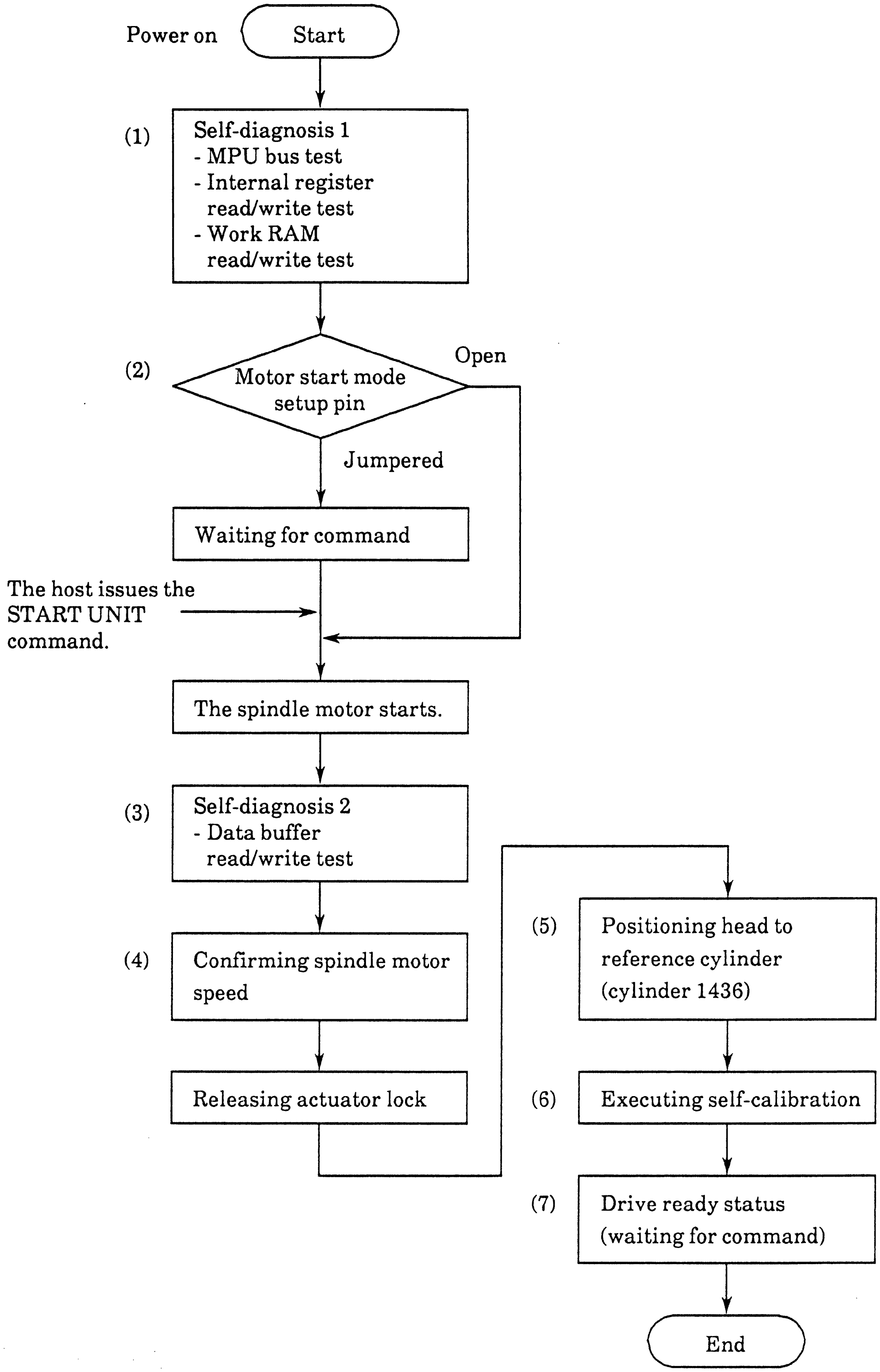


Figure 5.3 Power-on IDD operation sequence

5.5 Self-calibration

The IDD occasionally performs self-calibration in order to sense and calibrate mechanical external forces on the actuator, data head off-tracks against the servo head, and spindle revolution axis eccentricity. This enables precise seek and read/write operations.

5.5.1 Self-calibration contents

(1) Sensing and compensating for external forces

The actuator suffers from external forces due to the FPC forces and winds accompanying disk revolution. The external forces vary with the disk drive and the cylinder where the head is positioned. To execute stable fast seek operations, external forces are occasionally sensed.

The disk is divided into 14 areas from the innermost to the outermost circumference. The head is positioned sequentially on the representative cylinders of all areas. The firmware of the drive senses and stores the value of the actuator motor drive current required to keep the head on track. This includes the current offset in the electronic circuit system.

The forces are compensated by adding the sensed value to the current value during execution of normal seek operation. The current value is calculated from the revolution deviation.

(2) Sensing and compensating off-tracks and eccentricity

Off-tracks may be caused between the servo head and the read/write heads or the spindle revolution axis may be eccentric mainly due to mechanical temperature fluctuations. They are occasionally sensed to ensure stable read/write operation.

To sense off-tracks and eccentricity, data side servo data is written beforehand in the special cylinder outside the data area of each head.

For sensing, the head is positioned to the special cylinder, and the firmware reads the data side servo data of each head. The firmware reads 32 data items per revolution, averages the four consecutive values, and stores eight offset eccentricity data items per revolution. This process is repeated for each head.

For compensation, offset eccentricity data is fetched for the head relative to the sector specified by the host during normal on-track control. The data is used as the target position in controlling servo head positioning. Likewise, the servo head position is controlled to generally follow an offset and eccentric zig-zag route. Thus the data side head is positioned to the center of the data track and enables stable reading and writing.

5.5.2 Execution timing of self-calibration

Self-calibration is executed when:

① The power is turned on.

② The IDD receives the REZERO UNIT command from the host.

③ The self-calibration execution timechart of the IDD specifies self-calibration. The IDD performs self-calibration according to the timechart based on the time elapsed from power-on. The timechart is shown in Table 5.1. After power-on, self-calibration is performed about every five minutes for the first 30 minutes, about every 10 minutes for the second 30 minutes, and about every 30 minutes after that.

Table 5.1 Self-calibration execution timechart

Time elapsed after power-on	
About 5 minutes About 10 minutes About 15 minutes About 20 minutes About 25 minutes About 30 minutes	(About every 5 minutes)
About 40 minutes About 50 minutes About 60 minutes	(About every 10 minutes)
About 90 minutes About 120 minutes About 150 minutes . . .	(About every 30 minutes)

5.5.3 Command processing during self-calibration

If the IDD receives a command execution request from the host while executing self-calibration according to the timechart, the IDD terminates self-calibration and starts executing the command. In other words, if a disk read or write service is necessary, the IDD positions the head to the track requested by the host, reads or writes data, and restarts calibration.

This enables the host to execute the command without waiting for a long time, even when the IDD is performing self-calibration. The command execution wait time is about 100 ms or less.

5.6 Read/write Circuit

The read/write circuit consists of the head IC in the DE, the write circuit, the read circuit, and the write frequency variable circuit. Figure 5.4 is a block diagram of the read/write circuit.

5.6.1 Head IC

The head IC (M52848FP) is mounted inside the DE. The head IC consists of an 11-channel preamplifier and a write current driver and senses a write error. Each channel is connected to each data head. The head IC switches the heads by the head select signals (HS0 to 3). The IC switches the write current values by write current select signals (WC0/1). The IC generates a write error sense signal (WUS) when a write error occurs due to head short-circuit or head disconnection.

5.6.2 Write circuit

The write data is converted into NRZ data (WDT) and sent to the write circuit with the write clock (WCLK). The NRZ write data is then converted into 1/7 RLL code by the encoder circuit, and the data is written onto the media.

(1) 1/7 RLL encoder

The drive uses the 1/7 RLL recording format. The 1/7 RLL encoder converts two bits of NRZ data into three bits of 1/7 RLL code. Table 5.2 describes the rules. In the 1/7 RLL code, one to seven /0's are inserted between two '1' code bits.

Assuming the bit cycle of the data is t, the minimum code bit cycle is 4t/3 to 16t/3 for all input data. Figure 5.5 shows an example of converting 1/7 RLL codes

Table 5.2 1/7 RLL code set

Previous Code Word Last Bit Z_3	NRZ data bit				1/7 RLL code bit		
	Present		Next				
	Y_0	Y_1	Y_2	Y_3	Z_0	Z_1	Z_2
0	1	0	0	X	1	0	1
0	1	0	1	X	0	1	0
0	1	1	0	0	0	1	0
0	1	1	*	*	1	0	0
0	0	0	0	X	0	0	1
0	0	0	1	X	0	0	0
0	0	1	0	X	0	0	1
0	0	1	1	X	0	0	0
1	0	0	0	X	0	0	1
1	0	0	1	X	0	1	0
1	0	1	0	0	0	1	0
1	0	1	*	*	0	0	0

X : Don't Care
* : Not All Zeros

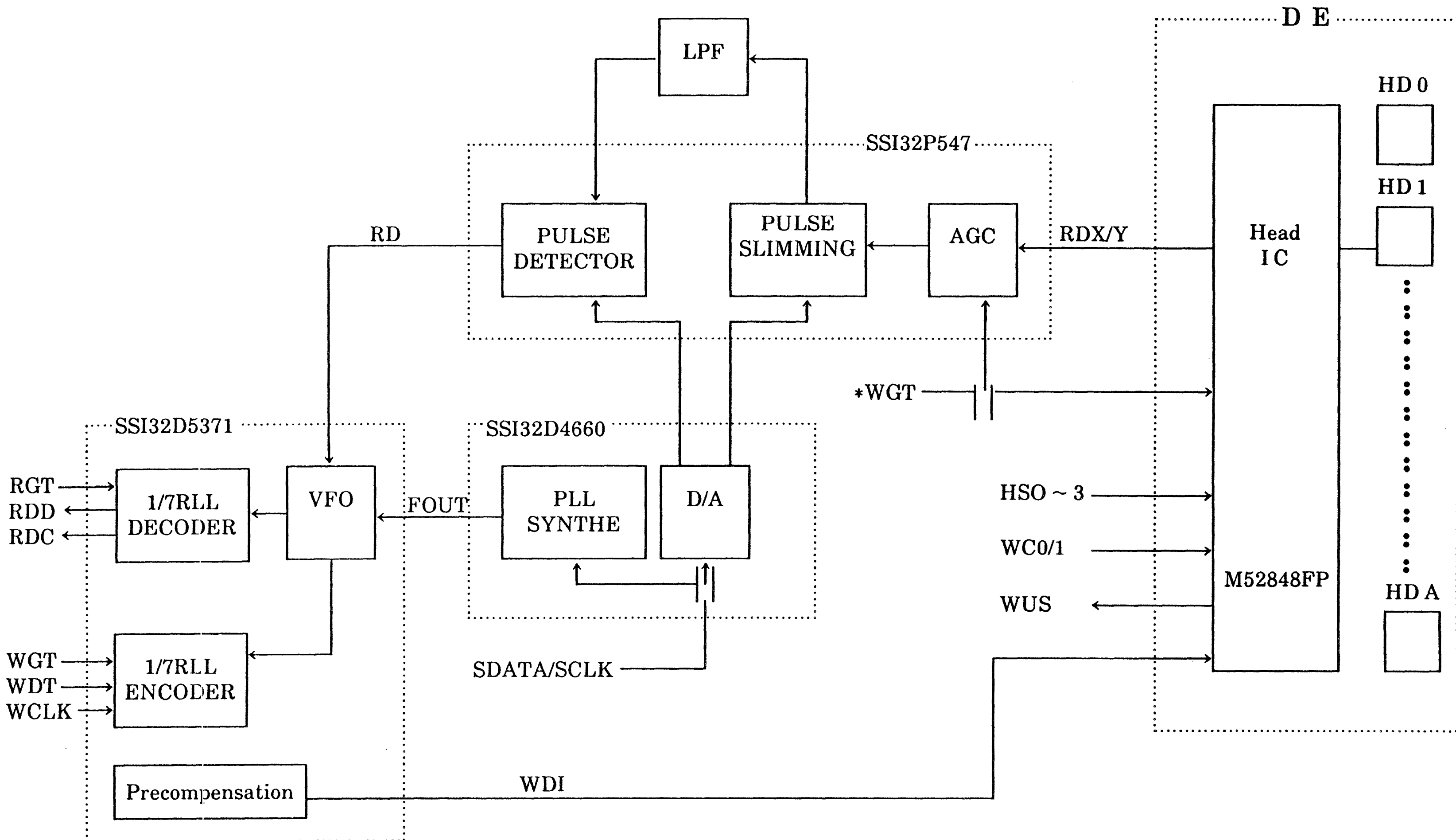


Figure 5.4 Read/write circuit

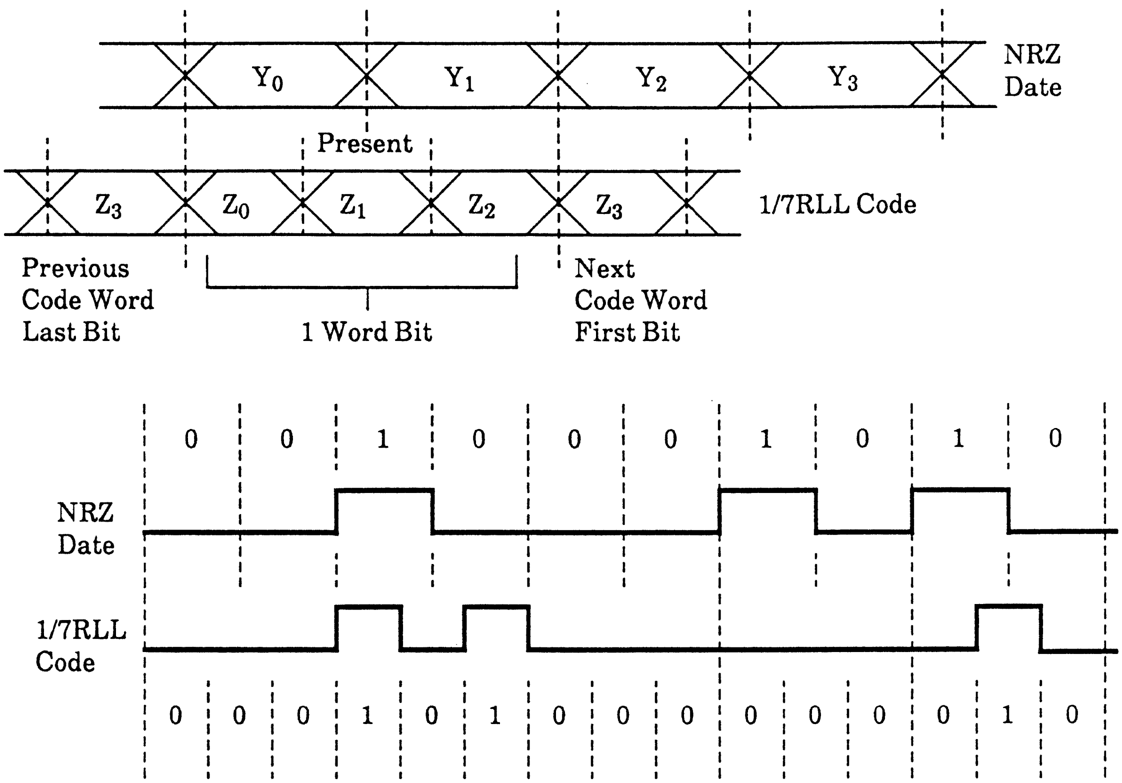


Figure 5.5 1/7 RLL code conversion

(2) Write precompensation

Write precompensation compensates, during a write process, for peak shifts generated in the recording media. Table 5.3 shows the write precompensation algorithm.

Table 5.3 Write precompensation algorithm

BIT	BIT	BIT	BIT	BIT	COMPENSATION
n−2	n−1	n	n+1	n+2	BIT n
1	0	1	0	1	NONE
0	0	1	0	0	NONE
1	0	1	0	0	EARLY
0	0	1	0	1	LAST

LATE: Bit n is time shifted (delayed) from its nominal time position towards the bit n+1 time position.
EARLY: Bit n is time shifted (advanced) from its nominal time position towards the bit n-1 time position.

5.6.3 Read circuit

The AGC amplifier regulates the output from the head IC to a constant level. The output then passes through the equalizer, LPF, and pulse detector circuits, and is converted to logic signals (RD). The VFO circuit generates clock signals in synchronization with the RD signals, and the 1/7 decoder circuit converts the clock and RD signals to NRZ data and transfers it to buffer memory.

(1) AGC amplifier

The AGC amplifier automatically regulates the output amplitude to a constant value even when the input amplitude level fluctuates. The AGC amplifier output is maintained at a constant level even when the head output fluctuates due to the head characteristics or outer/inner head positions.

(2) Equalizer circuit

The equalizer circuit shapes the head output waveforms and reduces the peak shift caused by waveform interference. The equalizer circuit also regulates the head output value, which fluctuates due to frequency differences, to a constant value to increase resolution. The circuit is also called a pulse slimming circuit or cosine equalizer circuit. Figure 5.6 is the block diagram and I/O waveforms of the equalizer circuit.

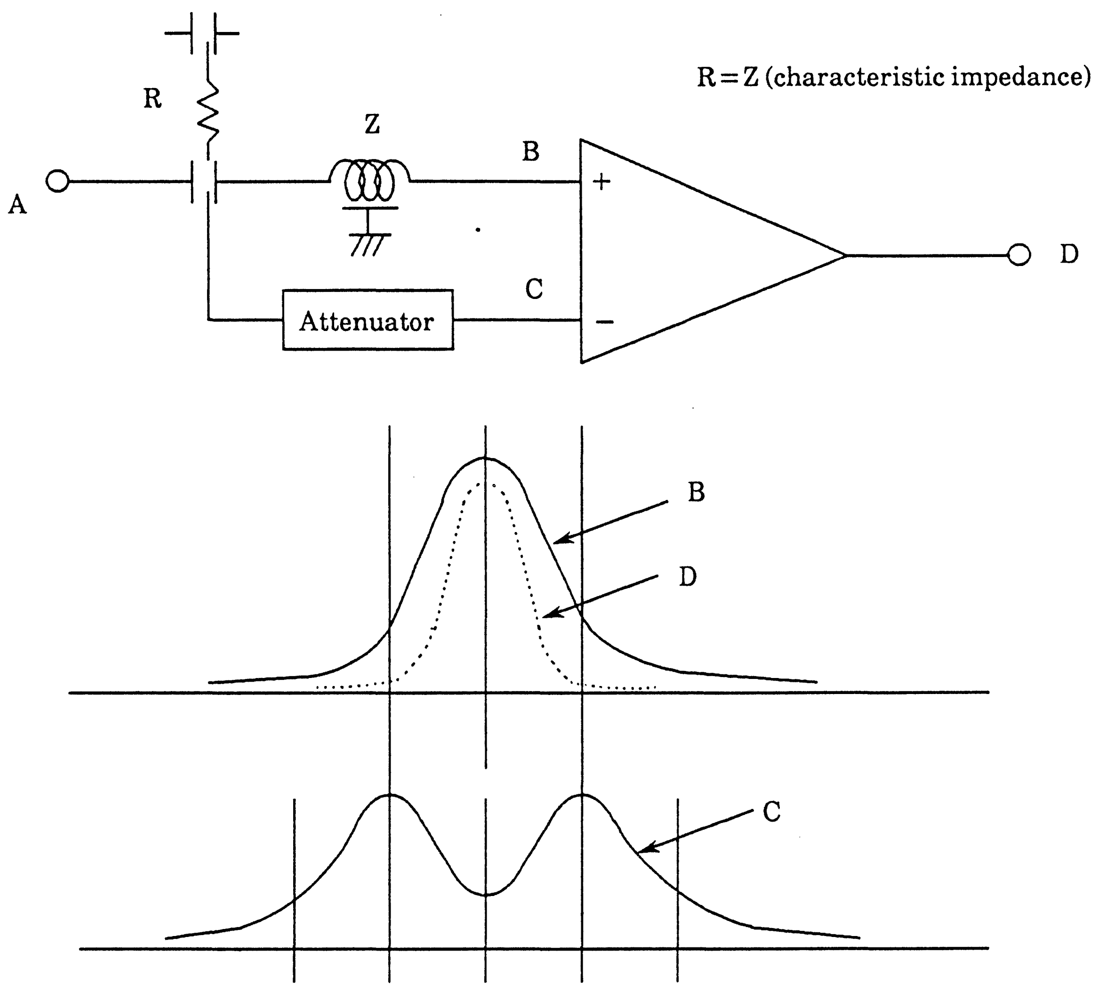


Figure 5.6 Equalizer block diagram and I/O waveforms

(3) LPF circuit

The low pass filter (LPF) circuit eliminates unnecessary high frequencies. The LPF circuit can connect up to four circuits of different filter cut-off frequencies, which can be switched according to frequency band.

(4) Pulse detector circuit

The pulse detector circuit detects the peaks of reproduced waveforms by the differentiator and zero-cross comparator circuits, and detects only peaks that are over a slice level of about 50% against the reproduced waveforms.

Therefore, the peak intervals in the reproduced waveforms of the analog signals are converted to pulse intervals of the logic signals (RD output). Figure 5.7 is the block diagram and I/O waveforms of the pulse detector circuit.

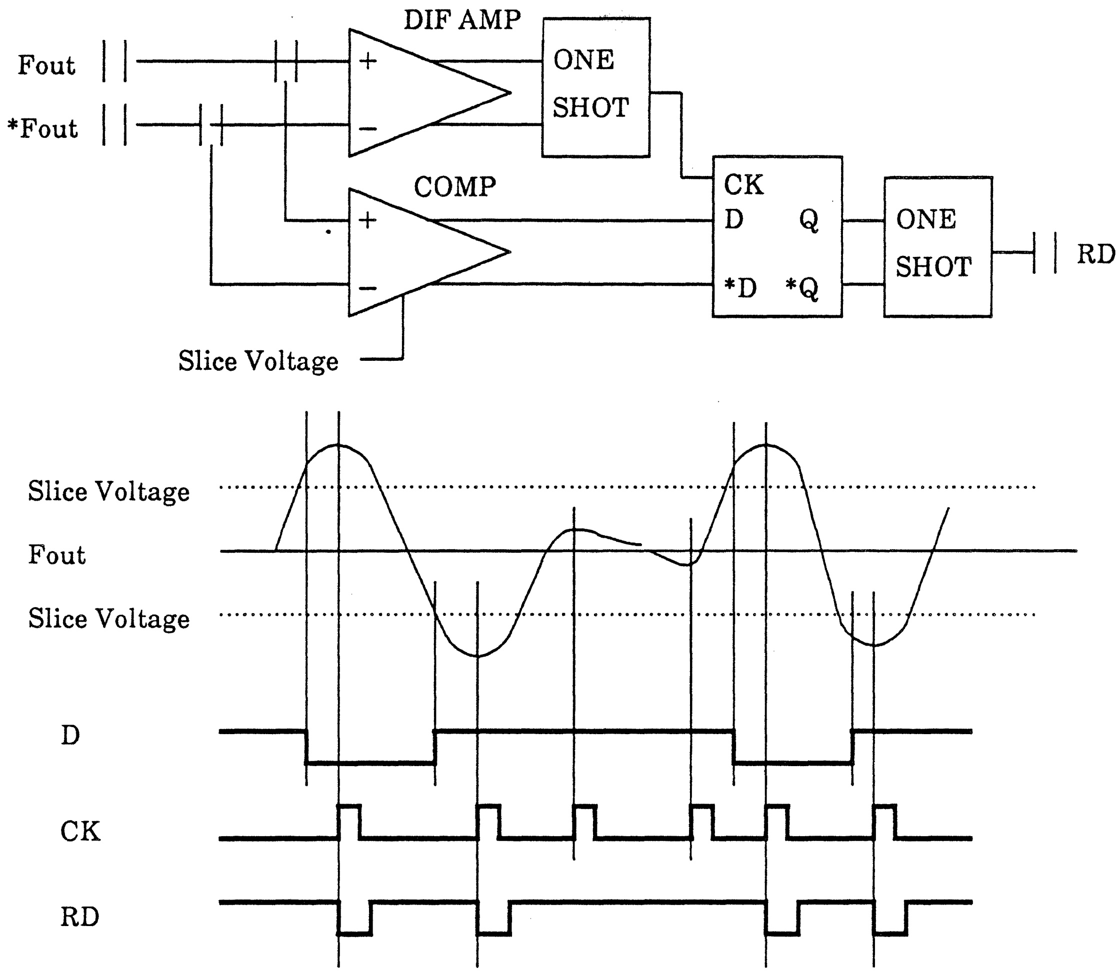


Figure 5.7 Pulse detector block diagram and I/O waveforms

(5) VFO circuit

The VFO circuit generates clocks in synchronization with the output (RD) of the pulse detector circuit. To write data, the VFO circuit generates clocks in synchronization with the clock signals from a synthesizer.

(6) 1/7 RLL decoder

The 1/7 RLL decoder converts the data recorded in the 1/7 recording format (described in Table 5.2) to NRZ data.

5.6.4 Write modulation frequency variable circuit

The drive uses constant density recording to increase recording density. This is different from the conventional method of recording data with a fixed write modulation frequency. In the constant density recording method, a cylinder is divided into zones and the write moduration frequency is varied so that the recording density of the inner cylinder of each zone is constant. The drive divides the cylinder into four zones to vary the write modulation frequency. Table 5.4 describes the write modulation frequency and recording density (BPI) of each zone.

Table 5.4 Write modulation frequency and recording density (BPI) of each zone

Zone	I	II	III	IV
Cylinder	0000 ~ 0606	0607 ~ 0847	0848 ~ 1157	1158 ~ 1438
1F (MFRPS)	4.573171	4.317073	4.050000	3.658537
2F (MFRPS)	18.292683	17.268293	16.200000	14.634146
BPI	38,212	40,046	43,771	46,383

The MPU transfers the write frequency setup data (SDATA/SCLK) to the write frequency variable circuit (SSI32D4660) to change the write modulation frequency. The write modulation frequency variable circuit contains a digital-to-analog (D/A) converter to change the slice levels and the attenuator values of the equalizer circuit for each zone.

5.7 Servo Control

Servo control is performed by the servo control circuit and the firmware in the digital signal processor (DSP).

The actuator motor and the spindle motor are submitted to servo control. The actuator motor is controlled for moving and positioning the head to the track containing the desired data. The spindle motor is controlled to turn the disk at a constant velocity or in synchronization with the synchronization signals.

The actuator motor is controlled according to the servo data that is written on the servo side beforehand (see Subsection 5.7.2). Off-track condition are sensed by periodically executing calibration to position each data head at the center of data tracks, based on the servo data on the data side (see Subsection 5.7.3).

5.7.1 Servo control circuit

Figure 5.8 is the block diagram of the servo control circuit. The following describes the functions of the blocks:

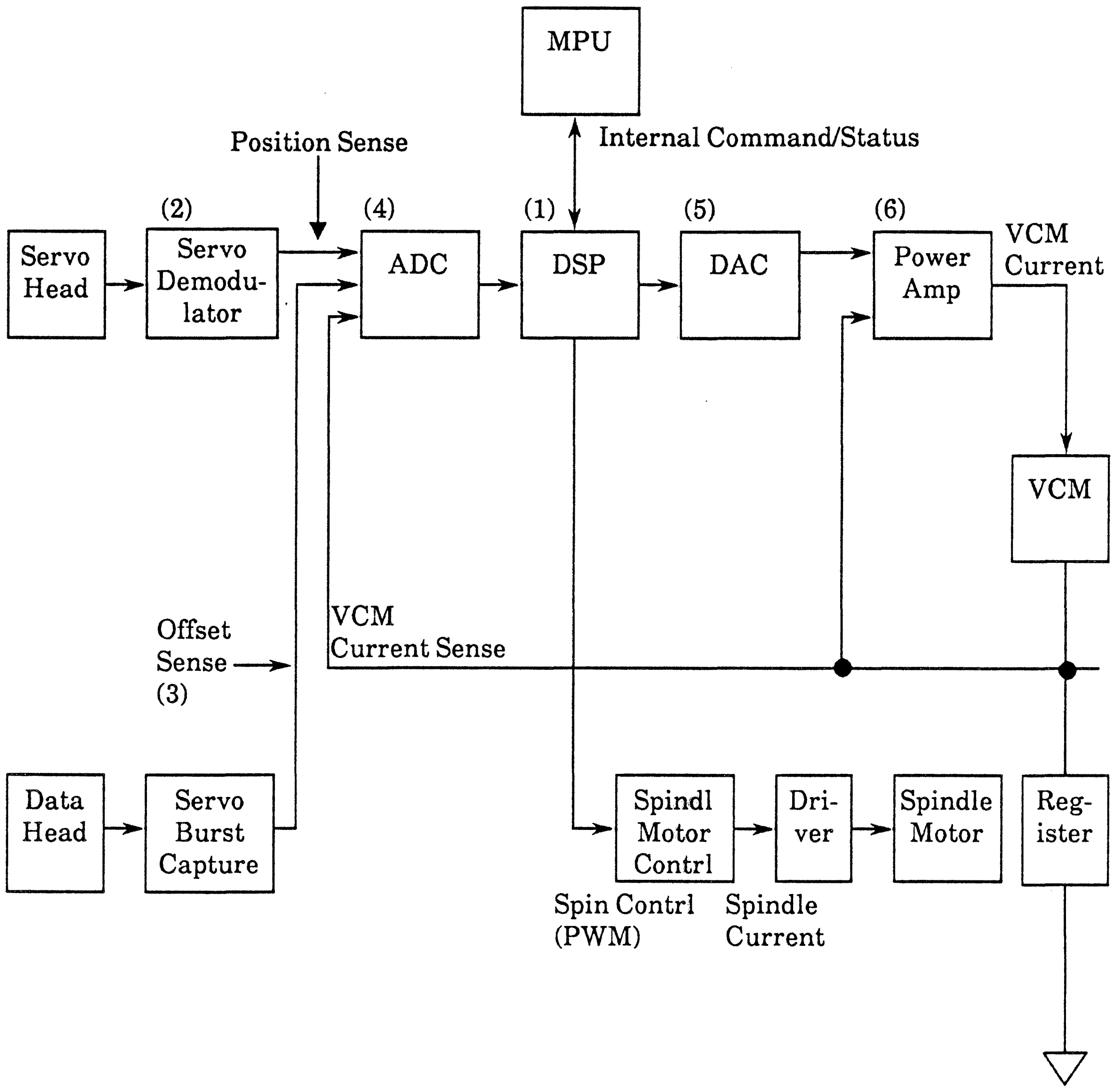


Figure 5.8 Block diagram of servo control circuit

(1) Digital signal processor (DSP)

The DSP operates according to instructions from the microprocessor unit (MPU). In other words, the DSP starts the spindle motor, moves the heads to the reference cylinders, seeks the specified cylinder, and executes calibration according to the internal commands between the MPU and DSP as defined in the IDD. The DSP reports completion of internal commands and errors to the MPU.

The major internal commands are listed below.

a. Spindle motor start

Starts the spindle motor and accelerates it to normal speed when power is applied.

b. Move head to reference cylinder

Drives the VCM to position the head at the innermost reference cylinder (cylinder 1436). The logical initial cylinder is at the outermost circumference (cylinder 0). If the host issued the REZERO UNIT command, the DSP, positions the head to the innermost reference cylinder, then performs seek to the outermost cylinder (cylinder 0).

c. Seek to specified cylinder

Drives the VCM to position the head to the specified cylinder.

d. Calibration

Senses and stores the thermal offset of each data side against the servo side and the mechanical forces on the actuator.

(2) Servo demodulator

The servo demodulator receives signals from the servo surface and converts them into position signals. The servo head outputs the servo signals as illustrated in Figure 5.9. Two-phase position signals (POSN and POSQ) are generated by the AGC, synchronization pulse detector, VFO, peak hold, and differential amplifier circuits in the servo demodulator circuit. The difference between the amplitudes of servo signals ODD1 and EVEN1 is the POSN signal. The difference between the amplitudes of ODD2 and EVEN2 is the POSQ signal. Likewise, two position sense signals (POSN and POSQ), repeated for every four cylinders, are obtained.

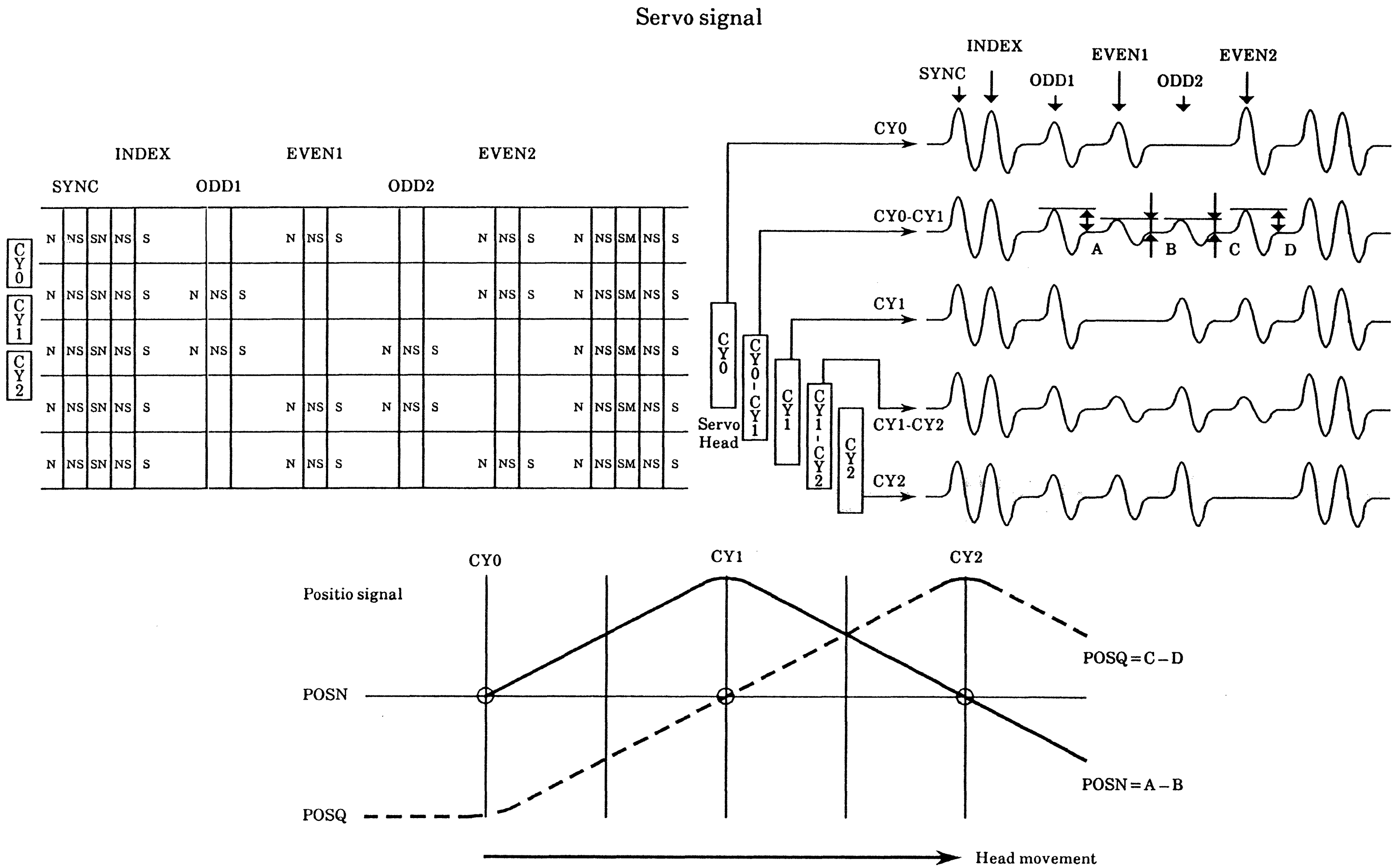


Figure 5.9 Servo signal to position sense signal conversion

(3) Servo burst capture circuit

The servo burst capture circuit outputs signals that indicate the scale of offset from the servo data of the special cylinder on the data surface. AGC, SERVO A, and SERVO B burst signals are output from the data surface servo signals via the data head as shown in Figure 5.10. The servo signals are converted into offset sense signals by the AGC, peak hold, and differential amplifier circuits in the servo burst capture circuit. First, the amplitudes of the SERVO A and SERVO B signals are captured by holding the signal peaks at the timing of the HOLD A and HOLD B signals. At that time the AGC circuit is in hold mode. The difference between the peak-held signals is obtained in the differential amplifier and is output as the offset sense signal. The offset signal is then read by the DSP at the timing of the ADC TIMING signal via an analog-to-digital (A/D) converter. In Figure 5.10, an example with no offset is illustrated on the left-hand side and an example with offset is illustrated on the right-hand side.

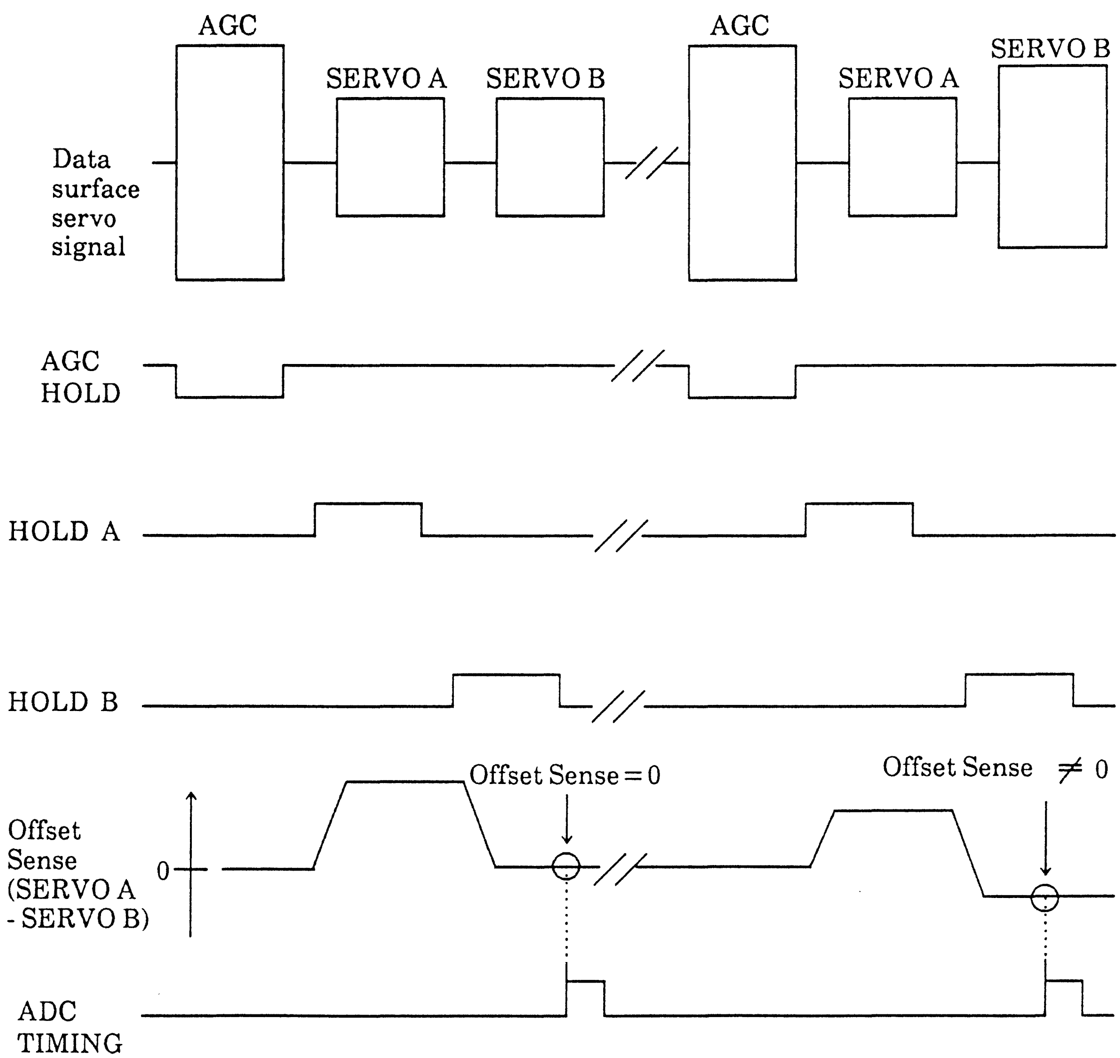


Figure 5.10 Conversion data surface servo signal to offset sense signal

(4) A/D converter (ADC)

The A/D converter (ADC) receives the position sense signals, offset sense signals, and VCM current sense signals, converts them to digital, and transfers the digital signal to the DSP.

(5) D/A converter (DAC)

The D/A converter (DAC) converts the VCM drive current value (digital value) calculated by the DSP into analog values and transfers them to the power amplifier.

(6) Power amplifier

The power amplifier feeds currents, corresponding to the DAC output signal voltage to the VCM.

(7) Spindle motor control circuit

The spindle motor control circuit controls the spindle motor. This circuit decodes the Hall signal from the spindle motor, selects the drive transistor for later stages, and controls the current by turning on and off the transistor according to the spindle control signals (PWM) output from the DSP. This circuit also senses motor overcurrent and limits motor currents.

(8) Driver circuit

The driver circuit receives signals from the spindle motor control circuit and feeds currents to the spindle motor. This circuit consists of six FETs.

(9) VCM current sense resistor

This resistor converts the VCM current into voltage to control power amplifier currents and supplies information about the VCM drive current values to the DSP via the ADC.

5.7.2 Servo surface format

The actuator motor (VCM) positions the head to the target cylinder. The actuator motor is controlled according to the servo data, which is recorded on the servo furface beforehand. The servo surface are on the uppermost surface of the disk stack assembly (opposite to the head 0 side).
The servo data on the servo surface consists of combinations of servo signals Odd1, Odd2, Even1, and Even2. Figure 5.11 describes the physical layout of the servo tracks. The five areas indicated by ① to ⑤ in Figure 5.11 are described below.

① Dead space (DS)

The dead space is at the innermost part of the disk. The head is in contact with the disk in this space when the actuator is locked or when the spindle starts turning or stops.

② Inner guard band 2 (IGB2)

This area is between the dead space and inner guard band 1. This area is used with IGB1 to position the head onto the innermost reference cylinder (cylinder 1436) (this is initialization). IGB2 is also used to sense whether the actuator is at an inner position, out of the ordinary seek operation range.

③ Inner guard band 1 (IGB1)

This area is used with IGB2 to position the head onto the innermost reference cylinder (cylinder 1436) (this is initialization). IGB1 is also used to sense whether the actuator is at an inner position, out of the ordinary seek operation range.

④ Servo zone

This zone corresponds to the data recording portion of the data surface used by the user. Normal seek operations are performed inside this zone.

⑤ Outer guard band (OGB)

The outer guard band is at the outermost position of the disk. OGB is used to sense whether the actuator has exceeded the normal seek operation range.

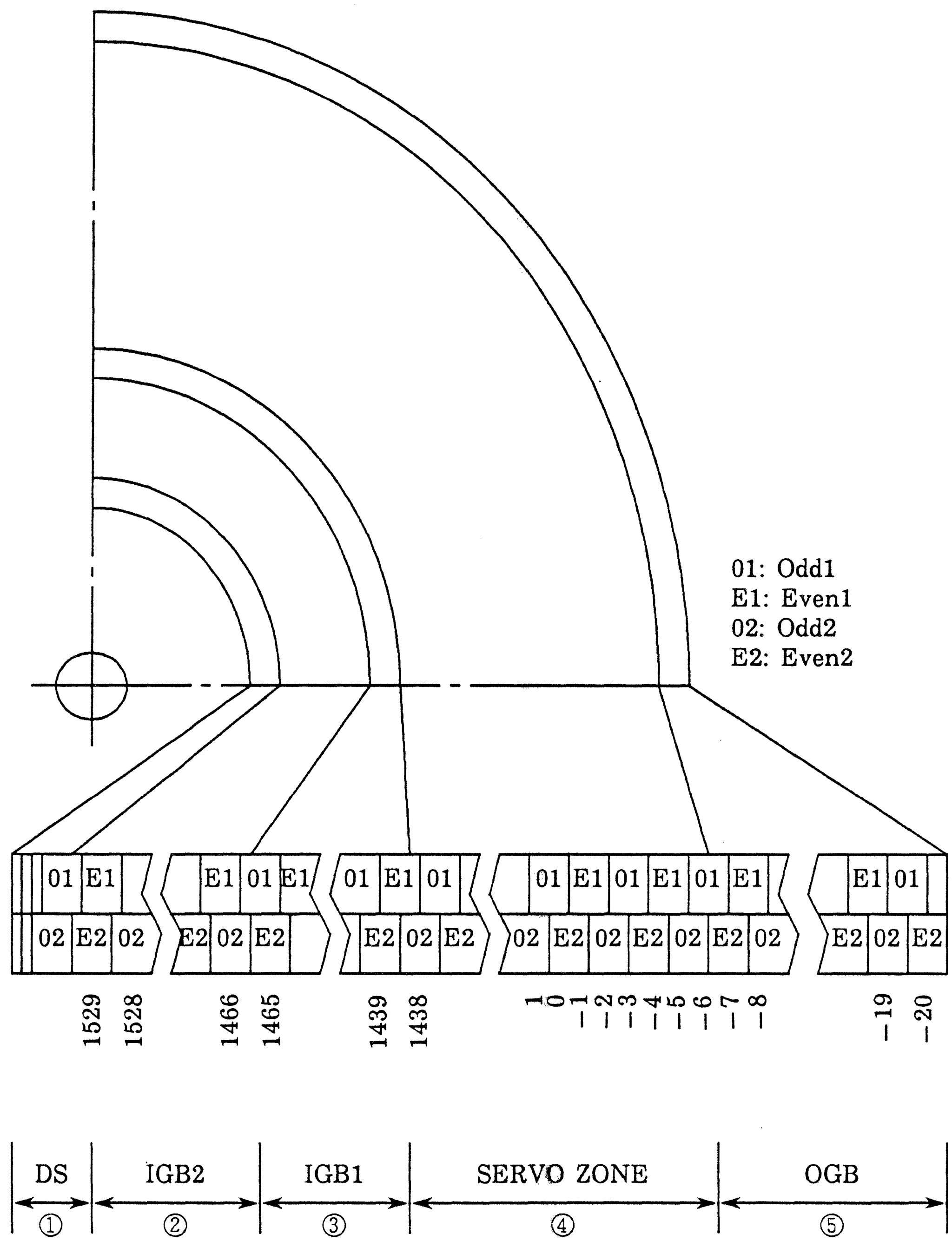
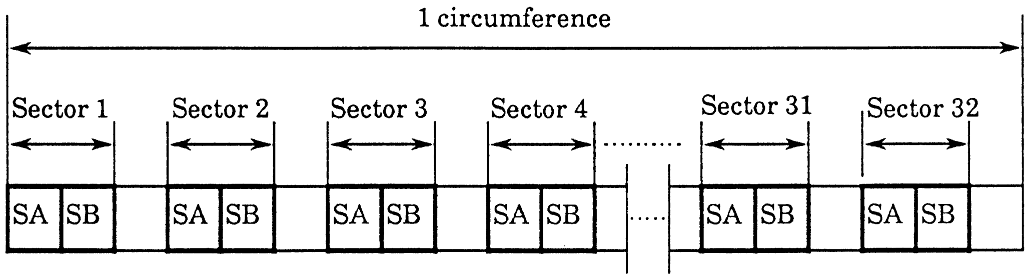


Figure 5.11 Servo surface format

5.7.3 Servo surface format

To sense offset of the data surface against the servo surface, servo data is written earlier on each data surface in the outer and inner tracks outside the data area. The offset is sensed by positioning the heads on data surface onto these special tracks during calibration to read the servo data on the data surface.

As shown in Figure 5.12, the servo format of the special track on the data surface consists of pairs of signals called servo A and servo B. The offset amount is sensed by the difference between the amplitudes of servo A and servo B signals. There are 32 pairs of servo A and servo B in a circumference.



SA: Servo A
SA: Servo B

Figure 5.12 Servo format of data surface special cylinder

5.7.4 Actuator motor control

The voice coil motor (VCM) is controlled by feeding back the servo data recorded on the servo surface. This control is executed by the firmware incorporated in the DSP. The DSP fetches the position sense data of the servo head at a constant interval of sampling time, executes calculation, and updates the VCM drive current.

The servo control of the actuator includes the operation to move the head to the reference cylinder, the seek operation to move the head to the target cylinder to read or write data, and the track-following operation to position the head onto the target track.

(1) Operation to move the head to the reference cylinder

The DSP moves the head to the reference cylinder upon receiving internal commands from the MPU, when the power is turned on or when the host issues the REZERO UNIT command. The reference cylinder is at the innermost circumference (cylinder 1436). The logical initial cylinder is at the outermost circumference (cylinder 0). In response to the REZERO UNIT command, the head is first positioned at the reference cylinder inside the drive then positioned at the outermost cylinder (cylinder 0) by seek operation.

a. When power is applied the heads are moved from the inner circumference shunt zone to the normal servo data zone in the following sequence:

   1. Micro current is fed to the VCM to press the head against the inner circumference.

   2. The actuator lock mechanism solenoid is energized to release the actuator lock.

   3. Micro current is fed to the VCM to move the head toward the outer circumference.

   4. Sequences 5 to 9 follow.

b. After power is turned on, the following sequence is performed to move the head to the reference cylinder:

   5. The head is moved slowly toward the inner circumference at a constant speed.

   6. IGB1 (inner guard band 1) is detected. Movement at a constant speed continues.

   7. Upon detection of IGB2 (inner guard band 2), the movement is reversed. The head is slowly moved toward the outer circumference at a low speed.

   8. IGB1 is detected. The movement toward the outer circumference continues.

   9. If the head is detected as having reached the normal servo zone, the head is stopped at the second cylinder (cylinder 1436) from there. Track following control starts.

(2) Seek operation

Upon a data read/write request from the host, the MPU confirms the necessity of access to the disk. If a read or instruction is issued, the MPU uses an internal command to instruct the DSP in the servo control circuit to seek the desired track.

Upon reception of this command, the DSP feeds the VCM current via the D/A converter and power amplifier to move the head. For each sampling timing, the VCM drive current is determined by calculating the difference (speed error) between the specified target speed and the speed estimated from the position sense data. The calculation is digitally executed by the firmware. When the head arrives at the target cylinder, the track is followed.

(3) Track following operation

Except during head movement to the reference cylinder and seek operation, the DSP does track following control. To position the data head at the center of a track, the DSP feeds micro current to the VCM. For each sampling time, the VCM drive current is determined by filtering the position difference between the target position and the position clarified by the detected position sense data. The filtering includes servo compensation and a notch filter that corresponds to the oscillation frequency of the mechanism. These are digitally controlled by the firmware.

5.7.5 Spindle motor control

The spindle motor has three Hall sensors to sense motor angle position. The spindle motor control circuit decodes the signals output from the Hall sensor, selects two out of six FET devices, and decides the phase and direction to feed the current out of the three phases of the motor. The DSP calculates the amount of drive current and transfers the value to the motor control circuit as a PWM signal. The motor control circuit then turns the FET devices on and off according to the PWM duty cycle. The PWM frequency is 24 kHz. The firmware detects revolution using the Hall index signals that are generated from one of the Hall signals (one Hall index signal pulse is generated per revolution).

The spindle motor control has three modes: start mode, revolution control mode, and spindle sync control mode.

(1) Start mode

When power is applied, the spindle motor is started in the following sequence:

1. After the power is turned on, the MPU issues the spindle motor start command to the DSP.

2. The DSP sets the PWM signal duty cycle to 100%.

3. The spindle motor control circuit starts feeding current to the motor.

4. The current limit circuit in the spindle motor control circuit feeds current, keeping the current under the limit value. The speed gradually increases.

5. When the DSP detects that the motor has reached rated speed, the DSP reports the completion of the start sequence to the MPU. Then the DSP enters the speed control mode.

(2) Speed control mode

After the start mode, the DSP enters the speed control mode. In this mode, the DSP maintains rated motor speed. This is performed by speed control firmware. The firmware reads the clock counter values at the timing of the Hall index signals (detection signals generated one pulse per revolution) and measures the time required for one revolution of the motor. The firmware then compares this time with the reference time to obtain the amount of error. The error is filtered and output as a PWM signal.

(3) Spindle sync control mode

The revolution control mode is switched to the spindle sync control mode in the sequence below:

1. The host issues a command that specifies the spindle sync mode (master drive mode or slave drive mode).

2. The MPU issues an internal command to the DSP.

3. The DSP exits the revolution control mode and enters the spindle sync control mode.

   Spindle sync is controlled to synchronize the reference synchronization signals with the index signals. If the drive is the master, the reference synchronization signals are divided signals of the crystal oscillator output in the drive. If the drive is the slave, the reference synchronization signals are entered from outside. The index signals are the reference for the starting data format, and are marked magnetically on the servo disk. One index signal pulse is output per revolution. The spindle sync control includes coarse and fine controls.

4. The coarse control is performed to shorten the time between the start and establishment of spindle synchronization. The DSP finely adjusts the speed within the range where normal read/write operation can be maintained if the phase difference between the reference synchronization signals and index signals does not satisfy the standard. In other words, the DSP accelerates or decelerates the motor to minimize the phase difference. The fine control mode starts when the phase difference is within the standard.

5. Fine control maintains the phase difference within the specified value. The firmware performs fine control by the position control. The firmware detects the phase difference, compensates for the servo, then outputs the calculation results as PWM signals to maintain spindle synchronization.

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