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NRW-FPGA-Based I&C System Qualification Project

User's Manual

Title: OPRM Unit User's Manual

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OPRM Unit User's Manual

NOTE

- Carefully read and fully understand this manual before operating the product.
- Retain this manual for future reference. (After reading this manual, store it in a handy location for easy reference whenever necessary.)
- Make sure to attach this manual to the product upon relocation and resale and provide it to the end user.

Introduction

Thank you for purchasing Toshiba Oscillation Power Range Monitor (OPRM) unit, HNU1200, used for the Power Range Neutron Monitor (PRNM) of Advanced Boiling Water Reactor (ABWR) application.

This manual outlines the product functions and provides instructions for operation, maintenance and troubleshooting, as well as safety precautions for optimized service.

This manual is organized in the following sections:

SAFETY PRECAUTIONS – Describes the safety precautions that are important information to protect users and other personnel from physical injury and avoid property damages, and to ensure safe and correct use of the product.

WARRANTY AND DISCLAIMER – Describes the warranty and disclaimer of the product.

CONTACT INFORMATION – Describes the contact information for inquiries and maintenance requests.

Section 1: General – Describes the purpose and application, configuration, specifications including input and output interface and Human-Machine Interface (HMI), power supply requirements and environmental conditions for the product.

Section 2: Acceptance, Storage and Installation of Product – Describes the procedures for acceptance, storage, and installation of the product.

Section 3: Prohibitions and Precautions for Handling – Describes the prohibitions and precautions for handling the product.

Section 4: Operation – Describes the preparation for operation including parameter setting and power activation, normal operation using HMI, setpoint adjustment operation using HMI, and emergency operation of the product.

Section 5: Functional Description – Describes the functions of the product including the safety functions and self-diagnosis functions.

Section 6: Maintenance and Inspection – Describes the procedures for voltage adjustment, surveillance test using test functions, maintenance, replacement, cleaning, failure diagnosis, and troubleshooting of the product.

Section 7: Abbreviations – Describes the abbreviations used in this manual.

This manual is used with the instruction manual for each module mounted on this OPRM unit. Please refer to the instruction manual for each module when detailed information on module operation and maintenance is necessary.

This manual is intended for engineers and managers with basic knowledge on OPRM.

SAFETY PRECAUTIONS

Safety precautions, provided in this manual and on the product itself, are important information to protect users and other personnel from physical injury and avoid property damages, and to ensure safe and correct use of the product.

Before performing installation, operation, maintenance, and inspection of the product, make sure to carefully and thoroughly read this manual and appendices attached hereto to gain sufficient knowledge of the product, safety information, and precautions.

SAFETY PRECAUTIONS (continued)

Be sure to fully understand the meanings of safety signal words and alert symbols shown below before reading the main text of this manual, and observe all the instructions.

Signal Word Definition

Signal Word	Definition
⚠ **DANGER**	Indicates an imminently hazardous situation that, if not avoided, will result in death or serious injury *1.
⚠ **WARNING**	Indicates a hazardous situation that, if not avoided, could result in death or serious injury *1.
⚠ **CAUTION** *4	Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury *2, or property damage *3.
NOTICE	Instruction for action, operation, or posture for ensuring safety, and requirement for prevention of failure and functional (performance) decrease of the product. Indicates information or a company policy that relates directly or indirectly to the safety of personnel or protection of property, including instructions for action, operation, and posture to ensure safety, and preventive measures against malfunction and functional/performance degradation of the product.
NOTE	Indicates (supplementary) information that helps users apply specific techniques and procedures described in the text to their specific needs, which includes: - Precautions when the product is stored or not in use, - Instructions for actions, operations and posture to ensure safety, and - Preventive measures against malfunction and functional/performance degradation of the product. The information is to be provided in the "**NOTE**" box.

*1 Serious injury includes loss of eyesight, physical injury, high and low temperature burns, electric shock, bone fracture, poisoning and other conditions having aftereffects and/or requiring hospitalization or long-term hospital visits for recovery.

*2 Minor or moderate injury includes physical injury, burns, electric shock and other conditions that do not require hospitalization or long-term hospital visits for recovery.

*3 Property damage includes (direct, incidental, or) consequential damages associated with any damages to assets and materials.

*4 Instructions indicated by the signal word "**CAUTION**" may also lead to a serious consequence according to circumstances. Be sure to follow ALL the instructions provided herein.

SAFETY PRECAUTIONS (continued)

Symbol Definition

Symbol	Definition
 Attention	This symbol indicates "**DANGER**" "**WARNING**" or "**CAUTION**" (See the signal word definition provided above.) This symbol indicates the presence of a hazard. This symbol may be associated with a picture and/or message inside or nearby to indicate a specific situation.
 Prohibited Action	This symbol indicates a specific action prohibited. This symbol may be associated with a picture and/or message inside or nearby to indicate a specific situation.
 Mandatory Action	This symbol indicates a specific mandatory action. This symbol may be associated with a picture and/or message inside or nearby to indicate a specific situation.

SAFETY PRECAUTIONS (continued)

1. Setup (Transportation/Installation/Wiring)

⚠ WARNING

Connect to Ground

■ **Be sure to ground the equipment properly.**

Refer to the outline drawing of the system for grounding points.

Failure to follow these instructions could result in electric shock or fire.

No overvoltage/ overcurrent

■ **Do not apply voltage or current exceeding the rating provided in the specification to I/O terminals of the power source and signals.**

Failure to follow these instructions could result in fire and destruction of the equipment by overheat.

⚠ CAUTION

No disassembly/ modification

■ **Do not disassemble or modify the equipment and modules.**

Failure to follow the instruction could result in impairment of safety as well as malfunction and failure of the equipment.

■ **Avoid installation and storage under the following conditions.**

- High dust level
- Corrosive gas (such as SO_2 and H_2S) and inflammable gas
- Unacceptable level of vibration or shock
- Condensation due to drastic temperature change
- High or low temperatures deviated from installation conditions
- Vicinity of equipment that generates strong radio waves or magnetic/electric fields

Failure to follow the instruction could result in impairment of safety as well as malfunction and failure of the equipment

SAFETY PRECAUTIONS (continued)

2. Maintenance/Inspection (Daily Inspection and Periodic Inspection/Calibration)

⚠ WARNING

Power off

■ **Turn the power switch off before inspecting the terminal block, connector, or live part inside the equipment.**

Failure to follow the instruction could result in electric shock or physical injury.

Power off

■ **Turn off the power before mounting/dismounting modules, plugging/unplugging connectors and connecting the equipment.**

Failure to follow the instruction could result in electric shock and equipment failure.

⚠ CAUTION

Only qualified personnel

■ **Use only qualified personnel* who have received safety training for, maintenance, inspection and calibration.**

* Qualification requirements are in accordance with customer's standards.

Failure to follow the instruction could result in electric shock, physical injury, radiation exposure and failure of the equipment.

SAFETY PRECAUTIONS (continued)

⚠ CAUTION

Periodic maintenance/ inspection

■ **Perform periodic maintenance, inspection, and calibration.**

Failure to perform calibration at least once a year and to perform periodic inspection could result in oversight of equipment anomalies.

Periodic replacement of consumables / maintenance parts

■ **Replace consumables and maintenance parts periodically.**

Perform preventive maintenance (replacement of parts) to reduce equipment failures.

NOTICE

■ **Place a module removed from the unit on a conductive mat over a grounded table**

Failure to follow the instruction could result in static electricity damaging parts.

■ **Keep a module removed from the chassis unit in an antistatic bag.**

Failure to follow the instruction could result in failure of the equipment, since touching a module with an electrostatically charged hand may cause electrostatic breakdown.

SAFETY PRECAUTIONS (continued)

3. Replacement of Life-limited Parts

⚠ CAUTION	
 Check rating	■ **Check the rating of consumables before replacement including fuse, lamp, packing filter, etc., and replace them with new consumables with the same rating.** See the Electrical Cable Wiring Diagram and a yellow sticker on fuse holder attached to the equipment to check ratings of fuses and lamps.
 Power off	■ **Turn off the main power switch of the equipment before replacing fuses such as power fuse and protection fuse.** Failure to follow the instruction could result in electric shock and fire.

SAFETY PRECAUTIONS (continued)

4. Daily Operation

⚠ WARNING

Check power

CAUTION
Electric Shock

■ **Check that capacity, frequency, voltage, and regulation of the power supply comply with specifications of the equipment before use.**

Failure to follow the instruction could result in electric shock, physical injury and damage to the equipment.

Power off

Contact us

■ **Stop using the equipment, turn off the power, and then contact our service representative in case of abnormal rise in ambient/internal temperatures or failure of the equipment.**

Failure to follow the instruction could result in fire due to overheat.

⚠ CAUTION

Periodic replacement of consumables

■ **Replace consumables for the equipment periodically.**

Failure to follow the instruction could result in failure and reduced life of the product.

SAFETY PRECAUTIONS (continued)

5. Disposal

⚠ CAUTION	
 Follow disposal regulations	■ **Observe appropriate regulations of local government for disposal of the equipment and parts thereof.** Failure to follow the instruction could result in health hazards, since the equipment may contain hazardous substances including lead (solder) and GaAs (Light Emitting Diode (LED) lamp). Inhaling vapors and powders of such substances may be harmful to human health.

WARRANTY AND DISCLAIMER

Warranty

Full details of the warranty are provided in the terms and conditions and specifications.

Resale and Relocation

This equipment is designed, manufactured, installed and delivered based on the customer's particular specification. No warranty is provided for its functions, characteristics or safety if the equipment is resold or relocated.

Disclaimer

1. Handling of the product

   Toshiba shall not be responsible for any defects or failures arising from failure to follow the instructions provided in this manual.

2. Performance guarantee under abnormal service conditions

   (1) Toshiba shall be exempted from the liability for damages and underperformance of the product arising when the product is installed in an environment not specified in the specification, or when the installation location becomes noncompliant to the specified environmental conditions.

   (2) Toshiba shall be exempted from the liability for damages and underperformance of the product arising when cables/connectors not stipulated in the specification are connected to the product.

   (3) Toshiba shall be exempted from the liability for damages and underperformance of the product arising when a power supply not stipulated in the specification is applied to the product.

3. Modification to the product

   Toshiba may be exempted from the responsibility for performance warranty of the product modified by customer or other companies.

CONTACT INFORMATION

Customer Service

For inquiries and maintenance requests, contact us at the following address and phone number:

Address: 1, Toshiba-Cho, Fuchu-Shi, Tokyo 183-8511 Japan

Phone: 042-333-2684

NOTE

- For inquiries, let us know the product name and information on the name plate such as model, serial number, manufacturing date, etc.
- In case of an accident, provide information as much detail as possible on the accident conditions and events that occurred before and after the accident in addition to the information above.

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1 General

1.1 Purpose and Application

This Oscillation Power Range Monitor (OPRM) unit, HNU1200, is used for the Power Range Neutron Monitor (PRNM) of Advanced Boiling Water Reactor (ABWR) application. There are four divisions of PRNM for ABWR application. The OPRM is a functional subsystem of the Average Power Range Monitor (APRM). There are four OPRM channels, with each OPRM as part of the each APRM channel.

The OPRM unit has the following safety-related functions:

(1) Generating neutron flux oscillation signal (Normalized Oscillation Signal)

(2) Generating the following trip signals, and providing to the Relay unit:

- Growth Rate-Based Trip (GRA Trip signal)
- Amplitude-Based Maximum Trip (ABA Trip signal)
- Period-Based Trip (PBDA Trip signal)
- OPRM Inoperative signal

(3) Providing data signals, bypass state, trip state, annunciator, and operation state to the Engineered Safety Features Logic & Control System (ELCS) Flat Display (FD).

The OPRM unit receives the 52 Local Power Range Monitor (LPRM) Levels (52 detectors in total) from 4 LPRM units and forms 44 OPRM Cell configurations to monitor the neutron flux behavior of all regions of the core. Each OPRM Cell represents a combination of four LPRM signals selected from the LPRM strings at the four corners of a four-by-four fuel bundle square region. For locations near the periphery where one corner of the square does not include an LPRM string, the OPRM Cells use the inputs from the remaining three LPRM strings. For each Cell, the peak to average value of the OPRM signal is determined to evaluate the amplitude of oscillation and to be used in the setpoint algorithm. The OPRM trip protection algorithm consists of trip logic depending on signal oscillation amplitude, a signal oscillation period, and signal oscillation growth rate. If one of the Cells fulfills one of the algorithms, the OPRM unit generates a trip signal.

Bypass of one APRM channel also bypasses one corresponding OPRM channel. The OPRM unit also receives the APRM Level and the Core Flow Level from the APRM unit and the trip algorithms are automatically bypassed if the APRM Level is less than 30% (initial setpoint) or the Core Flow Level is greater than 60% (initial setpoint).

The OPRM unit transmits data including bypass state information and trip state information to the ELCS and the[ ]^{a,c} The OPRM unit also transmits data recorded for offline analyses to a Transient Data Recorder (TDR).

1.2 Configuration

The OPRM unit consists of a set of functionally partitioned modules. The modules are connected by removable connectors to allow easy maintenance and inspection.

The modules are housed in the OPRM unit. The middle plane, which consists of printed circuit boards and connectors located in the OPRM unit, provides inter-module connections for power supply and signals.

The functional structure of this unit is shown in the block diagram of Figure 1.2.1. An external view of the unit is shown in Figure 1.2.2.

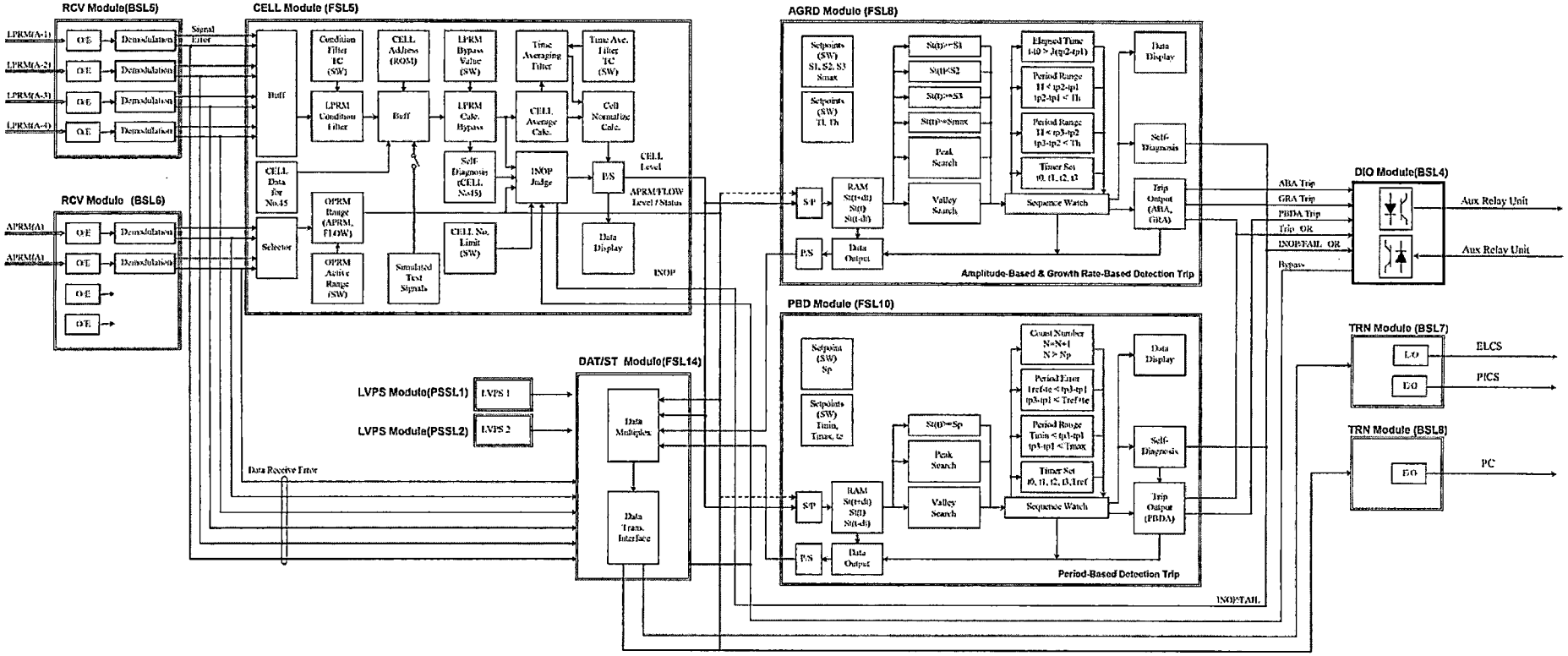
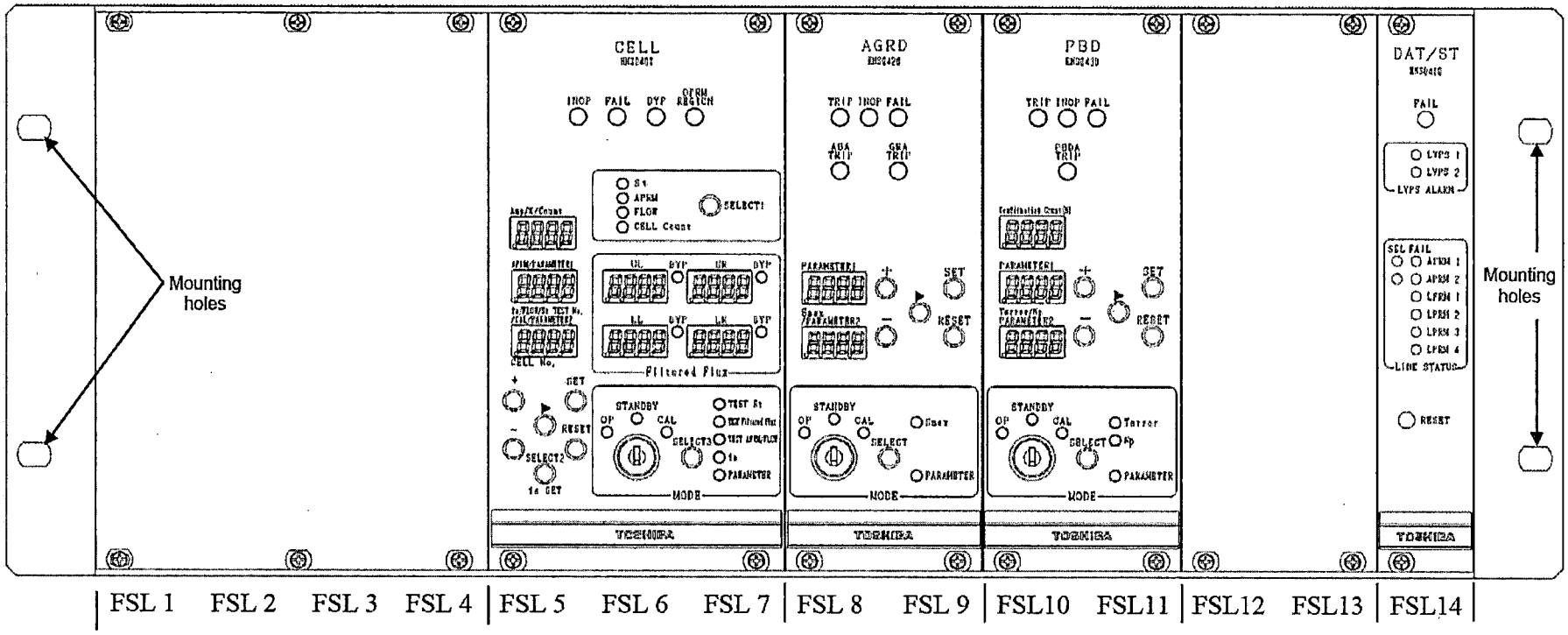


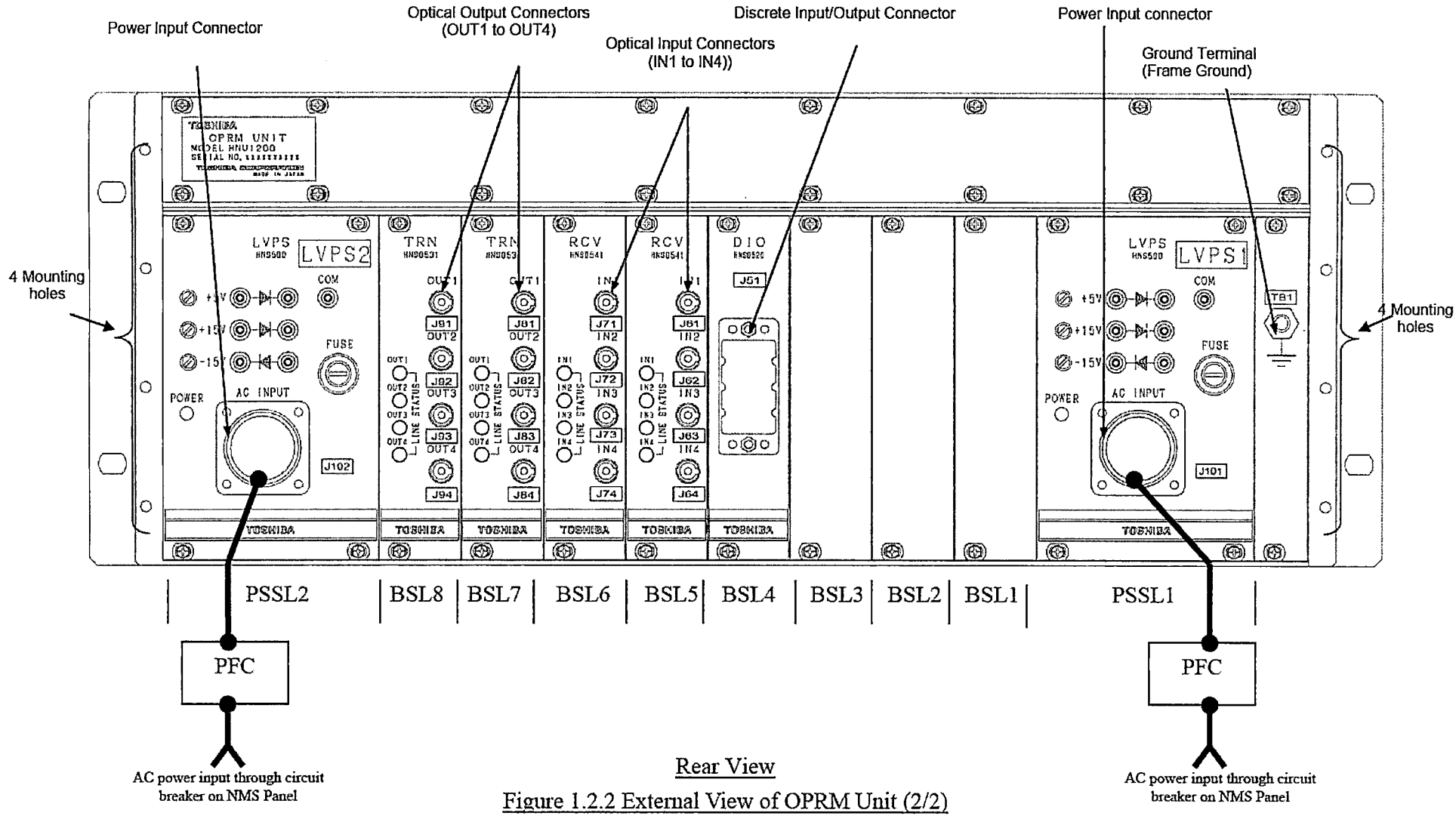
Figure 1.2.1 Block Diagram of OPRM Unit



Front View

FSL: Front Slot

Figure 1.2.2 External View of OPRM Unit (1/2)



Rear View

Figure 1.2.2 External View of OPRM Unit (2/2)

BSL: Back Slot
PFC: Power Factor Correction module
PSSL: Power Supply Slot

Table 1.2.1 Functional Description of Components

Slot ID	Item Name /Type	Functional Description
FSL5-7	CELL module /HNS0400	This module converts LPRM Levels to Normalized Oscillation Signals (safety signal), and provides the data to the AGRD and PBD modules for trip judgments.
FSL8, 9	AGRD module /HNS0420	This module performs Amplitude-Based Detection Algorithm judgment and Growth Rate-Based Detection Algorithm judgment (safety functions).
FSL10, 11	PBD module /HNS0430	This module performs Period-Based Detection Algorithm judgment (safety function).
FSL14	DAT/ST module /HNS0410	This module indicates a power status and input data status on the front panel. This module multiplexes the serial data from modules in the OPRM unit, and transmits the multiplexed data (safety related data) to the TRN modules.
PSSL 1	LVPS module /HNS0500	This module supplies DC+5V, ±15V power to each module (LVPS1). This component comprises redundant power supply lines to the OPRM unit.
BSL 4	DIO module /HNS0520	This module receives discrete input from the Relay unit. This module provides trip signal (safety function) to the Relay unit.
BSL 5	RCV module /HNS0541	This module receives LPRM unit data from the LPRM unit, and provide to the CELL module for processing Normalized Oscillation Signals (safety signal).
BSL 6	RCV module /HNS0541	This module receives APRM level and core flow data from the APRM unit to be used for determination auto bypass judgment in the CELL module.
BSL 7	TRN module /HNS0531	This module transmits OPRM unit data to the ELCS-FD (safety function).
BSL 8	TRN module /HNS0531	This module receives OPRM unit data from the DAT/ST module that has safety functions, and provides the data to the Transient Data Recorder (TDR).
PSSL 2	LVPS module /HNS0500	This module supplies DC+5V, ±15V power to each module (LVPS2). This component comprises redundant power supply lines to the OPRM unit.
N/A	Unit chassis /22890-375	Unit chassis is used to connect module interfaces for exchanging safety signals between modules in the unit.
FSL1-4, 12, 13, BSL1-3	(Blank panels)	Blank panels serve as a part of unit chassis and have no specific function.
N/A	Power Factor Correction module (PFC) /BPC-10	Input line filter for the LVPS modules. This component comprises redundant power supply lines to the OPRM unit.

1.3 Specifications
1.3.1 Input Signal
1.3.1.1 LPRM Unit Data from LPRM Unit

Signal Form	Optical serial signal
Connector	[ ]a,c
Connecting to	RCV module (Slot ID:BSL5)
Number of Ports	4 (Ports "IN1" to "IN4") Port allocation is as follows. Port "IN1" for LPRM unit 1 Port "IN2" for LPRM unit 2 Port "IN3" for LPRM unit 3 Port "IN4" for LPRM unit 4
Transmission Code	Manchester Code
Transmission Speed	[ ]a,c Mbps ([ ]a,c MHz)
Types of Data	● 52 channels of "LPRM Level" data (13 channels × 4) from 4 LPRM unit ● "Transmission ID data" that identifies the LPRM unit number 1 to 4 For more details, refer to Transmission Format and Bit Configuration.
Transmission Format	See Figure 1.3.1.1-1
Bit Configuration	See Figure 1.3.1.1-2

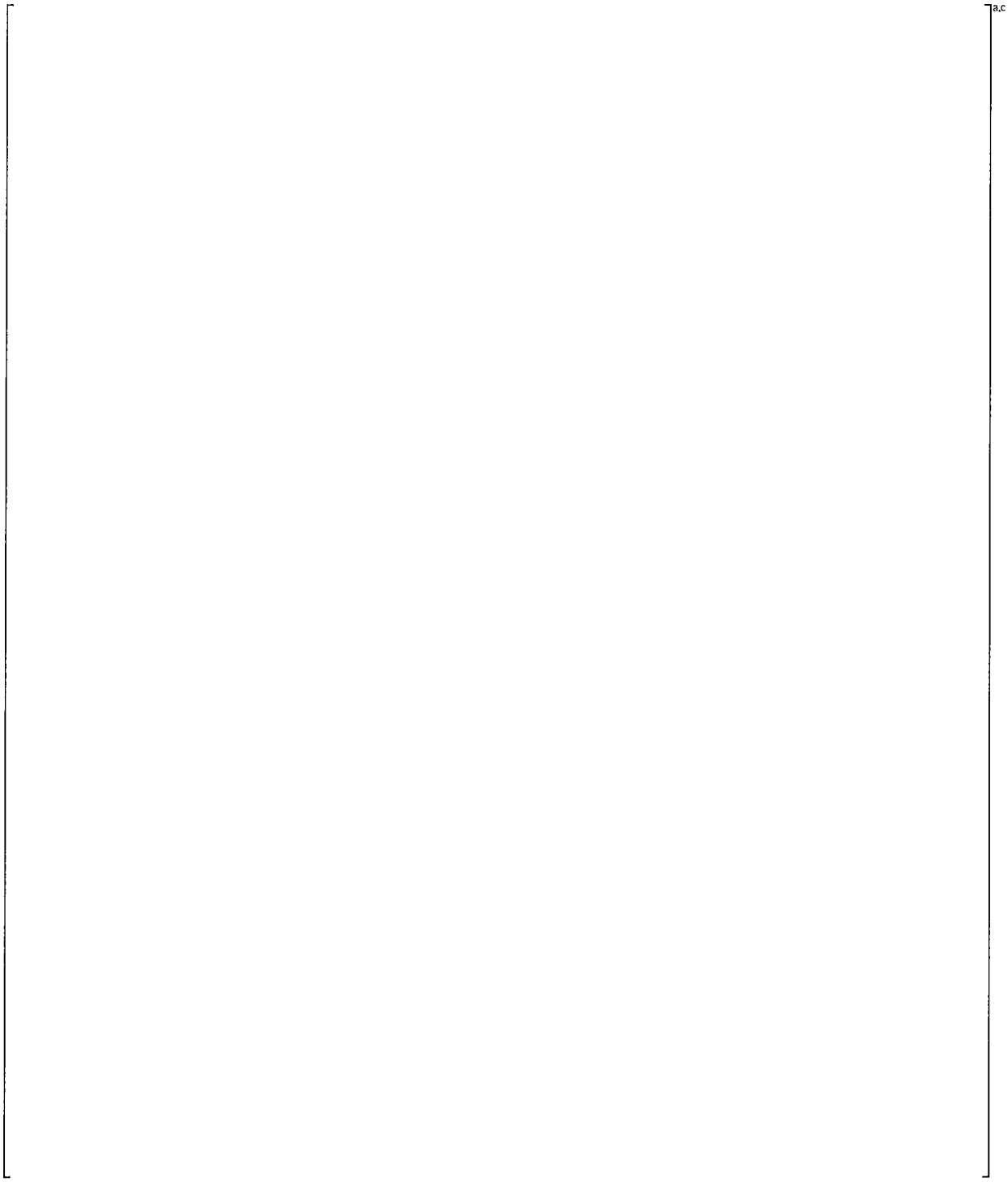


Figure 1.3.1.1-1 Transmission Format of Transmission Data from LPRM Unit

Figure 1.3.1.1-2 Bit Configuration of Transmission Data from LPRM Unit

1.3.1.2 APRM Unit Data from APRM Unit

Signal Form	Optical serial signal
Connector	[ ]^{a,c}
Connecting to	RCV module (Slot ID:BSL6)
Number of Ports	2 (There are four ports from "IN1" to "IN4", but only "IN1" and "IN2" are available for this OPRM application.) Port allocation is as follows. Ports "IN1" and "IN2" for redundant inputs from APRM unit. Ports "IN3" and "IN4" are not used.
Transmission Code	Manchester Code
Transmission Speed	[ ]^{a,c}Mbps ([ ]^{a,c}MHz)
Types of Data	● The "APRM Level" data from the APRM unit using first transmission frame (1/2) ● The "Core Flow Level " and "Trip and Alarm Data (of APRM unit)" data from the APRM unit using second transmission frame (2/2) For more details, refer to Transmission Format and Bit Configuration.
Transmission Format	See Figure 1.3.1.2-1.
Bit Configuration	See Figure 1.3.1.2-2.

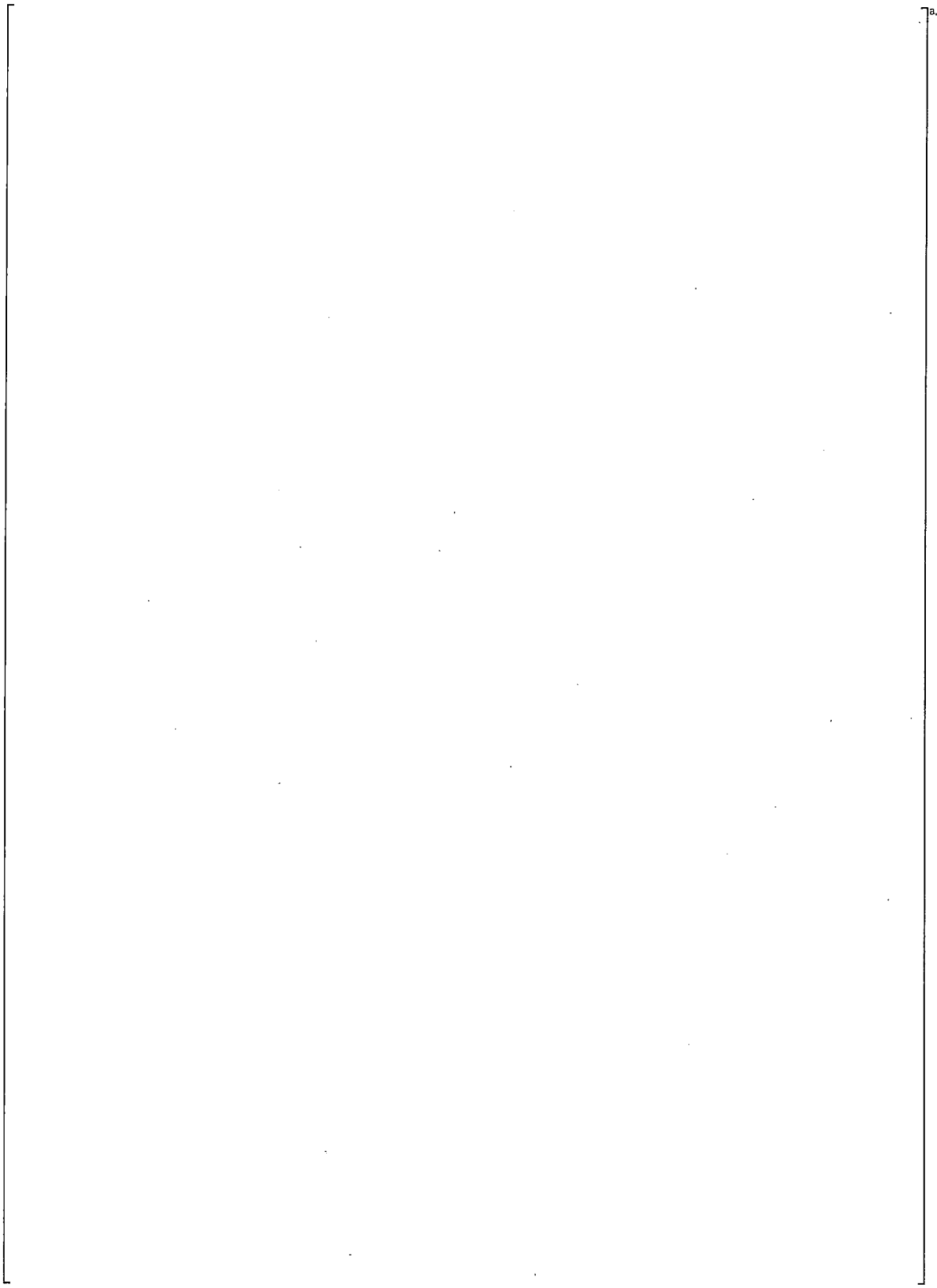


Figure 1.3.1.2-1 Transmission Format of Transmission Data from APRM Unit

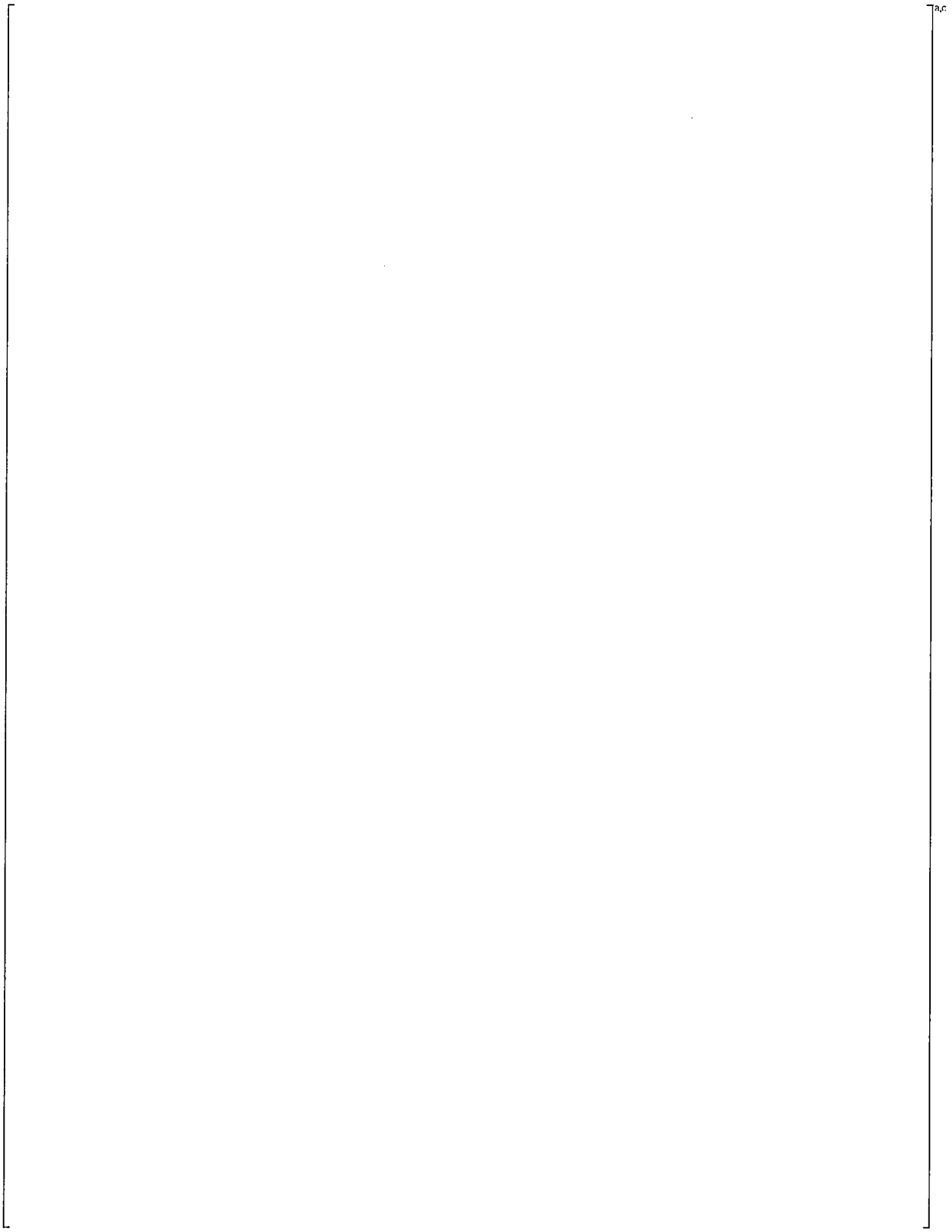


Figure 1.3.1.2-2 Bit Configuration of Transmission Data from APRM Unit

1.3.1.3 APRM Bypass Signal from Relay Unit

Signal Form	Isolated–type, voltage contact input (Photo coupler)
Connecting to	DIO module (Slot ID:BSL4)
Number of Cables	1 (from the Relay unit)
Logic Level	When the +24VDC is supplied to the "JJ" terminal or the "JJ" terminal is open, the "APRM Bypass signal" is not active under the condition that +24VDC is supplied to the "COM4" terminal. When the "JJ" terminal is connected to 0 VDC, the "APRM Bypass signal" is active under the condition that +24VDC is supplied to the "COM4" terminal.
Withstand Voltage	[ ]a,c
Insulated Resistance	[ ]a,c
Connector	Square-type connector:[ ]a,c (Kyocera ELCO) equivalent
Guide Key	Thick guide key: 2, Thin guide key: 1
Types of Data	The "APRM Bypass signal" from the Relay unit. For more details, refer to Pin Assignment.
Pin Assignment	Figure 1.3.1.3-1

[a,c]

Figure 1.3.1.3-1 Pin Assignment of the Relay Unit Input and Output

1.3.2 Output Signal

1.3.2.1 OPRM Multiplexed Data to ELCS and [ ]a,c

Signal Form	Optical serial signal
Connector	[ ]a,c
Connecting to	TRN module (Slot ID:BSL7)
Number of Ports	4 (Ports "OUT1" to "OUT4") Any port can be used for connection to ELCS and [ ]a,c refer to wiring diagram of NMS Panel and/or System O&M Manual.
Transmission Code	Manchester Code
Transmission Speed	[]a,c Mbps ([]a,c MHz)
Transmission Cycle	[]a,c millisecond (ms) (A transmission of 1 frame takes []a,c ms and a processing cycle is [ ]a,c ms, thus [ ]a,c frame data is transmitted per processing cycle. One data set is divided into []a,c frames to be transmitted. Therefore all the channels of the remaining [ ]a,c frames are to be [ ]a,c
Types of Data	● The "Normalized Oscillation Signal (for OPRM Cells [ ]a,c" using transmission frame [ ]a,c ● The "OPRM Cell Data (for OPRM Cells [ ]a,c" using transmission frame [ ]a,c ● Various setpoint data and trip and alarm information using transmission frames [ ]a,c For more details, refer to Transmission Format and Bit Configuration.
Transmission Format	See Figure 1.3.2.1-1
Bit Configuration	See Figure 1.3.2.1-2

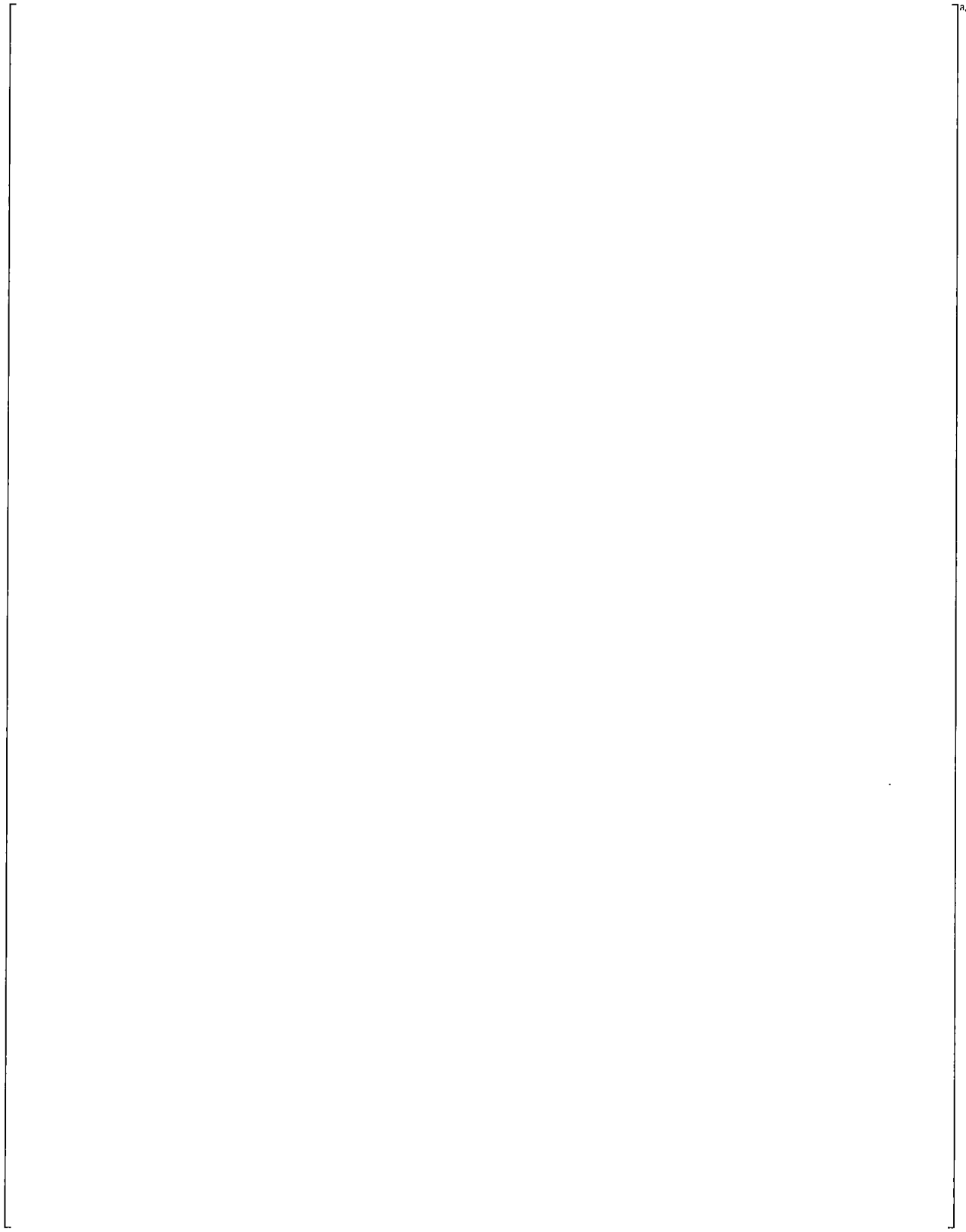


Figure 1.3.2.1-1 Transmission Format of Transmission Data to ELCS and [ ] (1/2)

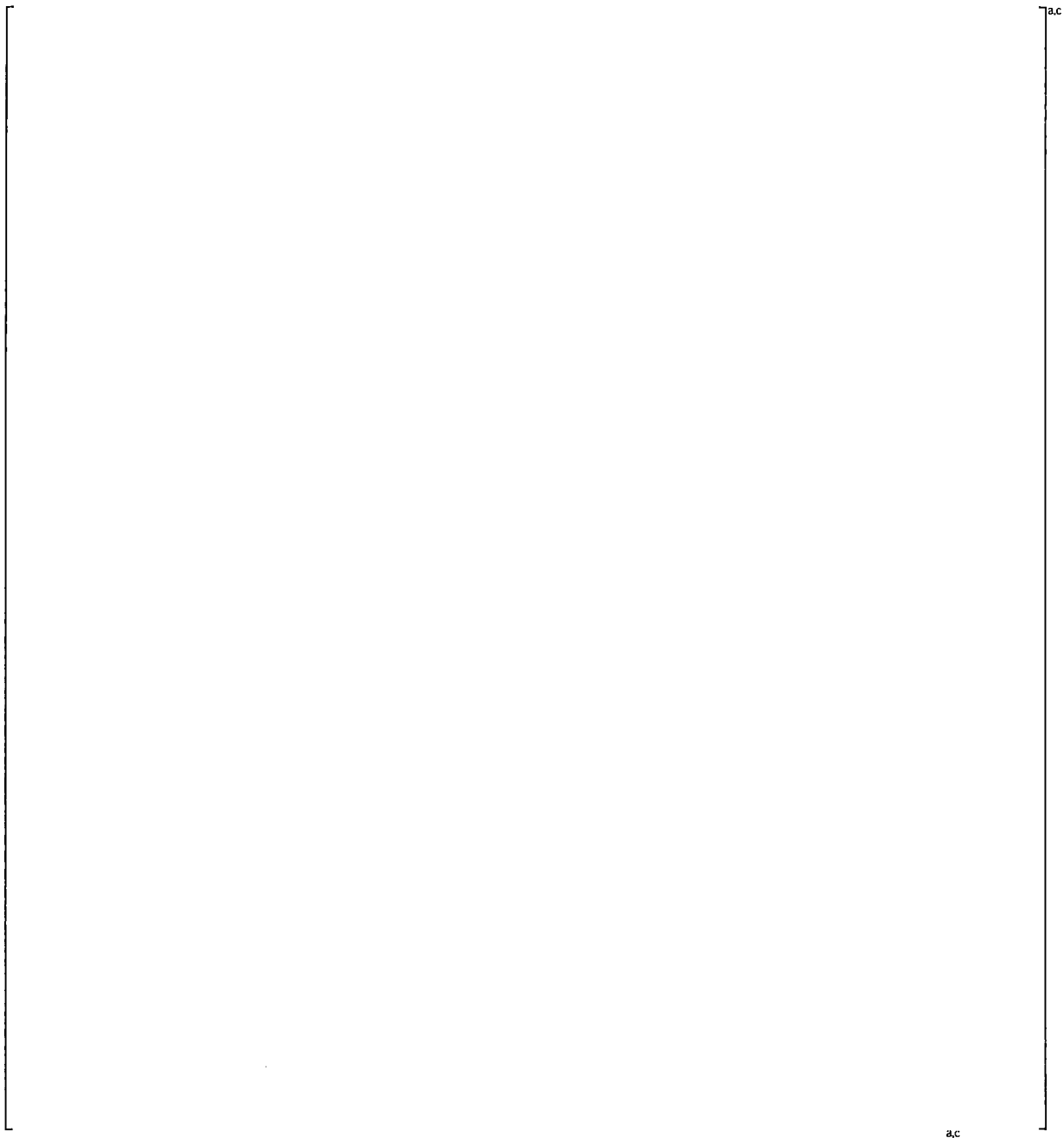


Figure 1.3.2.1-1 Transmission Format of Transmission Data to ELCS and [ ] (2/2)

[ ]a,c

Figure 1.3.2.1-2 Bit Configuration of Transmission Data to ELCS and[ ]a,c (1/5)

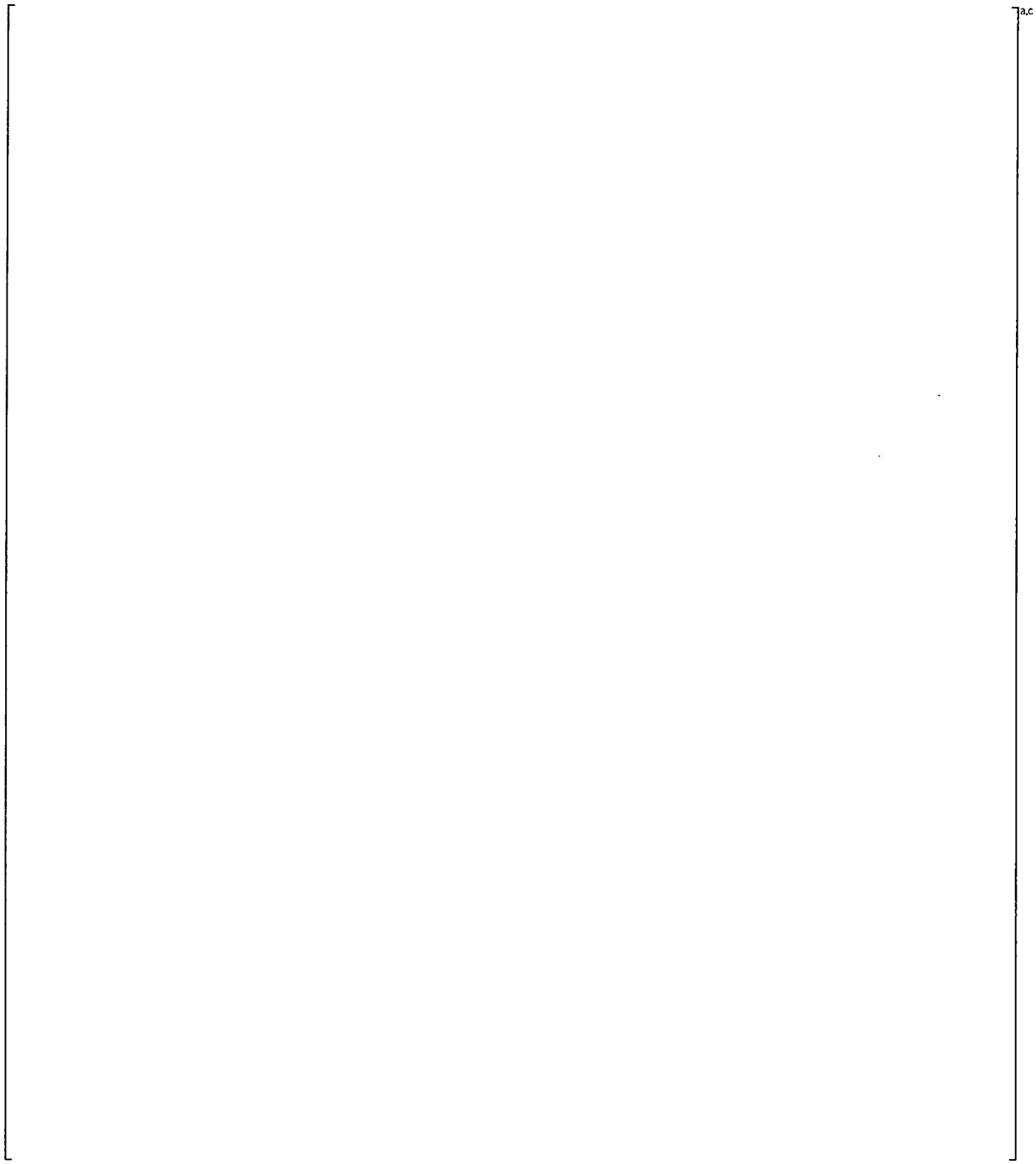


Figure 1.3.2.1-2 Bit Configuration of Transmission Data to ELCS and[ ](2/5)

[a,c]

Figure 1.3.2.1-2 Bit Configuration of Transmission Data to ELCS and [ ] [a,c] (3/5)

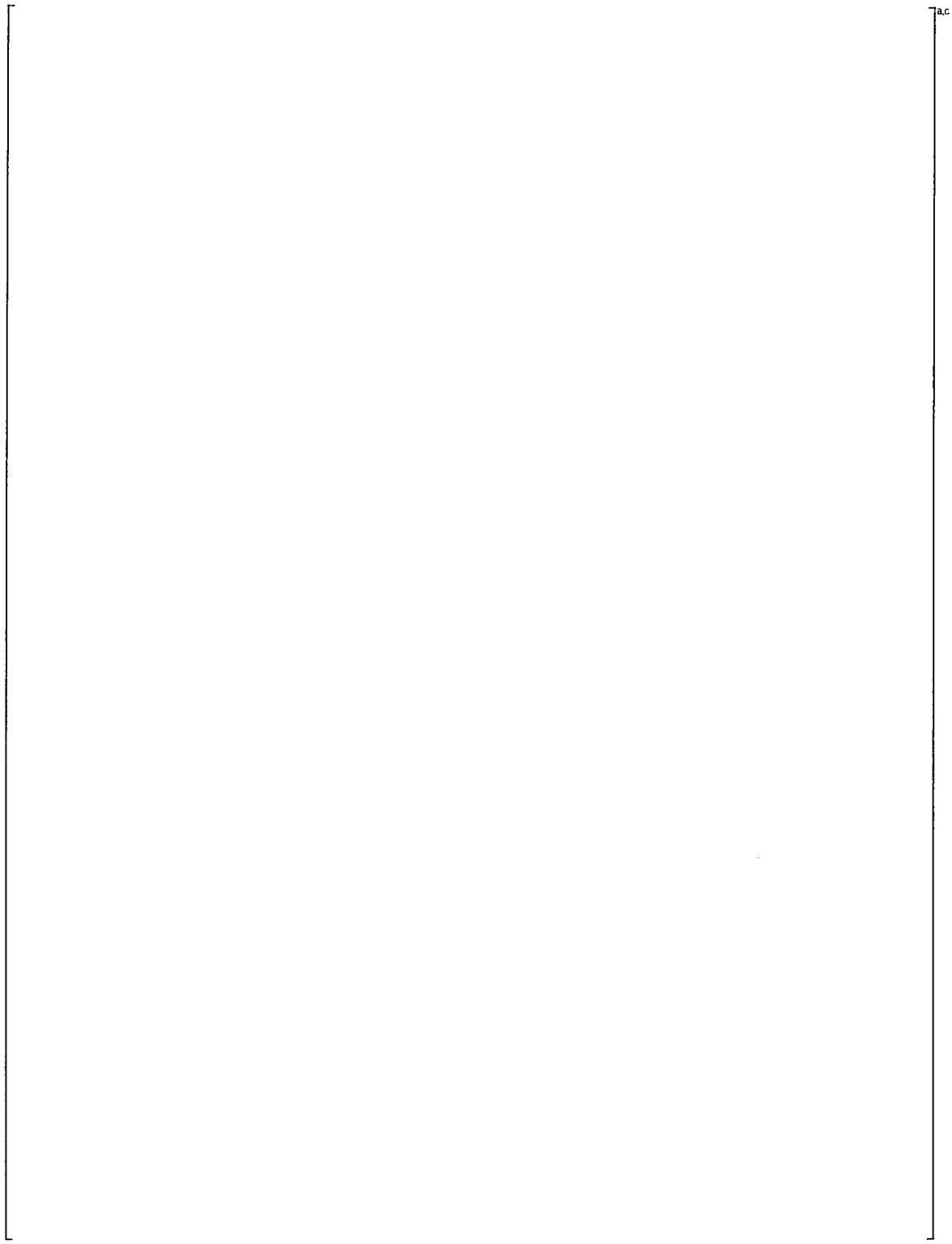


Figure 1.3.2.1-2 Bit Configuration of Transmission Data to ELCS and[ ]a,c (4/5)

[ ]a,c

Figure 1.3.2.1-2 Bit Configuration of Transmission Data to ELCS and [ ]a,c (5/5)

1.3.2.2 OPRM Record Data to TDR

Signal Form	Optical serial signal
Connector	[ ]^{a,c}
Connecting to	TRN module (Slot ID:BSL8)
Number of Ports	4 (Ports "OUT1" to "OUT4") Any port can be used for connection to TDR. Refer to wiring diagram of Neutron Monitoring System (NMS) Panel and/or System Operations and Maintenance (O&M) Manual.
Transmission Code	Manchester Code
Transmission Speed	[]^{a,c}Mbps ([]^{a,c}MHz)
Transmission Cycle	[]^{a,c}ms (A transmission of 1 frame takes []^{a,c}ms and a processing cycle is [ ]^{a,c}ms, thus [ ]^{a,c}frame data is transmitted per processing cycle. One data set is divided into [ ]^{a,c}frames to be transmitted. Therefore all the channels of the remaining [ ]^{a,c}frames are to be [ ]^{a,c}
Types of Data	● The "Normalized Oscillation Signal (for OPRM Cells [ ]^{a,c}" using transmission frame [ ]^{a,c} ● The "OPRM Cell Data (for OPRM Cells [ ]^{a,c}" using transmission frame [ ]^{a,c} ● Various setpoint data and trip and alarm information using transmission frames [ ]^{a,c} For more details, refer to Transmission Format and Bit Configuration.
Transmission Format	See Figure 1.3.2.2-1.
Bit Configuration	See Figure 1.3.2.2-2.

[a,c]

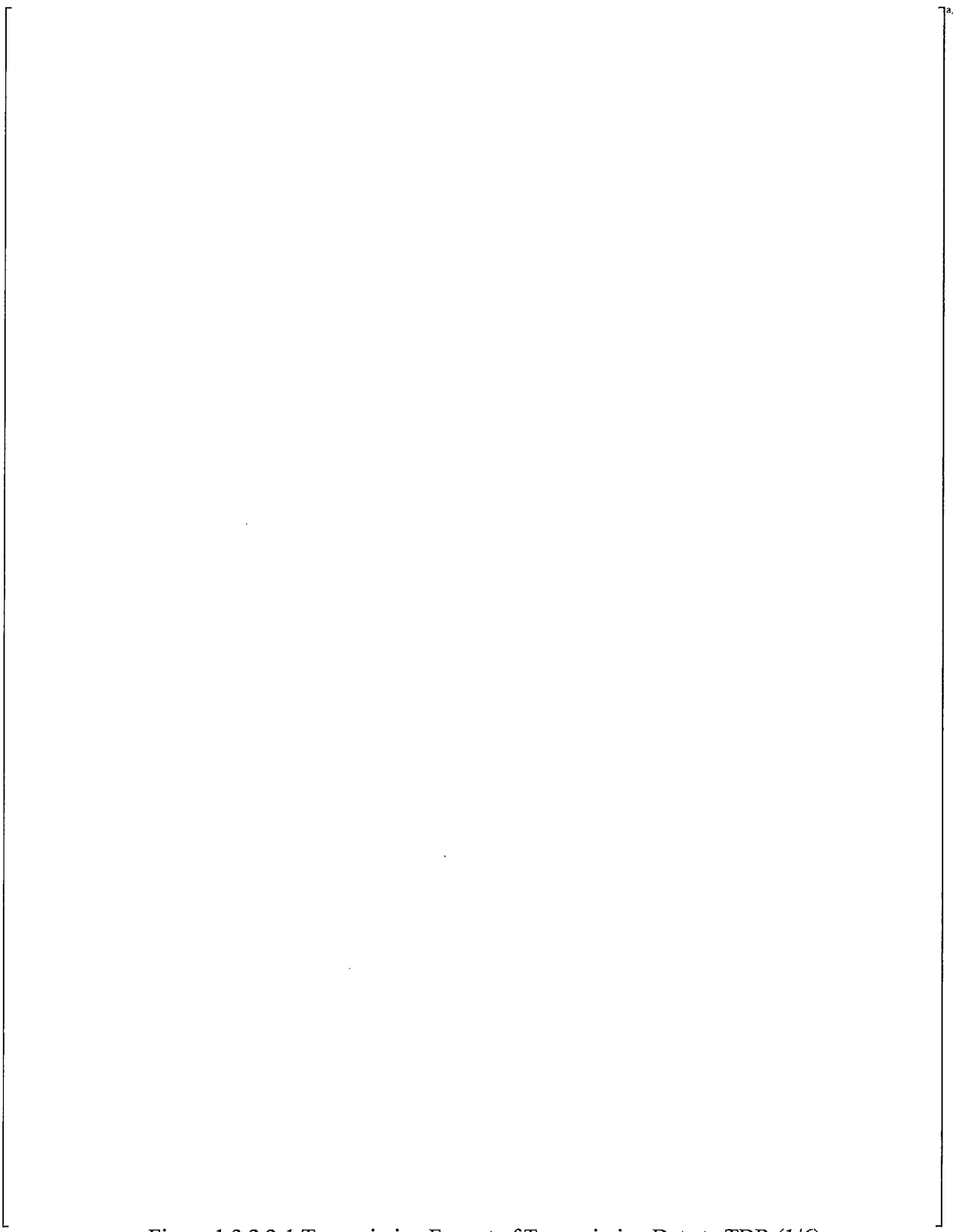


Figure 1.3.2.2-1 Transmission Format of Transmission Data to TDR (1/6)

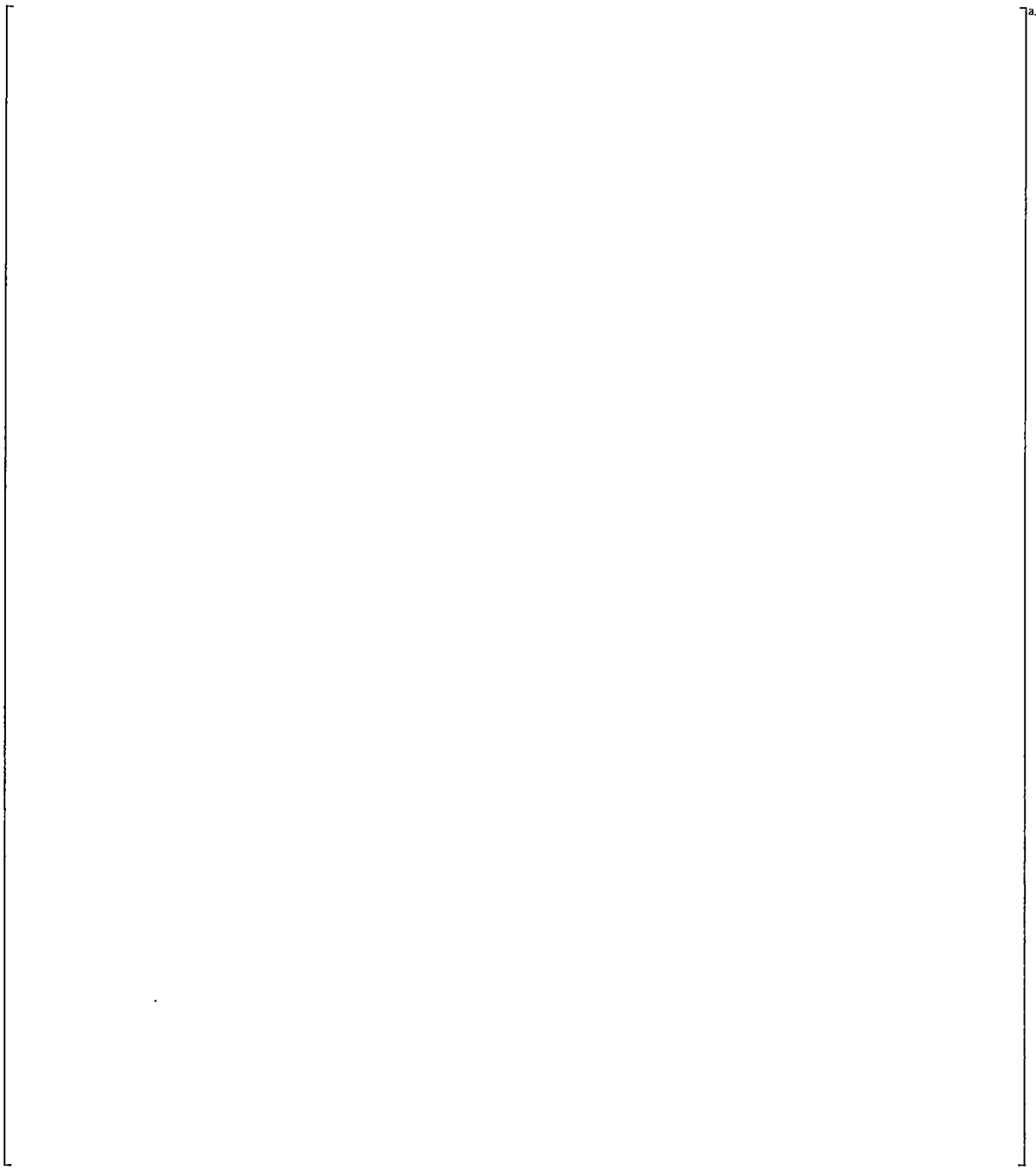


Figure 1.3.2.2-1 Transmission Format of Transmission Data to TDR (2/6)

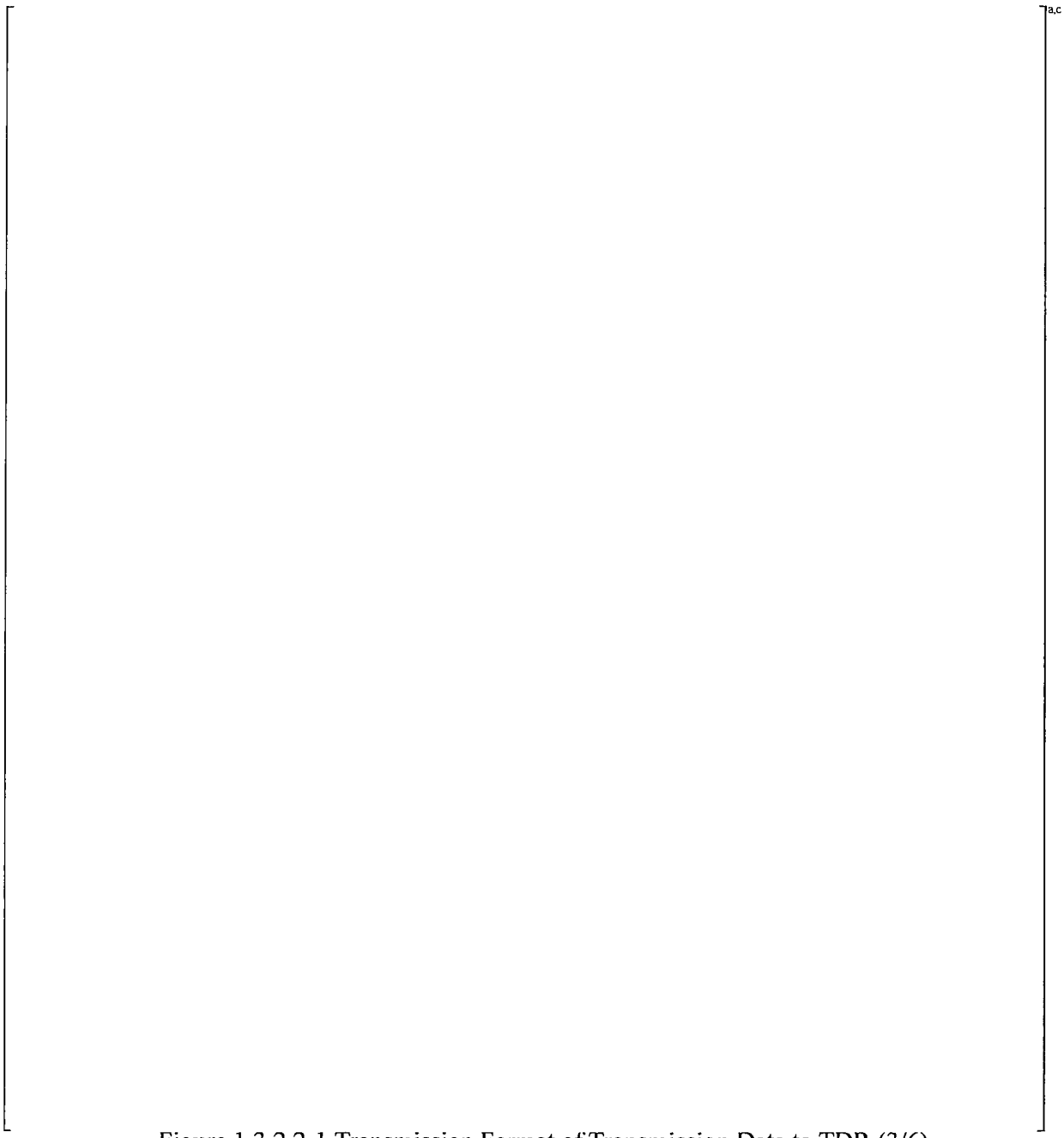


Figure 1.3.2.2-1 Transmission Format of Transmission Data to TDR (3/6)

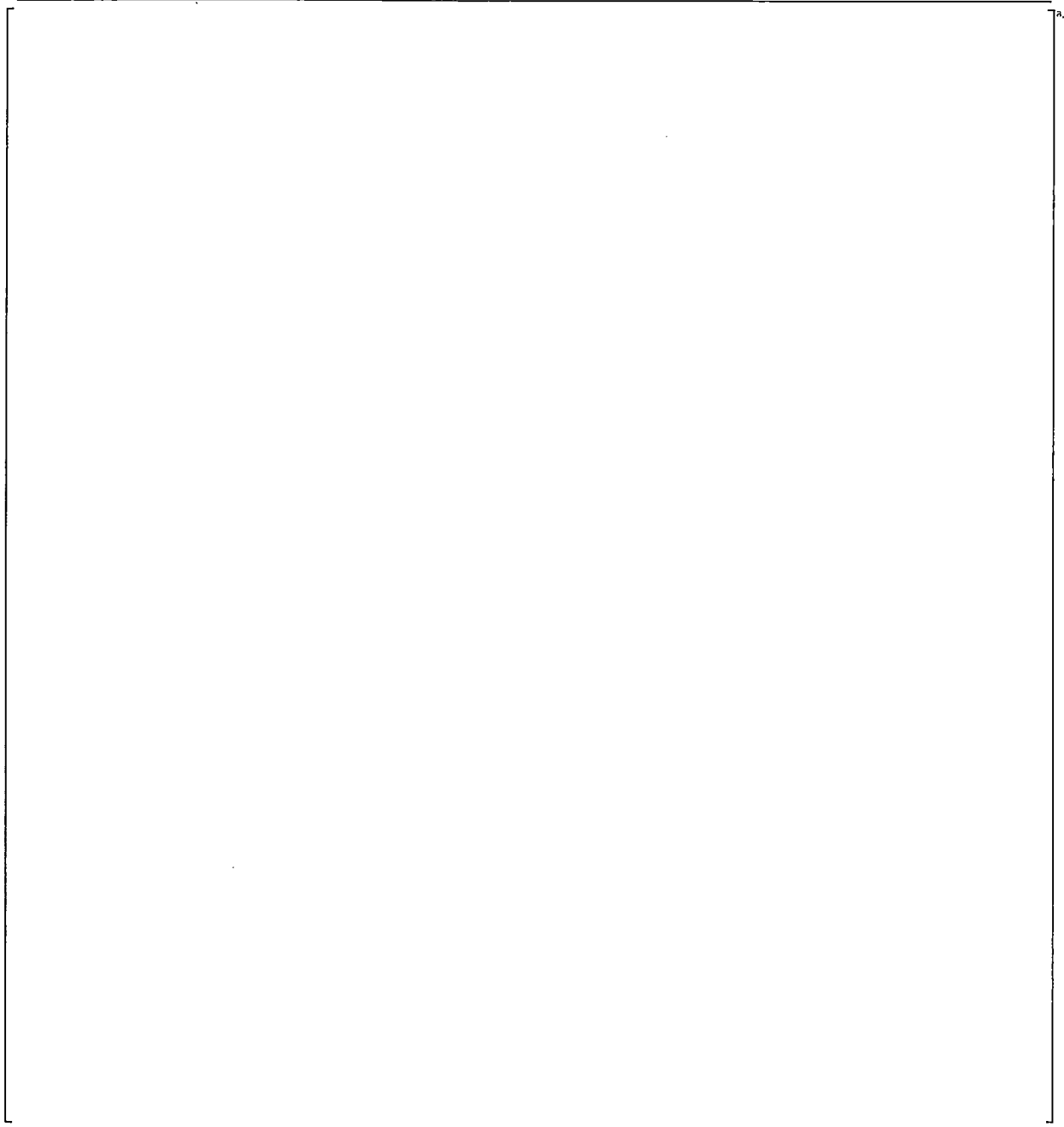


Figure 1.3.2.2-1 Transmission Format of Transmission Data to TDR (4/6)

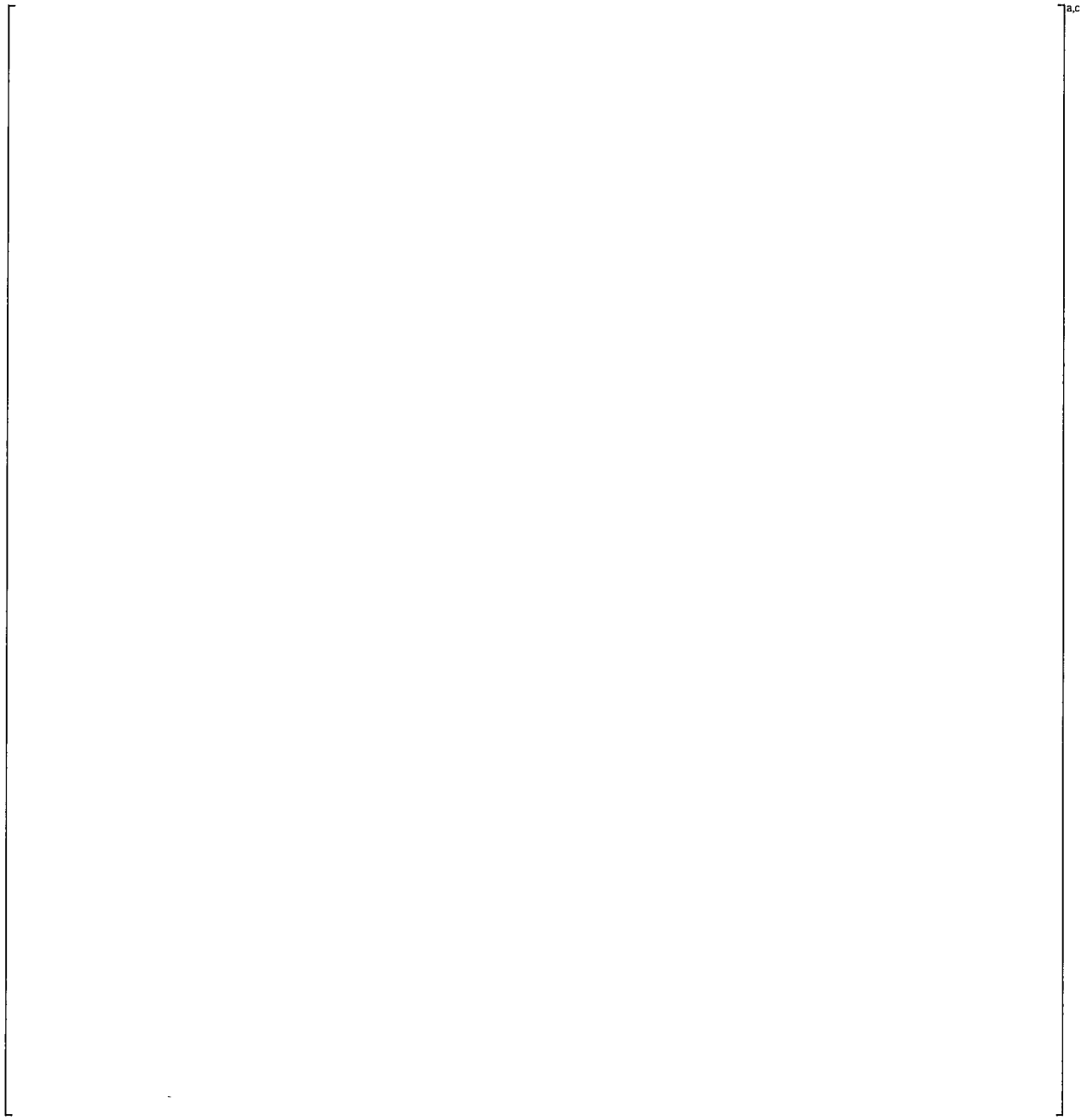


Figure 1.3.2.2-1 Transmission Format of Transmission Data to TDR (5/6)

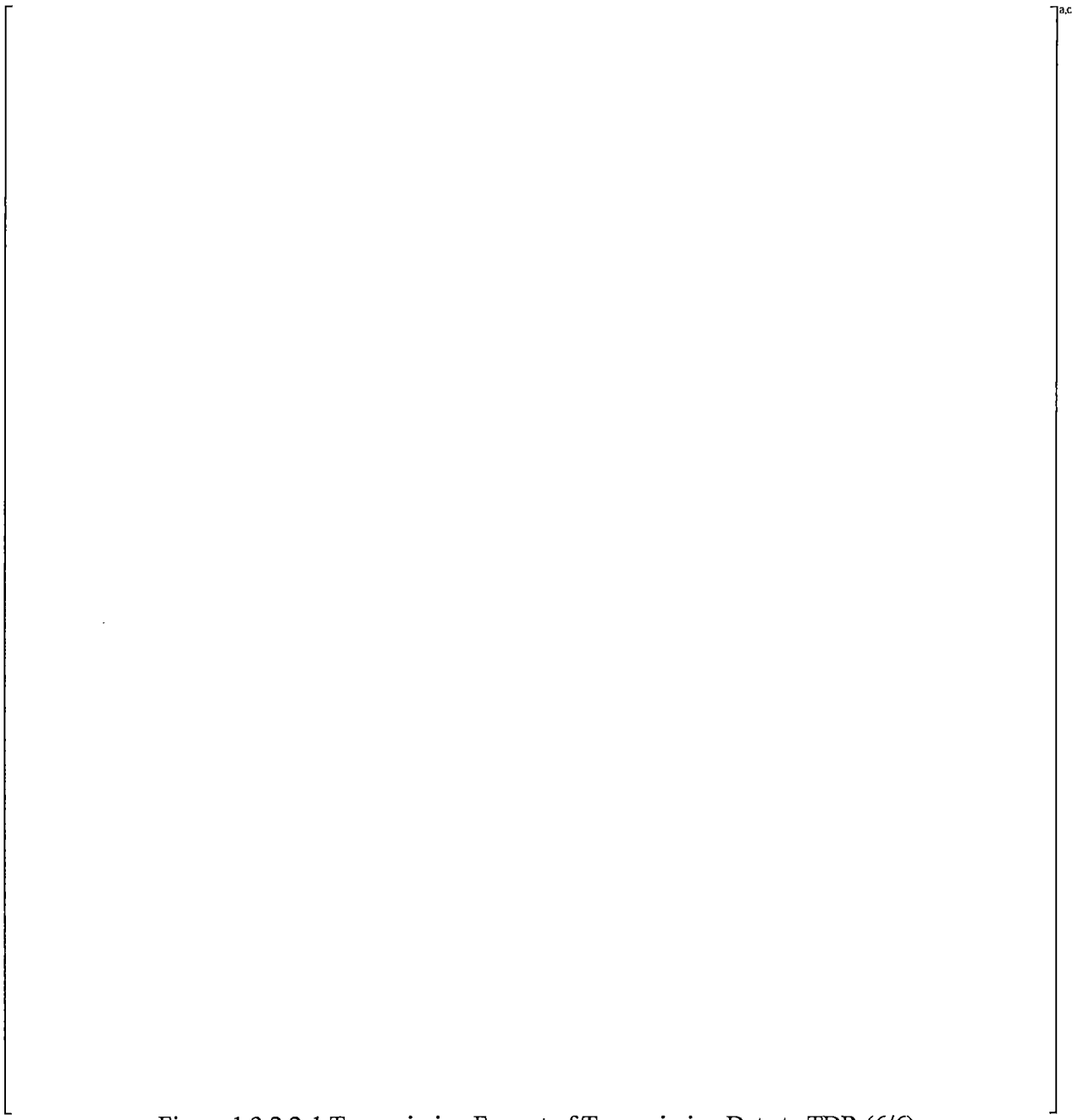
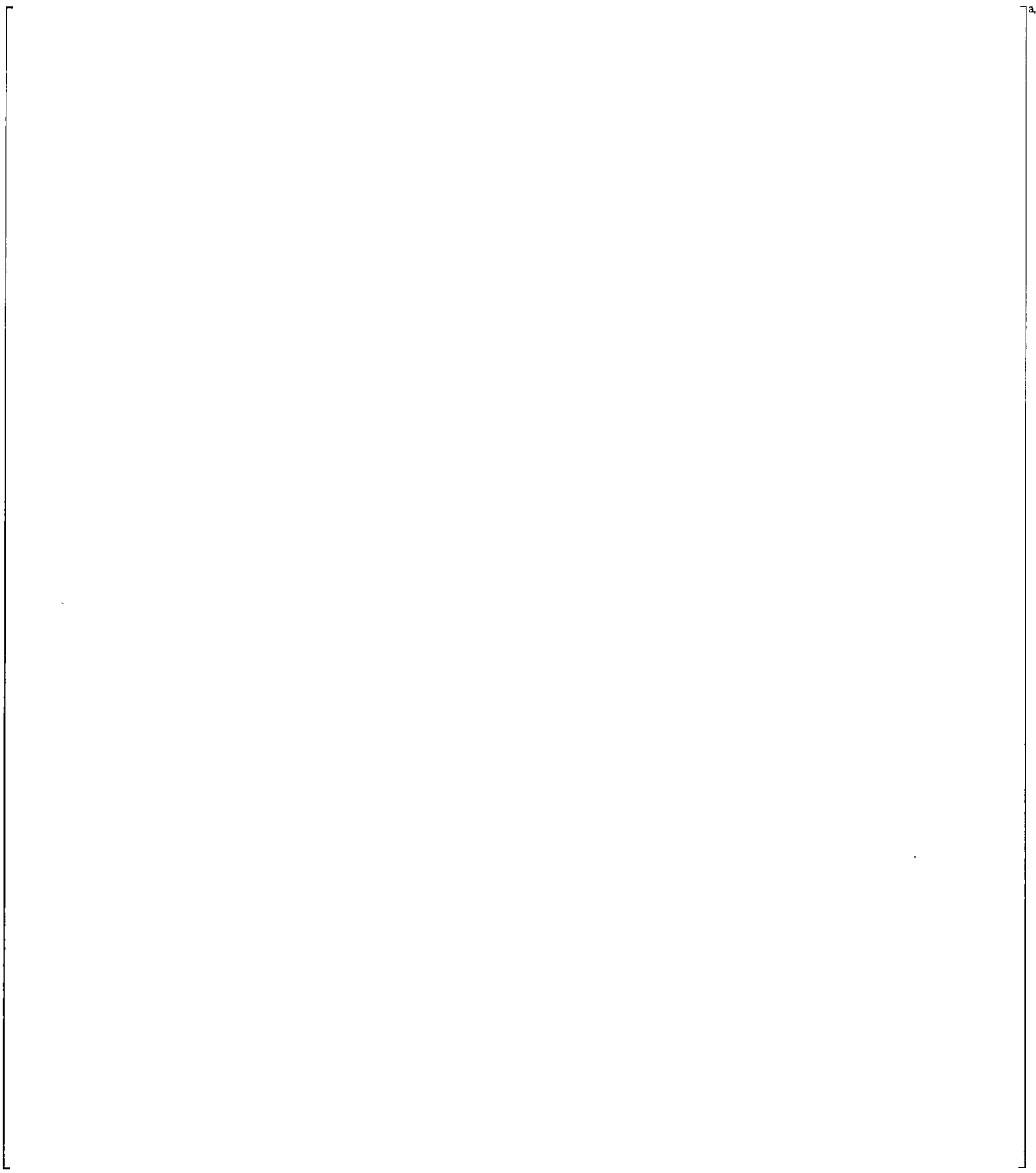


Figure 1.3.2.2-1 Transmission Format of Transmission Data to TDR (6/6)

[a,c



]

Figure 1.3.2.2-2 Bit Configuration of Transmission Data to TDR (1/7)

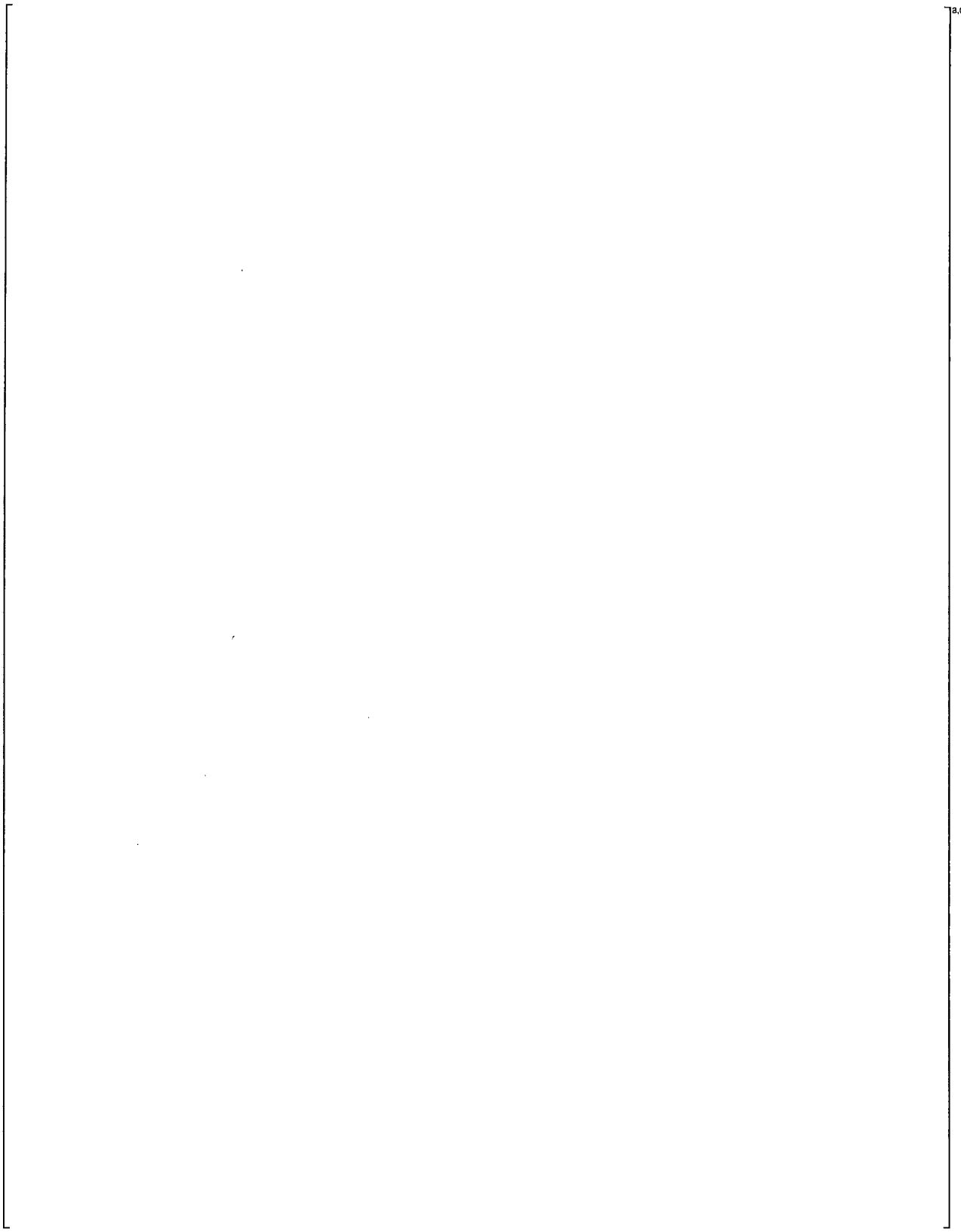


Figure 1.3.2.2-2 Bit Configuration of Transmission Data to TDR (2/7)

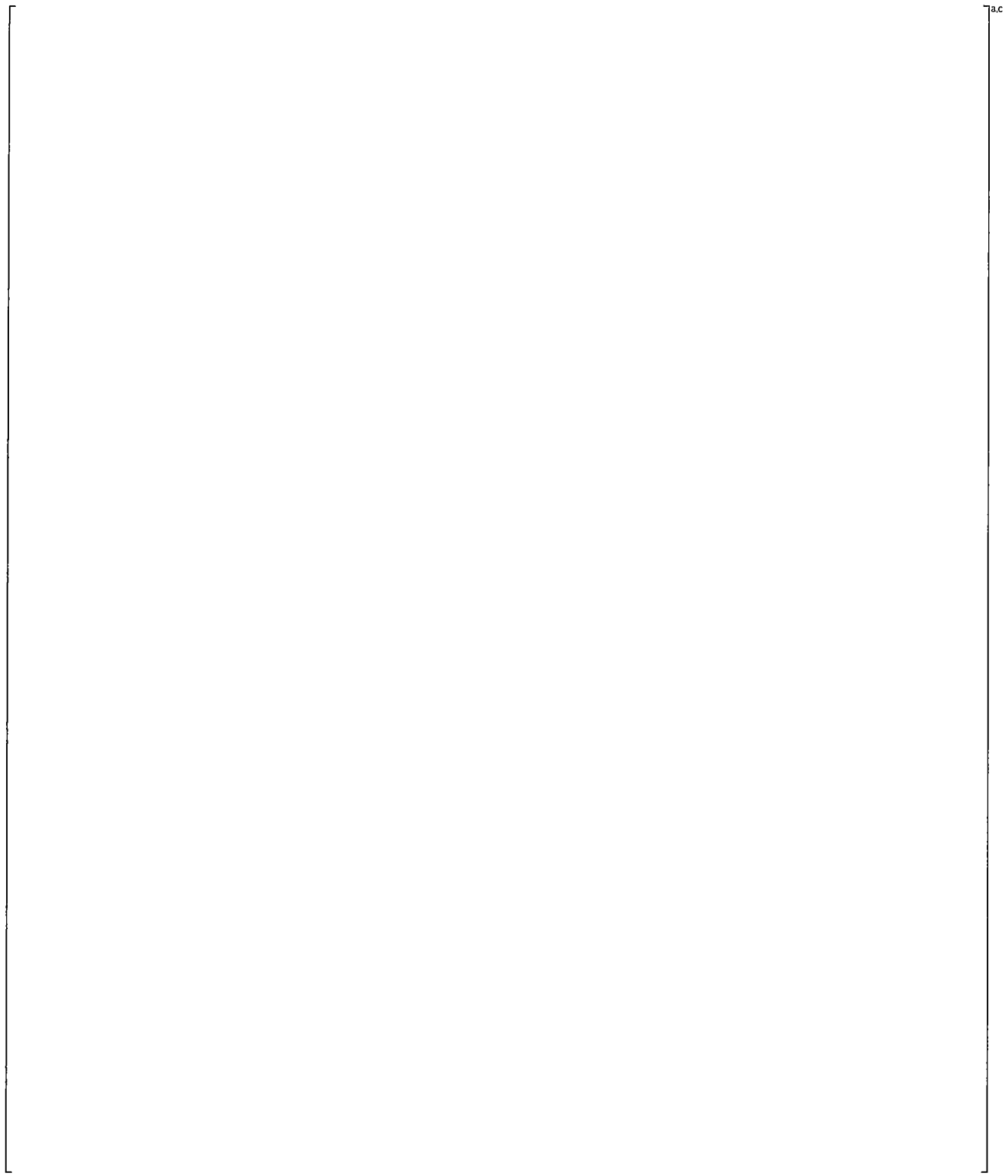


Figure 1.3.2.2-2 Bit Configuration of Transmission Data to TDR (3/7)

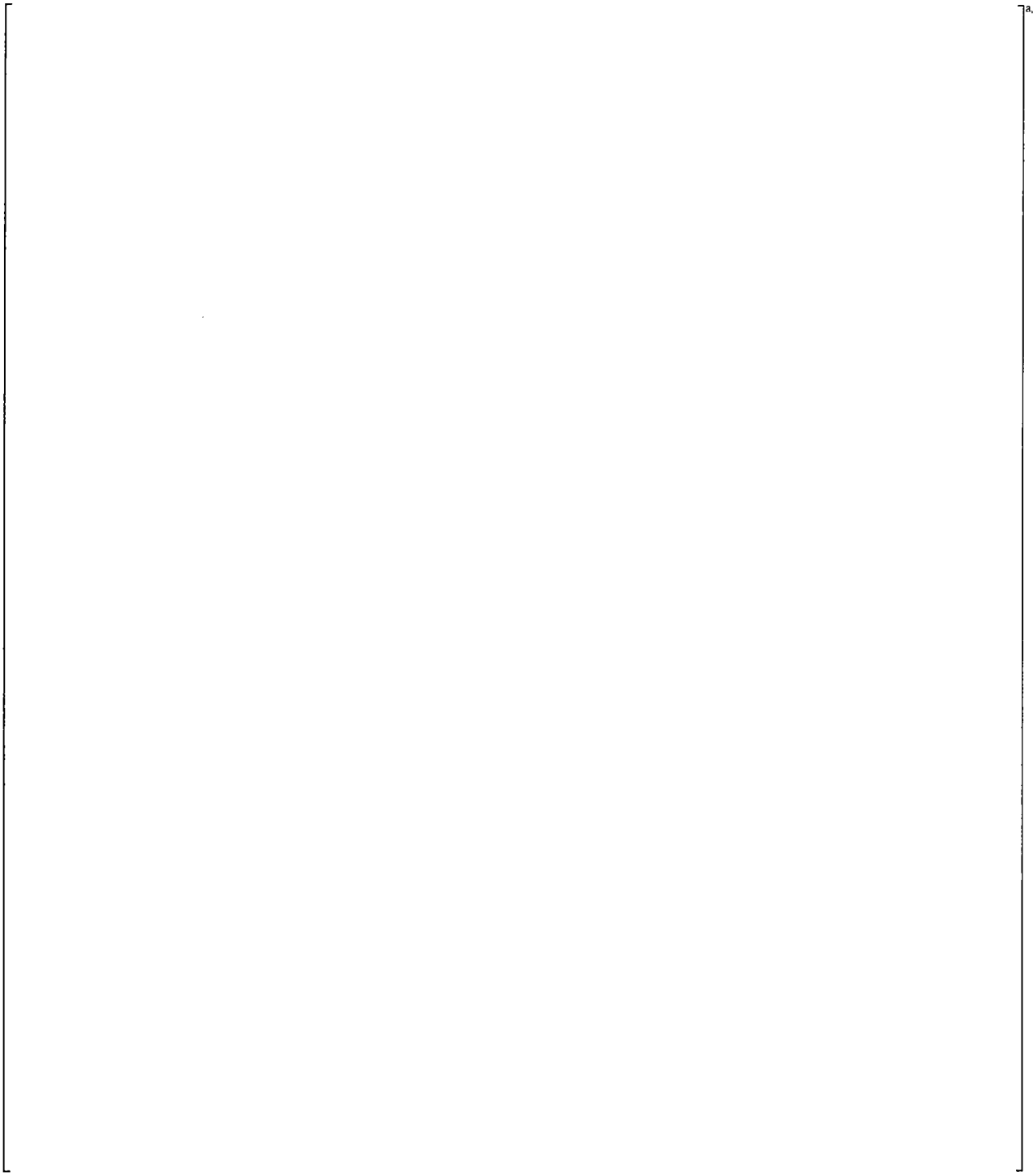


Figure 1.3.2.2-2 Bit Configuration of Transmission Data to TDR (4/7)

[ ]a,c

Figure 1.3.2.2-2 Bit Configuration of Transmission Data to TDR (5/7)

Figure 1.3.2.2-2 Bit Configuration of Transmission Data to TDR (6/7)

Figure 1.3.2.2-2 Bit Configuration of Transmission Data to TDR (7/7)

1.3.2.3 Transmission Signals to Relay Unit

Signal Form	Insulated no-voltage contact output[ ]a,c
Connecting to	DIO module (Slot ID:BSL4)
Number of Cables	1 (from the Relay unit)
Logic Level	Contact open [ ]a,c when a signal turns on. Contact close [ ]a,c when a signal turns off. < Exception > Contact open [ ]a,c when the "OPRM Automatic Bypass" signal turns off. Contact close [ ]a,c when the "OPRM Automatic Bypass" signal turns on.
Applied Voltage	[ ]a,c (external source from Relay unit)
Output Current (load current per an output)	[ ]a,c mA or less
Withstand Voltage	[ ]a,c
Insulated Resistance	[ ]a,c
Connector	Square-type connector:[ ]a,c (Kyocera ELCO) equivalent
Guide Key	Thick guide key: 2, Thin guide key: 1
Types of Data	The following safety-related signals to the Relay unit. ● Trip (Scram) signal ● PBDA Trip signal ● ABA Trip signal ● GRA Trip signal ● OPRM Inoperative signal For more details, refer to Pin Assignment.
Pin Assignment	See Figure 1.3.1.3-1.

1.3.3 Display Functions

1.3.3.1 CELL Module HMI

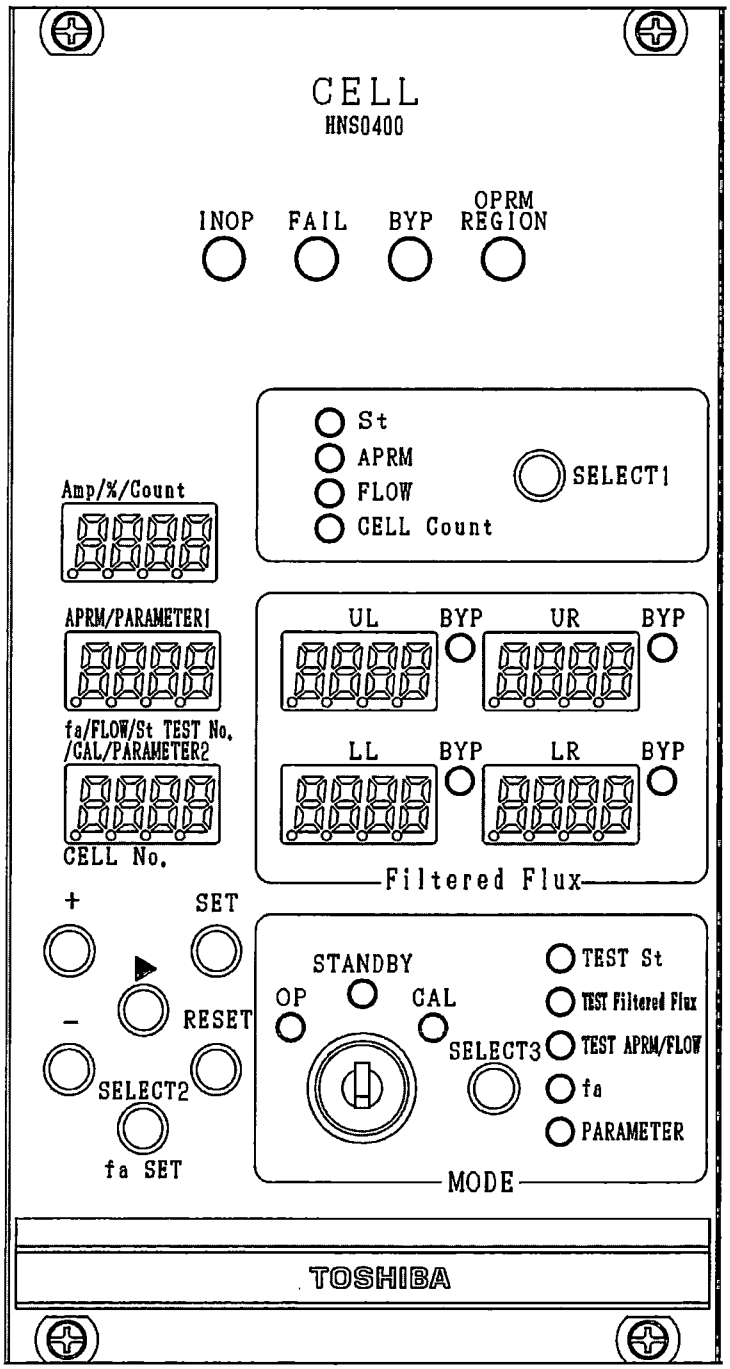


Figure 1.3.3.1 HMI of CELL Module

1.3.3.1.1 Alarm Displays

The CELL module has the following alarm displays.

Table 1.3.3.1.1 Alarm Displays on CELL Module

Indicator Name	Indication Item	LED Color	Operation
INOP	OPRM Inoperative	Yellow	This LED turns on when "OPRM Inoperative signal" of the CELL module is generated. The conditions for "OPRM Inoperative signal" generation are shown in the "Assumed Cause" column of Table 6.4. The LED stays on until the "RESET" button on the CELL module is pressed after the OPRM Inoperative signal is cleared.
FAIL	OPRM Minor Failure	Yellow	This LED turns on when "OPRM Minor Failure signal" of the CELL module is generated. The conditions for "OPRM Minor Failure signal" generation are shown in the "Assumed Cause" column of Table 6.4. The LED stays on until the "RESET" button on the CELL module is pressed after the OPRM Minor Failure signal is cleared.

1.3.3.1.2 Status Displays

The CELL module has the following status displays.

Table 1.3.3.1.2 Status Displays on CELL Module

Indicator Name	Indication Item	LED Color	Operation
BYP	OPRM Bypass	Yellow	This LED turns on when APRM Level and Core Flow Level satisfy the "OPRM Auto Bypass" conditions defined in Section 5.2. This LED turns on when the OPRM unit receives the "APRM Bypass signal" from the Relay unit as defined in Section 1.3.1.3.
OPRM REGION	On operation region	Green	This LED turns on when APRM Level and Core Flow Level satisfy the "OPRM Region" conditions defined in Section 5.2.

1.3.3.1.3 Numerical Displays and Related Status Displays

The CELL module has the following 7 numerical displays (4 digits 7-segment Light Emitting Diode (LED)).

- Amp/%/Count
- APRM/PARAMETER1
- fa/FLOW/St TEST No./CAL/PARAMETER2, CELL No.
- Upper Left (UL)
- Upper Right (UR)
- Lower Left (LL)
- Lower Right (LR)

These numerical displays indicate the numerical values listed below depending on the modes selected by the key switch on the front panel of the CELL module. One of the 4 indication items (i.e., "St," "APRM," "FLOW," and "CELL Count") is selected by using the "SELECT1" push button. Every time the "SELECT1" push button is pressed, the item selected switches in rotation, its corresponding status display LED turns on, and its value is shown on the "Amp/%/Count" display.

Table 1.3.3.1.3-1 Numerical Displays and Related Status Displays on CELL Module (1)

Mode	7 Segment LED					Status Display LED							
	Amp/%/Count	UL	UR	LL	LR	St	APRM	FLOW	CELL Count	Filtered Flux			
										UL BYP	UR BYP	LL BYP	LR BYP
All Mode	Normalized Oscillation Signal (0.000 to 9.999)*	Filtered Flux value of UL position (Indicate the selected Cell) (0.0 to 125.0)*	Filtered Flux value of UR position (Indicate the selected Cell) (0.0 to 125.0)*	Filtered Flux value of LL position (Indicate the selected Cell) (0.0 to 125.0)*	Filtered Flux value of LR position (Indicate the selected Cell) (0.0 to 125.0)*	On	Off	Off	Off	Indicate the bypass status of selected Cell			
	APRM Level (0.0 to 125.0%)*					Off	On	Off	Off				
	FLOW Level (0.0 to 200.0%)*					Off	Off	On	Off				
	Number of Active OPRM Cell (0 to 44)*					Off	Off	Off	On				

*: Display Range

The "UL," "UR," "LL," and "LR" numerical displays have "BYP" LED indicator (LED color is yellow) on their right side that shows the corresponding filtered flux value is bypassed.

These numerical displays also indicate the numerical values listed below depending on the modes selected by the key switch on the front panel of the CELL module. One of the 5 indication items (i.e., "TEST St," "TEST Filtered FLUX," "TEST APRM/FLOW," "fa," and "PARAMETER") is selected by using the "SELECT3" push button. Every time the "SELECT3" push button is pressed, the item selected switches in rotation, its corresponding status display LED turns on, and corresponding statuses are shown as listed in Table 1.3.3.1.3-2 below.

Table 1.3.3.1.3-2 Numerical Displays and Related Status Displays on CELL Module (2)

Mode	7 Segment LED						Status Display LED				
	APRM/PARAMETER1	Upper Position: fa/FLOW/St TEST No./CAL/PARAMETER2 Lower Position: CELL No.	UL	UR	LL	LR	TEST St	TEST Filtered FLUX	TEST APRM/ FLOW	fa	PARAMETER
OP, STANDBY	Off	Setected Cell Number (1 to 45)	Filtered Flux value of UL position	Filtered Flux value of UR position	Filtered Flux value of LL position	Filtered Flux value of LR position	Off	Off	Off	Off	Off
	1	Time Average Filter Cut-off Frequency Setpoint									On
	2	LPRM Lower-limit Setpoint									
	3	Conditioning Filter Cut-off Frequency Setpoint									
	4	Minimum Number of Active OPRM Cell Setpoint									
	5	OPRM Region APRM Level Setpoint									
	6	OPRM Region Core Flow Level Setpoint									
	7	OPRM Region APRM Level Hysteresis Setpoint									
	8	OPRM Region Core Flow Level Hysteresis Setpoint									
	9	Minimum Number of Active LPRMs Setpoint									
CAL	Off	1	Filtered Flux value of UL position	Filtered Flux value of UR position	Filtered Flux value of LL position	Filtered Flux value of LR position	Off	Off	Off	Off	Off
	Off	Test Number					On				
	Off	Filtered Flux Calibration Input Value					Off	On			
	APRM Level Calibration Input Value	FLOW Level Calibration Input Value							On		
	Current Time Average Filter Cut-off Frequency Setpoint	New Time Average Filter Cut-off Frequency Setpoint							Off	On	

Detailed description of the parameters shown in the table above (item numbers 1 through 9 indicated on "APRM/PARAMETER 1" numerical display) is shown in Table 4.1.2-1.

1.3.3.1.4 Mode Selection and Display Function

The CELL module has the Operation Mode/Sub-Mode described in Table 1.3.3.1.4-1.
The CELL module has a key switch on the front panel to select Operation Mode.
The CELL module has a "SELECT3" push button on the front panel to select Sub-Mode.
The CELL module indicates mode information described in Table 1.3.3.1.4-2 on the front panel LED.

Table 1.3.3.1.4-1 Mode Selection and Display Function of CELL Module (1)

Mode	Sub-Mode	: Action
OP		: CELL module performs normal measuring and monitoring
	PARAMETER	: CELL module displays parameters on the front panel display
STANDBY		: CELL module perform normal measuring and monitoring : CELL module generates "OPRM Inoperative signal"
	PARAMETER	: CELL module displays parameters on the front panel display
CAL		: CELL module generates "OPRM Inoperative signal"
	TEST St	: CELL module enables Normalized Oscillation Signal Calibration Function
	TEST Filtered Flux	: CELL module enables Filtered Flux Calibration Function
	TEST APRM/FLOW Level	: CELL module enables APRM and Core Flow Level Calibration Function
	fa	: CELL module enables "Time Average Filter Cut-off Frequency" modification

Table 1.3.3.1.4-2 Mode Selection and Display Function of CELL Module (2)

Indication Item	Color
"OP" mode	Green
"STANDBY" mode	Yellow
"CAL" mode	Yellow
"PARAMETER" sub-mode	Green
"TEST St" sub-mode	Yellow
"TEST Filtered Flux" sub-mode	Yellow
"TEST APRM/FLOW" sub-mode	Yellow
"fa" sub-mode	Yellow

1.3.3.1.5 Push Buttons

The CELL module has the following buttons on the front panel for "Time Average Filter Cut-off Frequency" setpoint adjustment, mode selection and alarm reset operation,

Table 1.3.3.1.5 Push Buttons on CELL Module

Button Name	Purpose
"▶"	For selecting a digit position to set a value
"+"	For incrementing the value
"-"	For decrementing the value
"SET"	For setting the new (changed) values.
"RESET"	For resetting alarm indications
"SELECT1"	For selecting an indication item of "Amp/%/Count"
"SELECT2"	For selecting an indication item of "fa/FLOW/St TEST No./CAL/PARAMETER2"
"SELECT3"	For selecting a sub mode and indication item of "UL," "UR," "LL," and "LR"

1.3.3.2 AGRD Module HMI

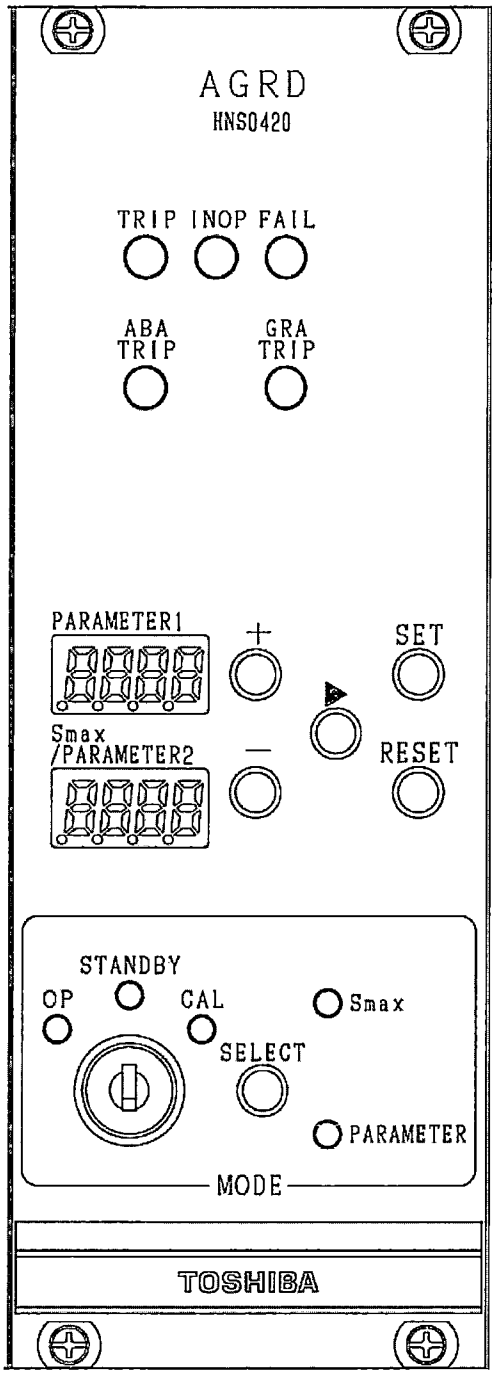


Figure 1.3.3.2 HMI of AGRD Module

1.3.3.2.1 Alarm Displays

The AGRD module has the following alarm displays.

Table 1.3.3.2.1 Alarm Displays on AGRD Module

Indicator Name	Indication Item	LED Color	Operation
TRIP	ABA Trip or GRA Trip	Red	This LED turns on when the "ABA Trip signal" or "GRA Trip signal" is generated. The conditions for "ABA Trip signal" and "GRA Trip signal" generation are described in Sections 5.3.1 and 5.3.2. The LED stays on until the "RESET" button on the AGRD module is pressed after the trip signal is cleared.
INOP	OPRM Inoperative	Yellow	This LED turns on when "OPRM Inoperative signal" of the AGRD module is generated. The conditions for "OPRM Inoperative signal" generation are shown in the "Assumed Cause" column of Table 6.4. The LED stays on until the "RESET" button on the AGRD module is pressed after the OPRM Inoperative signal is cleared.
FAIL	OPRM Minor Failure	Yellow	This LED turns on when "OPRM Minor Failure signal" of the AGRD module is generated. The conditions for "OPRM Minor Failure signal" generation are shown in the "Assumed Cause" column of Table 6.4. The LED stays on until the "RESET" button on the AGRD module is pressed after the OPRM Minor Failure signal is cleared.
ABA TRIP	ABA Trip	Red	This LED turns on when the "ABA Trip signal" is generated. The conditions for "ABA Trip signal" generation are described in Section 5.3.1. The LED stays on until the "RESET" button on the AGRD module is pressed after the ABA Trip signal is cleared.
GRA TRIP	GRA Trip	Red	This LED turns on when the "GRA Trip signal" is generated. The conditions for "GRA Trip signal" generation are described in Section 5.3.2. The LED stays on until the "RESET" button on the AGRD module is pressed after the GRA Trip signal is cleared.

1.3.3.2.2 Numerical Displays and Related Status Displays

The AGRD module has 2 numerical displays (4 digits 7-segment Light Emitting Diode (LED)) and 2 status displays.

These numerical displays indicate the numerical values listed below depending on the modes selected by the key switch on the front panel of the AGRD module. Every time the "SELECT" push button is pressed, the item selected switches in rotation, its corresponding status display LED turns on, and corresponding statuses are shown as listed in Table 1.3.3.2.2 below.

Table 1.3.3.2.2 Numerical Displays and Related Status Displays on AGRD Module

Mode	7 Segment LED		Status Display LED	
	PARAMETER1	Smax/PARAMETER2	Smax	PARAMETER
OP, STANDBY	Off	Off	Off	Off
	1	Threshold Setpoint		On
	2	Minimum Threshold Setpoint		
	3	Growth Rate Factor		
	4	Maximum Amplitude Trip Setpoint		
	5	Growth Rate Amplitude Setpoint		
	6	Time Window for Minimum Threshold Setpoint		
	7	Time Window for Trip Setpoint		
	8	ABA and GRA Trip Hold Time Setpoint		
	9	Peak and Valley Detection Width Setpoint		
CAL	Off	Off	Off	Off
	Current Maximum Amplitude Trip Setpoint	New Maximum Amplitude Trip Setpoint	On	Off

Detailed description of the parameters shown in the table above (item numbers 1 through 4, and 6 through 9 indicated on "PARAMETER 1" numerical display) is shown in Table 4.1.2-2.
The "Growth Rate Amplitude Setpoint" is the setpoint calculated using the equation defined in Section 5.3.2.

1.3.3.2.3 Mode Selection and Display Function

The AGRD module has the Operation Mode/Sub-Mode described in Table 1.3.3.2.3-1.
The AGRD module has a key switch on the front panel to select Operation Mode.
The AGRD module has a "SELECT" push button on the front panel to select Sub-Mode.
The AGRD module indicates mode information described in Table 1.3.3.2.3-2 on the front panel LED.

Table 1.3.3.2.3-1 Mode Selection and Display Function of AGRD Module (1)

Mode	Sub-Mode	: Action
OP		: AGRD module performs normal measuring and monitoring
	Parameter	: AGRD module displays Parameters on the front panel display
STANDBY		: AGRD module performs normal measuring and monitoring : AGRD module generates "OPRM Inoperative signal"
	Parameter	: AGRD module displays parameters on the front panel display
CAL		: AGRD module generates "OPRM Inoperative signal"
	Smax	: AGRD module enables "Maximum Amplitude Trip Setpoint" modification

Table 1.3.3.2.3-2 Mode Selection and Display Function of AGRD Module (2)

Indication Item	Color
"OP" mode	Green
"STANDBY" mode	Yellow
"CAL" mode	Yellow
"Parameter" sub-mode	Green
"Smax" sub-mode	Yellow

1.3.3.2.4 Push Buttons

The AGRD module has the following buttons on the front panel for "Maximum Amplitude Trip Setpoint" adjustment, mode selection and alarm reset operation.

Table 1.3.3.2.4 Push Buttons on AGRD Module

Button Name	Purpose
"▶"	For selecting a digit position to set a value
"+"	For incrementing the value
"-"	For decrementing the value
"SET"	For setting the new (changed) values.
"RESET"	For resetting alarm indications
"SELECT"	For selecting an indication item of "PARAMETER1" and "Smax/PARAMETER2"

1.3.3.3 PBD Module HMI

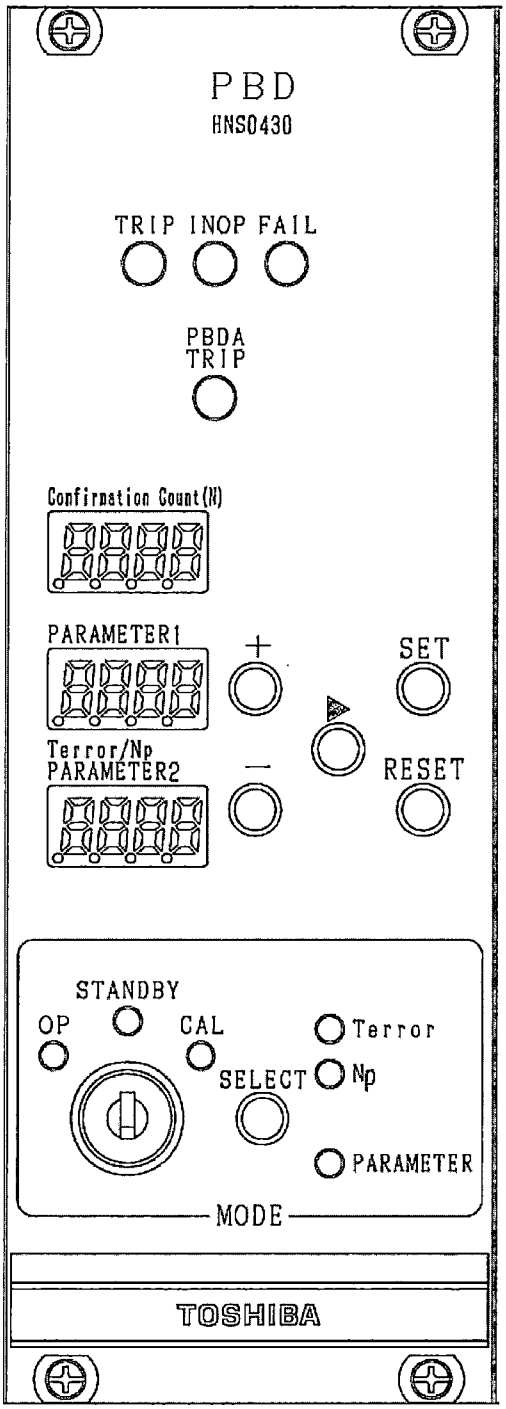


Figure 1.3.3.3 HMI of PBD Module

1.3.3.3.1 Alarm Displays

The PBD module has the following alarm displays.

Table 1.3.3.3.1 Alarm Displays on PBD Module

Indicator Name	Indication Item	LED Color	Operation
TRIP	PBDA Trip	Red	This LED turns on when the "PBDA Trip signal" is generated. The conditions for "PBDA Trip signal" generation are described in Section 5.3.3. The LED stays on until the "RESET" button on the PBD module is pressed after the trip signal is cleared.
INOP	OPRM Inoperative	Yellow	This LED turns on when "OPRM Inoperative signal" of the PBD module is generated. The conditions for "OPRM Inoperative signal" generation are shown in the "Assumed Cause" column of Table 6.4. The LED stays on until the "RESET" button on the PBD module is pressed after the OPRM Inoperative signal is cleared.
FAIL	OPRM Minor Failure	Yellow	This LED turns on when "OPRM Minor Failure signal" of the PBD module is generated. The conditions for "OPRM Minor Failure signal" generation are shown in the "Assumed Cause" column of Table 6.4. The LED stays on until the "RESET" button on the PBD module is pressed after the OPRM Minor Failure signal is cleared.
PBDA TRIP	PBDA Trip	Red	This LED turns on when the "PBDA Trip signal" is generated. The conditions for "PBDA Trip signal" generation are described in Section 5.3.3. The LED stays on until the "RESET" button on the PBD module is pressed after the PBDA Trip signal is cleared.

1.3.3.3.2 Numerical Displays

The PBD module has the following 3 numerical displays (4 digits 7-segment Light Emitting Diode (LED)).

- Confirmation Count (N)
- PARAMETER1
- Terror/Np/PARAMETER2

The "Confirmation Count (N)" display indicates a Confirmation Count used for PBDA Trip judgment (For more detailed explanation of PBDA Trip judgment, see Section 5.3.3). Indication is available for values from 0 through 127.

The "PARAMETER1" and "Terror/Np/PARAMETER2" displays indicate the numerical values listed below depending on the modes selected by the key switch on the front panel of the PBD module. One of the 3 indication items (i.e., "Terror," "Np" and "PARAMETER") is selected by using the "SELECT" push button. Every time the "SELECT" push button is pressed, the item selected switches in rotation, its corresponding status display LED turns on, and its value is shown on the 7-segment LED display.

Table 1.3.3.2.2 Numerical Displays and Related Status Displays on PBD Module

Mode	7 Segment LED			Status Display LED		
	Confirmation Count (N)	PARAMETER1	Terror/Np/ PARAMETER2	Terror	Np	PARAMETER
OP, STANDBY	Confirmation Count	Off	Off	Off	Off	Off
		1	Period Minimum Setpoint			On
		2	Period Maximum Setpoint			
		3	Period Tolerance Setpoint			
		4	Confirmation Count Trip Setpoint			
		5	Maximum Amplitude Trip Setpoiunt			
		6	PBDA Trip Hold Time Setpoint			
		7	Peak and Valley Detection Width Setpoint			
CAL		Off	Off	Off	Off	Off
		Current Period Tolerance Setpoint	New Period Tolerance Setpoint	On	Off	Off
		Current Confirmation Count Trip Setpoint	New Confirmation Count Trip Setpoint	Off	On	Off

Detailed description of the parameters shown in the table above (item numbers 1 through 7 indicated on "PARAMETER 1" numerical display) is shown in Table 4.1.2-3.

1.3.3.3.3 Mode Selection and Display Function

The PBD module has the Operation Mode/Sub-Mode described in Table 1.3.3.3.3-1.
The PBD module has a key switch on the front panel to select Operation Mode.
The PBD module has a "SELECT" push button on the front panel to select Sub-Mode.
The PBD module indicates mode information described in Table 1.3.3.3.3-2 on the front panel LED.

Table 1.3.3.3.3-1 Mode Selection and Display Function of PBD Module (1)

Mode	Sub-Mode	: Action
OP		: PBD module performs normal measuring and monitoring
	Parameter	: PBD module displays Parameters on the front panel display
STANDBY		: PBD module performs normal measuring and monitoring : PBD module generates "OPRM Inoperative Signal"
	Parameter	: PBD module displays parameters on the front panel display
CAL		: PBD module generates "OPRM Inoperative Signal"
	Setpoint Change	: PBD module enables "Period Tolerance" modification : PBD module enables "Confirmation Count Trip Setpoint" modification

Table 1.3.3.3.3-2 Mode Selection and Display Function of PBD Module (2)

Indication Item	Color
"OP" mode	Green
"STANDBY" mode	Yellow
"CAL" mode	Yellow
"Parameter" sub-mode	Green
"Period Tolerance" modify in "Setpoint Change" sub-mode (Terror)	Yellow
"Confirmation Count Trip Setpoint" in "Setpoint Change" sub-mode (Np)	Yellow

1.3.3.3.4 Push Buttons

The PBD module has the following buttons on the front panel for "Period Tolerance Setpoint (Te)" and "Confirmation Count Trip Setpoint (Np)" adjustment, mode selection and alarm reset operation.

Table 1.3.3.3.4 Push Buttons on PBD Module

Button Name	Purpose
"▶"	For selecting a digit position to set a value
"+"	For incrementing the value
"-"	For decrementing the value
"SET"	For setting the new (changed) values
"RESET"	For resetting alarm indications
"SELECT"	For selecting numerical displays and indication items

1.3.3.4 DAT/ST Module HMI

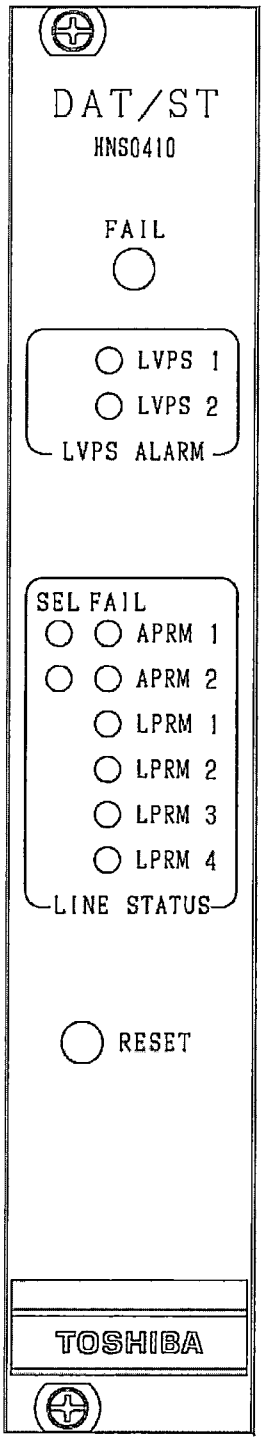


Figure 1.3.3.4 HMI of DAT/ST Module

1.3.3.4.1 Alarm Displays

The DAT/ST module has the following alarm displays, and a "RESET" push button to turn off alarm indications.

Table 1.3.3.4.1 Alarm Displays on DAT/ST Module

Indicator Name	Indication Item	LED Color	Operation
FAIL	OPRM Minor Failure	Yellow	This LED turns on when the conditions described in Section 5.7 are satisfied based on failure information from the modules in the OPRM unit. The conditions for "OPRM Minor Failure signal" generation of the DAT/ST module are shown in the "Assumed Cause" column of Table 6.4. The LED stays on until the "RESET" button on the DAT/ST module is pressed after the OPRM Minor Failure signal is cleared.
LVPS 1	LVPS module 1 power supply failure	Yellow	These LEDs turned on indicate what portion of OPRM unit functions is failed when the "OPRM Minor Failure signal" of the DAT/ST module is generated. The conditions for "OPRM Minor Failure signal" generation are shown in Section 5.7 and in the "Assumed Cause" column of Table 6.4. The LED stays on until the "RESET" button on the DAT/ST module is pressed after those alarm signals listed on the left are cleared.
LVPS 2	LVPS module 2 power supply failure	Yellow	
FAIL/APRM 1	APRM Unit 1 Data transmission failure	Yellow	
FAIL/APRM 2	APRM Unit 2 Data transmission failure	Yellow	
FAIL/LPRM 1	LPRM Unit 1 Data transmission failure	Yellow	
FAIL/LPRM 2	LPRM Unit 2 Data transmission failure	Yellow	
FAIL/LPRM 3	LPRM Unit 3 Data transmission failure	Yellow	
FAIL/LPRM 4	LPRM Unit 4 Data transmission failure	Yellow	

1.3.3.4.2 Status Displays

The DAT/ST module has the following status displays.

Table 1.3.3.4.2 Status Displays on DAT/ST Module

Indicator Name	Indication Item	LED Color	Operation
SEL/APRM 1	APRM Unit Data 1 is selected	Green	These LEDs turned on indicate what transmission port from APRM unit is selected for signal processing in the OPRM unit.
SEL/APRM 2	APRM Unit Data 2 is selected	Green	

1.3.3.5 TRN Module HMI

The TRN modules have following four indicators.

Table 1.3.3.5 Transmission Line Status Indicators on TRN Module

Indicator Name	LED Color	Operation
LINE STATUS -OUT1	Green or Orange	Green LED turns on during data transmission Orange LED turns on when data transmission stops.
LINE STATUS -OUT2		
LINE STATUS -OUT3		
LINE STATUS -OUT4		

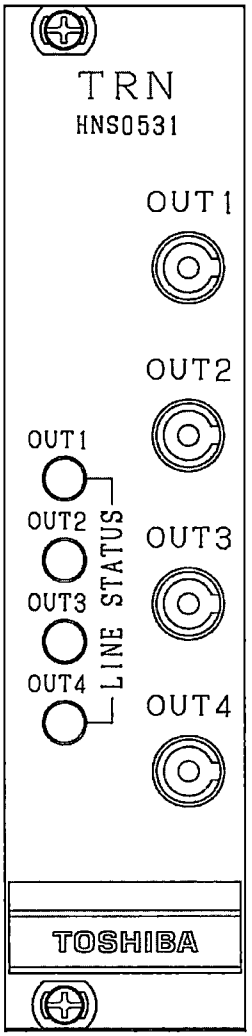


Figure 1.3.3.5 HMI of TRN Module

1.3.3.6 RCV Module HMI

The RCV modules have following four indicators.

Table 1.3.3.6 Transmission Line Status Indicators on RCV Module

Indicator Name	LED Color	Operation
LINE STATUS -IN1	Green	This LED turns on during data reception.
LINE STATUS -IN2		
LINE STATUS -IN3		
LINE STATUS -IN4		

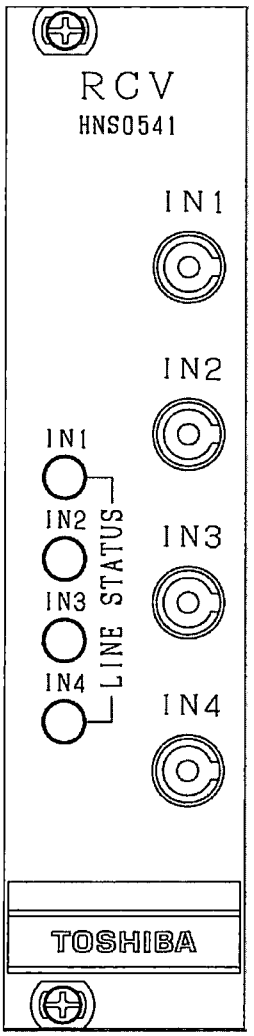
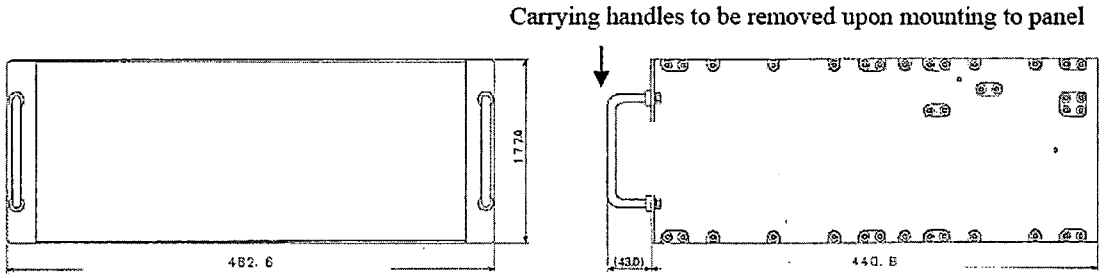


Figure 1.3.3.6 HMI of RCV Module

1.3.4 Dimensions and Mass

1.3.4.1 External Dimensions

177 mm (Height) ×482.6 mm (Width) ×440.8 mm (Depth)) (excluding protrusion)
(6.97 inch (Height) ×19.00 inch (Width) ×17.35 inch (Depth))



Front View (unit: mm) Right Side View (unit: mm)

Figure 1.3.4.1 External Dimensions of OPRM Unit

1.3.4.2 Mass

[ ]^{a,c}kg or less

1.3.5 Power Supply

The OPRM unit has two internal power supplies (LVPS modules) for redundancy. The LVPS modules are used with external Power Factor Correction module (PFC). The PFC receives Alternating Current (AC) voltage from an external AC power supply. The AC voltage is converted into DC voltage (about 220 VDC) by PFC. The PFC supplies the DC power to an LVPS module. The DC voltage from the PFC is converted into DC voltage (+5VDC, +15VDC, -15VDC) by the LVPS module. The LVPS module supplies the other modules inside the unit with the DC power.

1.3.5.1 Power Supply Requirements

There are two power supply lines to the OPRM unit for redundancy as shown in Figure 1.3.5.1. Turn on the two circuit breakers installed in the NMS Panel that are connected to redundant power supply lines to the OPRM unit.

Power supply requirements for one power supply line are as follows.

(1) Input Voltage 90 to 150VAC
(2) Frequency 57 to 63 Hz
(3) Input Current [ ]^{a,c}A or less (at 100VAC)
(4) Inrush Current [ ]^{a,c}A or less

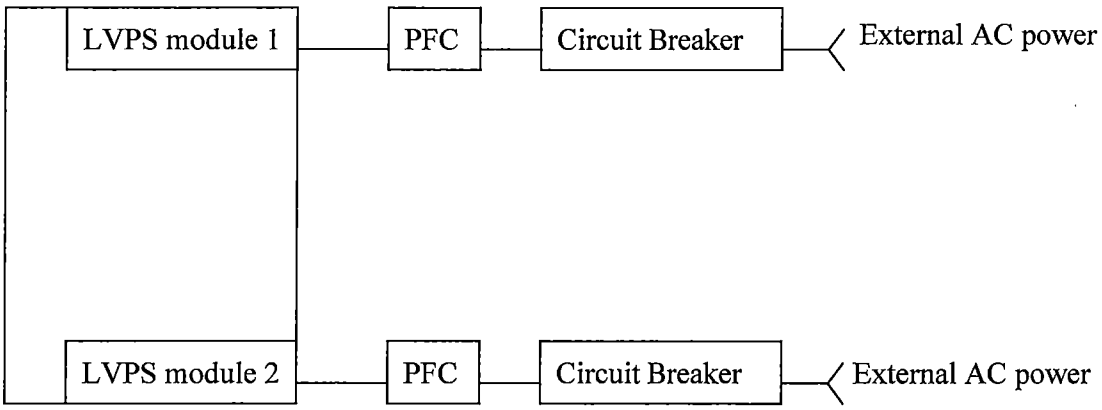


Figure 1.3.5.1 Redundant Power Supply Lines to OPRM Unit

1.3.6 Environmental Conditions

The NMS Panel that includes the OPRM unit is installed in the Main Control Room area where environment is mild. The environmental conditions, for which the OPRM unit is qualified based on environmental qualification requirements from EPRI TR-107330, are shown in Table 1.3.6.

Table 1.3.6 Environmental Conditions

	Normal Environmental Conditions	Abnormal Environmental Conditions
Temperature Range	Min 16°C(60°F), Max 40°C(104°F)	Min 4°C(40°F), Max 50°C(120°F)
Humidity Range	Min 40%, Max 95%*	Min 10%, Max 95%*
Radiation Exposure	10^3RADS	10^3RADS

*: non condensing

2 Acceptance, Storage and Installation of Product

2.1 Acceptance

Check the following after unpacking:

(1) Verify that the packing list matches the product received.

(2) Verify that there is no visible damage to the product.

2.2 Storage

2.2.1 Storage Conditions

Avoid storing the OPRM unit in the following environments to ensure long-term "stable" service. Such environments may cause damage to the unit appearance and functions, and result in its shorter life.

(1) Dusty areas

(2) Areas with corrosive gas (SO_2, H_2S) in the air

(3) Areas with high salinity environment

(4) Areas exposed to direct sunlight

(5) Areas with extremely low/high temperatures

(6) Areas exposed to water, vapor, and/or high humidity

2.2.2 Handling after Long-term Storage

Check the product for any discoloration, rust, and damage when using it after long-term storage (approximately one year). When no abnormality is found, supply the power (See Section 4.1.3) to the product, and measure and check each power supply voltage (+15 VDC, -15 VDC, and +5 VDC) at the front panel of the LVPS module before start using it (See Section 6.1.1 for voltage measurement of the LVPS module). If any abnormality is found, stop using the product immediately and contact our service representative.

2.3 Installation

2.3.1 Installation on Panel

The OPRM unit is mounted on the Neutron Monitoring System (NMS) Panel for use.

Before installing the unit, attach the rails for supporting the unit to the Panel.

For installing the unit, hold the front part and lower back of the unit in front of the Panel, adjust the unit position to the rails attached to the Panel, place the back of the unit onto the rails, and then evenly insert the unit all the way in.

Before starting the operation, fix the unit to the Panel with four fixing screws (M5 (metric screw)), two each for the right and left sides on the front surface, and eight fixing screws (M4 (metric screw)), four each for the right and left sides on the rear surface (Refer to Figure 1.2.2 for mounting holes on the unit).

⚠ CAUTION

■ **Be careful not to get your fingers caught between the panel and the unit when inserting the unit.**

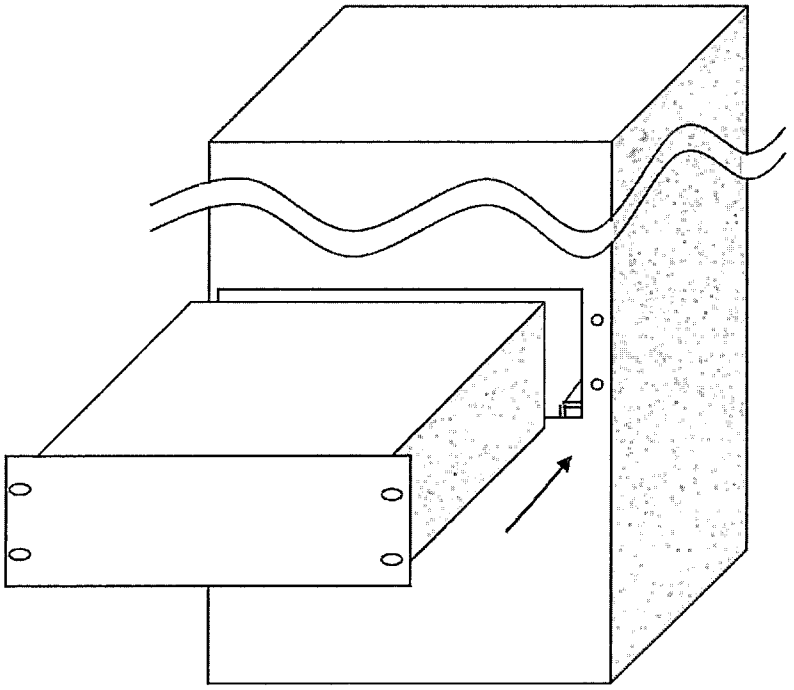


Figure 2.3.1 Installation of Unit

2.3.2 Connection

2.3.2.1 Connection to LVPS Module

Connect cable-wired MS connector plugs to the Power Input Connector ("AC Input") (connector type: [ ]^{a,c} or equivalent) of the LVPS modules. Assignment of the Power Input Connector pins is shown in Figure 2.3.2.1.

Refer to wiring diagram of NMS Panel and/or System O&M Manual for detailed cable wiring in the NMS Panel.

⚠ CAUTION

- **Be sure to connect the plugs correctly, as improper connection may cause injuries or burns due to failure of or damage to equipment.**

[ ]^{a,c}

Figure 2.3.2.1 Pin Assignment of Power Input Connector of LVPS Module

2.3.2.2 Connection to PFC

The "AC IN - L," "AC IN - N" terminals are connected to an external AC power source through a circuit breaker. The "AC IN - E" terminal is connected to a dedicated grounding point on flame chassis that is conducted to the grounding bus bar of NMS Panel.

The "DC OUT +," and "DC OUT -" terminals are connected to the "DC input (+)" and "DC input (-)" terminals of the LVPS module, respectively.

The PFCs are fixed to a dedicated area of NMS Panel with four screws (M4 (metric screw)).

Refer to wiring diagram of NMS Panel and/or System O&M Manual for detailed cable wiring in the NMS Panel.

Figure 2.3.2.2 Terminal Layout of PFC

2.3.2.3 Connection to DIO Module

Connect a dedicated plug connector that are wired with a cable to the Discrete Input/Output Connector (type: [ ]a or equivalent) of the DIO module. Assignment of the Discrete Input/Output Connector pins is shown in Figure 2.3.2.3. Use the plug connector that has Thick Guide Key and Thin Guide Key to meet the key positions of the Discrete Input/Output Connector shown in Figure 2.3.2.3.

There is a screw lock device in the center of the plug connector for fixing to the Discrete Input/Output Connector. Be sure to secure the plug connector after connection.

Refer to wiring diagram of NMS Panel and/or System O&M Manual for detailed cable wiring in the NMS Panel.

Slot No.	Module Type	Thick Guide Key Position	Thin Guide Key Position
BSL4	HNS520	2	1

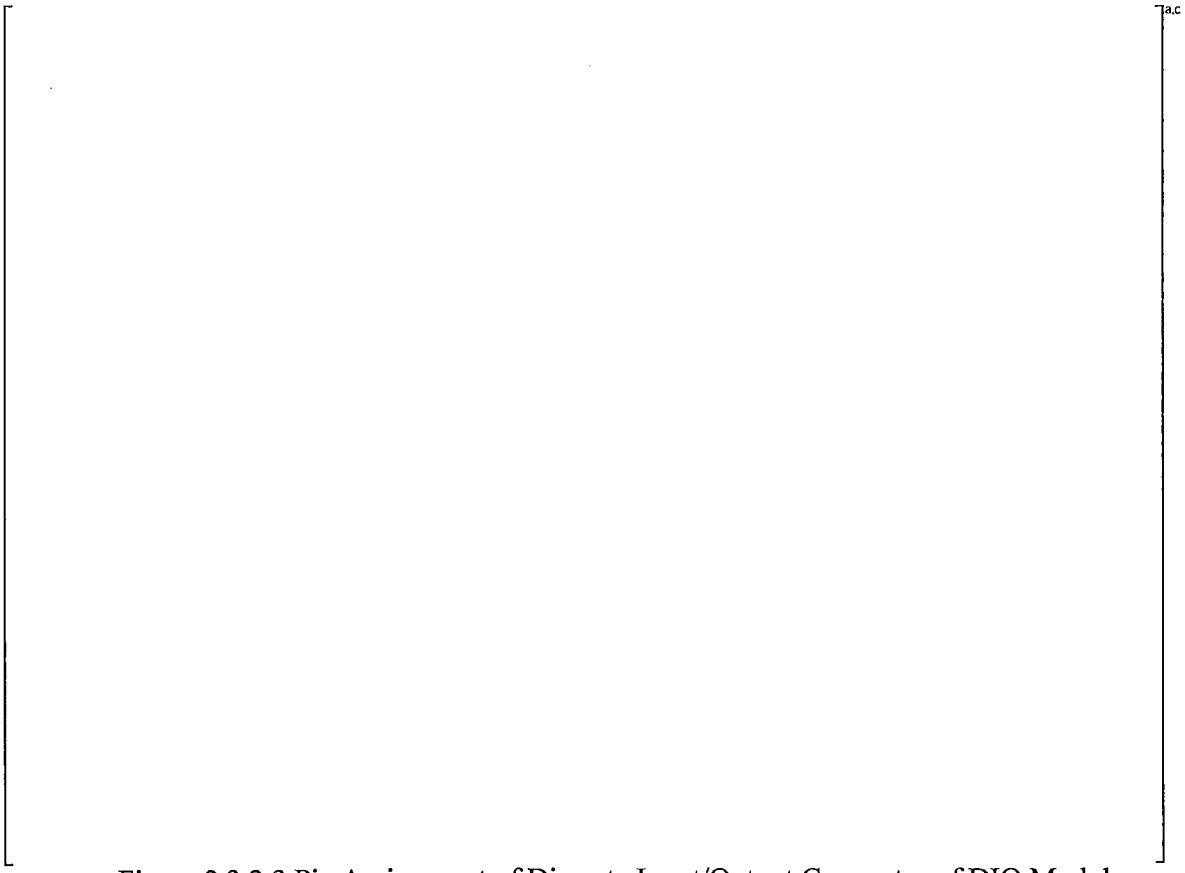


Figure 2.3.2.3 Pin Assignment of Discrete Input/Output Connector of DIO Module

2.3.2.4 Connection to TRN Module and RCV Module

Connect the FC-type plug connector with optic cable to the Optical Output Connectors of the TRN modules. Connect the FC-type plug connector with optic cable to the Optical Input Connectors of the RCV modules.

When inserting the plug, align the key of the plug with the key groove of the jack connector and tighten the plug securely.

Refer to wiring diagram of NMS Panel and/or System O&M Manual for detailed cable wiring in the NMS Panel.

2.3.2.5 Connection to Ground Terminal

Connect the ground (earth) cable wired in the NMS Panel to the Ground Terminal (FG) of the OPRM unit.

Refer to wiring diagram of NMS Panel and/or System O&M Manual for detailed cable wiring in the NMS Panel.

⚠ WARNING	
 Connect to Ground	■ **This terminal must be grounded before power activation.** Leakage of current due to equipment failure will cause electric shock.

3 Prohibitions and Precautions for Handling

⚠CAUTION	
	■ **Do not insert the modules mounted on the OPRM unit into any other units.** Application of unspecified voltage may result in failure. ■ **Do not insert the modules mounted on the OPRM unit into slots other than the specified slot.** Application of unspecified voltage may result in failure. ■ **Do not inspect inside the unit or operate internal switches while the unit power is on.** Failure to follow the instruction could result in electric shocks. ■ **Do not disassemble this unit and/or the modules.** Disconnection or improper connection may result in malfunctions. ■ **Do not modify this unit.** ■ **Do not use or store the unit in an environment exposed to condensation due to water or humidity.** Using the unit with condensation may result in electric shocks. ■ **Do not drop or hit the modules when mounting or dismounting.** ■ **Do not touch the parts or surfaces of the modules mounted on the unit without taking static electricity measures.**
	■ **Be sure to turn the unit power off before mounting/dismounting the modules for the unit.** ■ **Be sure to insert the modules into the unit firmly.** ■ **Implement the system design if this unit is used together with other equipment so that failure of the unit will not affect the safety of the plant and/or process.**

4 Operation

This section describes the basics of operating the OPRM unit. Read and thoroughly understand the instruction manual of each module before operating them. Settings of the modules must be made before power-on in accordance with each manual.

4.1 Preparation for Operation

4.1.1 Visual Inspection of Unit and Modules

Visually check if there are any damages or removed parts before using the unit.

4.1.2 Parameter Setting Check

Default parameters are set for the CELL, AGRD, PBD, RCV, and TRN modules. Values of factory settings are shown in the following tables. Although following tables show factory setting, if there is a plant-specific parameter based on plant operation experience, set the plant-specific parameter. For change of parameters, record the changed parameters and control those parameters in accordance with plant configuration control procedures.

Procedures to set parameters are as shown below.

Table 4.1.2-1 List of Parameters of CELL Module

Parameter	Setting Method	Setting Range	Factory Setting
LPRM Lower-limit Setpoint	Digital switch on Printed Circuit Board (PCB)	0.0 to 99.9%	5.0%
Conditioning Filter Cut-off Frequency Setpoint		0.500 to 3.500 Hz	1.000 Hz
Minimum Number of Active OPRM Cell Setpoint		0 to 44	32
OPRM Region APRM Level setpoint		0.0 to 99.9%	30.0%
OPRM Region Core Flow Level setpoint		0.0 to 99.9%	60.0%
OPRM Region APRM Level Hysteresis setpoint		0 to 9% FS	1% FS
OPRM Region Core Flow Level Hysteresis setpoint		0 to 9% FS	1% FS
Minimum Number of Active LPRMs		1 to 3	2
Time Average Filter Cut-off Frequency setpoint	Front panel operation	0.100 to 1.500 Hz	0.167 Hz

These setpoints except "Time Average Filter Cut-off Frequency setpoint" can be set using digital switch on printed circuit boards of the CELL module. See the instruction manual of the CELL module for parameter setting methods.

The operations to change "Time Average Filter Cut-off Frequency setpoint" are described in Section 4.3.1.

Table 4.1.2-2 List of Parameters of AGRD Module

Parameter	Setting Method	Setting Range	Factory Setting
Threshold Setpoint (S1)	Digital switch on PCB	1.00 to 1.99	1.10
Minimum Threshold Setpoint (S2)		0.50 to 1.99	0.92
Growth Rate Factor (DR3)		1.00 to 1.99	1.30
Maximum Amplitude Trip Setpoint (Smax)	Front panel operation	1.00 to 1.99	1.30
Time Window for Minimum Threshold Setpoint (Tl)	Digital switch on PCB	0.00 to 0.99s	0.31s
Time Window for Trip Setpoint (Th)		0.00 to 9.99s	2.20s
ABA and GRA Trip Hold Time Setpoint		0.0 to 9.9s	[ ]^{a,c}
Peak and Valley Detection Width Setpoint		0.001 to 0.010	0.001

These setpoints except "Maximum Amplitude Trip Setpoint" can be set using digital switch on printed circuit boards of the AGRD module. See the instruction manual of the AGRD module for parameter setting methods.

The operations to change "Maximum Amplitude Trip Setpoint" are described in Section 4.3.2.

Table 4.1.2-3 List of Parameters of PBD Module

Parameter	Setting Method	Setting Range	Factory Setting
Period Minimum Setpoint (Tmin)	Digital switch on PCB	0.00 to 9.99s	1.00s
Period Maximum Setpoint (Tmax)		0.00 to 9.99s	3.50s
Period Tolerance Setpoint (Te)	Front panel operation	0.000 to 0.999s	0.150s
Confirmation Count Trip Setpoint (Np)*		0 to 99	10
PBDA Amplitude Trip Setpoint (Sp)	Digital switch on PCB	1.00 to 1.99	1.10
PBDA Trip Hold Time Setpoint		0.0 to 9.9s	[ ]^{a,c}
Peak and Valley Detection Width Setpoint		0.001 to 0.010	0.001

*Note: The Confirmation Count (N) is the number of successive peaks and valleys of the Normalized Oscillation Signal (St) that is counted when the peaks and valleys have a period within a certain range. A PBDA Trip is generated when the Confirmation Count (N) continues for more than Confirmation Count Trip Setpoint (Np) and the Normalized Oscillation Signal (St) exceeds the PBDA Amplitude Trip Setpoint (Sp). Refer to Section 5.3.3 for detailed explanation of the PBDA Trip judgment.

These setpoints except "Period Tolerance Setpoint (Te)" and "Confirmation Count Trip Setpoint (Np)" can be set using digital switch on printed circuit boards of the PBD module. See the instruction manual of the PBD module for parameter setting methods.

The operations to change "Period Tolerance Setpoint (Te)" and "Confirmation Count Trip Setpoint (Np)" are described in Sections 4.3.3 and 4.3.4.

Table 4.1.2-4 List of Parameters of RCV Module

Module Type /Slot ID	Mounted Unit Channel*1	Setting of Digital Switch on RCV module			
		SW1	SW2	SW3	SW4
RCV Module (#1) /BSL5 (data reception from LPRM units)	OPRM (A)	[			]a,c
	OPRM (B)				
	OPRM (C)				
	OPRM (D)				
RCV Module (#2) /BSL6 (date reception from APRM unit)	OPRM (A)				
	OPRM (B)				
	OPRM (C)				
	OPRM (D)				
Optical Input Port Number		IN1	IN2	IN3	IN4

*1 OPRM (A) to (D) means four redundant OPRM channels in the PRNM System.

These parameters can be set using digital switch on printed circuit boards of the RCV module. See the instruction manual of the RCV module for parameter setting methods.

Table 4.1.2-5 List of Parameters of TRN Module

Module Type /Slot ID	Mounted Unit Channel*1	Setting of Digital Switch on TRN module			
		SW1	SW2	SW3	SW4
TRN Module (#1) /BSL7 (data transmission to ELCS and [ ]a,c	OPRM (A)	[			]a,c
	OPRM (B)				
	OPRM (C)				
	OPRM (D)				
TRN Module (#2) /BSL8 (data transmission to TDR)	OPRM (A)				
	OPRM (B)				
	OPRM (C)				
	OPRM (D)				
Optical Output Port Number		OUT1	OUT2	OUT3	OUT4

*1 OPRM (A) to (D) means four redundant OPRM channels in the PRNM System.

These parameters can be set using digital switch on printed circuit boards of the TRN module. See the instruction manual of the TRN module for parameter setting methods.

4.1.3 Power Activation

⚠ CAUTION	
●	■ **Take safety measures (Bypass the corresponding OPRM channel) first and then change the mode of each module. For OPRM channel bypass method, see system O&M manual.** An inoperative alarm is generated if the mode is changed by the key switch from "OP" mode to "CAL" or "STANDBY" mode during the corresponding OPRM channel not bypassed. The OPRM is a functional subsystem of the Average Power Range Monitor (APRM). There are four OPRM channels, with each OPRM as part of the each APRM channel. Bypass of one APRM channel also bypass one corresponding OPRM channel. Refer to System O&M Manual to bypass the corresponding OPRM channel.

Make sure to bypass the OPRM channel before taking the following procedure. See "CAUTION" above.

Make sure all the modules have been mounted on the OPRM unit before supplying power to the unit.

a. Insert the key into the key switch of the CELL module and turn to "STANDBY" position.

b. Insert the key into the key switch of the AGRD module and turn to "STANDBY" position.

c. Insert the key into the key switch of the PBD module and turn to "STANDBY" position.

d. Turn on the two circuit breakers installed in the NMS Panel that are connected to redundant power supply lines to the OPRM unit. Do not turn the power on/off by plugging/unplugging the connector to the LVPS module.

e. The "POWER" indicator (LED (green)) of the LVPS module turns on.

4.2 Module Operation

⚠ CAUTION	
●	■ **Take safety measures (Bypass the corresponding OPRM channel) first and then change the mode of each module. For OPRM channel bypass method, see system O&M manual.** An inoperative alarm is generated if the mode is changed by the key switch from "OP" mode to "CAL" or "STANDBY" mode during the corresponding OPRM channel not bypassed. The OPRM is a functional subsystem of the Average Power Range Monitor (APRM). There are four OPRM channels, with each OPRM as part of the each APRM channel. Bypass of one APRM channel also bypass one corresponding OPRM channel. Refer to System O&M Manual to bypass the corresponding OPRM channel.

Make sure to bypass the OPRM channel before taking the following procedure. See "CAUTION" above.

a. Insert the key into the key switch of the CELL module and turn to "OP" (Operation) position. Detailed explanation of each mode and sub-mode of the CELL module is shown in Section 1.3.3.1.4.

b. Insert the key into the key switch of the AGRD module and turn to "OP" (Operation) position. Detailed explanation of each mode and sub-mode of the AGRD module is shown in Section 1.3.3.2.3.

c. Insert the key into the key switch of the PBD module and turn to "OP" (Operation) position. Detailed explanation of each mode and sub-mode of the PBD module is shown in Section 1.3.3.3.3.

d. Whenever the key is turned to the position other than "OP," the OPRM Inoperative signal is generated and the "INOP" LED (yellow) turns on. After turning the key to "OP" position, press the "RESET" button to clear the "INOP."

e. Check if the alarm displays of the CELL, AGRD, PBD, and DAT/ST modules (see Sections 1.3.3.1.1, 1.3.3.2.1, 1.3.3.3.1, and 1.3.3.4.1 respectively) other than "INOP" are on. If they are on, press the "RESET" button of each module to turn them off.

See Section 6.4 "Failure Diagnosis and Measures" if alarm displays do not turn off.

The OPRM unit will enter the normal measurement/monitoring status now.

After all the modules on the OPRM unit are ready as above, cancel "Bypass" of the OPRM channel. See "CAUTION" above in this section.

The keys during operation must be controlled in accordance with plant operation procedures to prevent misoperation of the key switches.

4.3 Front Panel Setpoint Adjustment

The "Time Average Filter Cut-off Frequency setpoint," "Maximum Amplitude Trip Setpoint," "Period Tolerance Setpoint (Te)," and "Confirmation Count Trip Setpoint (Np)" can be adjusted through front panel operations during "CAL" mode.

Operational procedures are described in the following subsections.

⚠ CAUTION	
	■ **Take safety measures (Bypass the corresponding OPRM channel) first and then change the mode of each module. For OPRM channel bypass method, see system O&M manual.** An inoperative alarm is generated if the mode is changed by the key switch from "OP" mode to "CAL" or "STANDBY" mode during the corresponding OPRM channel not bypassed. The OPRM is a functional subsystem of the Average Power Range Monitor (APRM). There are four OPRM channels, with each OPRM as part of the each APRM channel. Bypass of one APRM channel also bypass one corresponding OPRM channel. Refer to System O&M Manual to bypass the corresponding OPRM channel.

4.3.1 Time Average Filter Cut-off Frequency Setpoint

Make sure to bypass the OPRM channel subject to "Time Average Filter Cut-off Frequency setpoint" change before taking the following procedure. See "CAUTION" in Section 4.3.

a. Turn the key switch of the CELL module to "CAL" position.

b. Press the "SELECT3" button on the right side of the key switch four times to turn on the "fa" LED (yellow). The current setpoint is displayed on the "PARAMETER1" display, and the input value to be changed is displayed on the "PARAMETER2" display.

c. Press the "▶" button to select a digit position to set a value. The selected digit starts blinking. Press the "+" button to increment the value. Press the "-" button to decrement the value.

d. After entering 4 numerical digits, press both of the "SET" and "fa SET" (SELECT2) buttons at the same time to complete the "Time Average Filter Cut-off Frequency setpoint" change. The "PARAMETER1" display is updated.

e. After setpoint change is completed, return the key switch of the CELL module to "OP" position and press the "RESET" button. The "INOP" LED turns off. Make sure no other alarms or failures are indicated on the LEDs.

After changing the setpoint, cancel "Bypass" of the OPRM channel. See "CAUTION" in Section 4.3.

4.3.2 Maximum Amplitude Trip Setpoint

Make sure to bypass the OPRM channel subject to "Maximum Amplitude Trip Setpoint" change before taking the following procedure. See "CAUTION" in Section 4.3.

a. Turn the key switch of the AGRD module to "CAL" position.

b. Press the "SELECT" button on the right side of the key switch to turn on the "Smax" LED (yellow). The current setpoint is displayed on the "PARAMETER1" display, and the input value to be changed is displayed on the "PARAMETER2" display.

c. Press the "▶" button to select a digit position to set a value. The selected digit starts blinking. Press the "+" button to increment the value. Press the "-" button to decrement the value.

d. After entering 3 numerical digits, press the "SET" button to complete the "Maximum Amplitude Trip Setpoint" change. The "PARAMETER1" display is updated.

e. After setpoint change is completed, return the key switch of the AGRD module to "OP" position and press the "RESET" button. The "INOP" LED turns off. Make sure no other alarms or failures are indicated on the LEDs.

After changing the setpoint, cancel "Bypass" of the OPRM channel. See "CAUTION" in Section 4.3.

4.3.3 Period Tolerance Setpoint

Make sure to bypass the OPRM channel subject to "Period Tolerance Setpoint (Te)" change before taking the following procedure. See "CAUTION" in Section 4.3.

a. Turn the key switch of the PBD module to "CAL" position.

b. Press the "SELECT" button on the right side of the key switch to turn on the "Terror" LED (yellow). The current 4-digit setpoint is displayed on the "PARAMETER1" display, and the input value to be changed is displayed on the "PARAMETER2" display.

c. Press the "▶" button to select a digit position to set a value. The selected digit starts blinking. Press the "+" button to increment the value. Press the "-" button to decrement the value.

d. After entering 4 numerical digits, press the "SET" button to complete the setpoint change. The "PARAMETER1" display is updated.

e. After setpoint change is completed, return the key switch of the PBD module to "OP" position and press the "RESET" button. The "INOP" LED turns off. Make sure no other alarms or failures are indicated on the LEDs.

After changing those setpoints, cancel "Bypass" of the OPRM channel. See "CAUTION" in Section 4.3.

4.3.4 Confirmation Count Trip Setpoint

Make sure to bypass the OPRM channel subject to "Confirmation Count Trip Setpoint (Np)" change before taking the following procedure. See "CAUTION" in Section 4.3.

a. Turn the key switch of the PBD module to "CAL" position.

b. Press the "SELECT" button on the right side of the key switch twice to turn on the "Np" LED (yellow). The current 2-digit setpoint is displayed on the "PARAMETER1" display, and the input value to be changed is displayed on the "PARAMETER2" display.

c. Press the "▶" button to select a digit position to set a value. The selected digit starts blinking. Press the "+" button to increment the value. Press the "-" button to decrement the value.

d. After entering 2 numerical digits, press the "SET" button to complete the setpoint change. The "PARAMETER1" display is updated.

e. After setpoint change is completed, return the key switch of the PBD module to "OP" position and press the "RESET" button. The "INOP" LED turns off. Make sure no other alarms or failures are indicated on the LEDs.

After changing those setpoints, cancel "Bypass" of the OPRM channel. See "CAUTION" in Section 4.3.

4.4 Emergency Operation

4.4.1 Operation in Case of Failure

Perform a failure diagnosis and identify failed equipment in accordance with Section 6.4 "Failure Diagnosis and Measures."

4.4.2 If Smoke or Fire is Detected

Immediately cut off the power supply to the unit. Turn off the two circuit breakers installed in the NMS Panel that are connected to redundant power supply lines to the OPRM unit. Do not turn the power off by unplugging the connector to the LVPS module.

⚠ CAUTION	
	■ **Immediately cut off power supply, if smoke or fire is detected.**

5 Functional Description

The following subsections are organized to explain the OPRM unit functions.

5.1 Normalized Oscillation Signal Calculation Function

5.2 OPRM Automatic Bypass Function

5.3 Trip Judgement Function

5.4 Discrete Input/Output Function

5.5 Optical Signal Transmitter

5.6 Optical Signal Receiver

5.7 Unit Status Display

5.1 Normalized Oscillation Signal Calculation Function

A second-order Butterworth filter is applied to the 52 LPRM input signals (LPRM Levels) for noise removal (Filtered Flux). The CELL module assigns LPRM Levels to the OPRM Cells in accordance with the OPRM Cell Information Table (See Figure 5.1 and Tables 5.1-1 and 5.1-2.).

Note: The OPRM unit for ABWR is configured with 44 Cells for the 52 LPRM Levels.

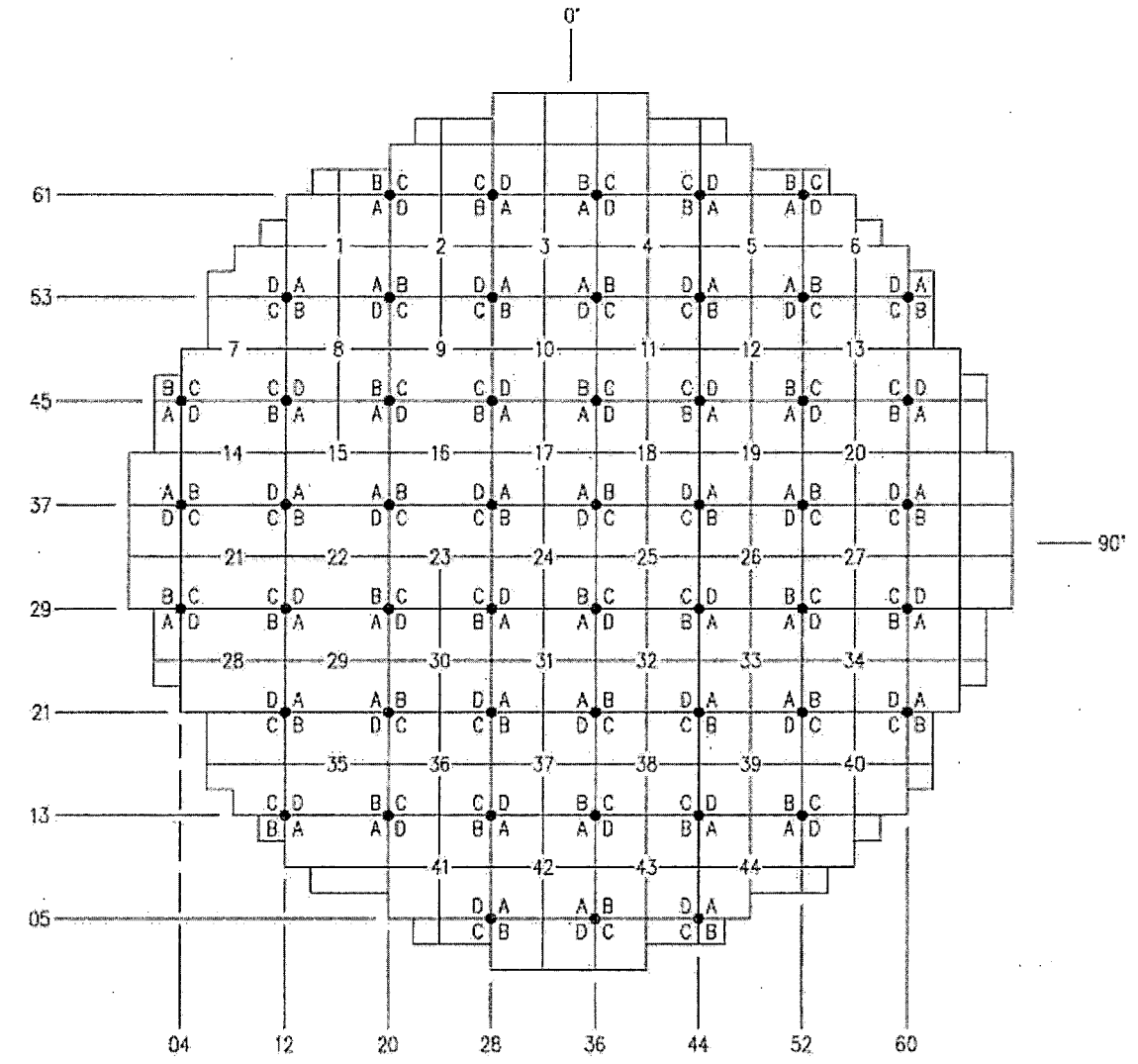
The "Averaged Flux" of each cell is calculated from the valid LPRM Levels (Filtered Flux) assigned to the 44 Cells using the following formula:

$$\text{Averaged Flux} = \text{Filtered Flux} / \text{Number of Active LPRMs}$$

Then, the Second-order Butterworth filter is applied to respective "Averaged Flux", and the "Time Averaged Flux" is calculated. The "Normalized Oscillation Signal" is obtained by normalizing the "Averaged Flux" using this "Time Averaged Flux."

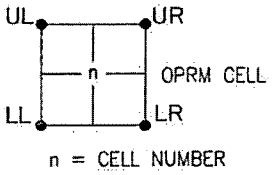
The "Normalized Oscillation Signal" is obtained by the following formula:

$$\text{Normalized Oscillation Signal} = \text{Averaged Flux}/\text{Time Averaged Flux}$$



A B / D C — LPRMs providing input to OPRM Divisions I,II,III,IV

Upper Left Letter = Input for OPRM Division I
Upper Right Letter = Input for OPRM Division II
Lower Right Letter = Input for OPRM Division III
Lower Left Letter = Input for OPRM Division IV
(Letter in the core map refer to LPRM detectors A,B,C,D per assembly)



n = CELL NUMBER

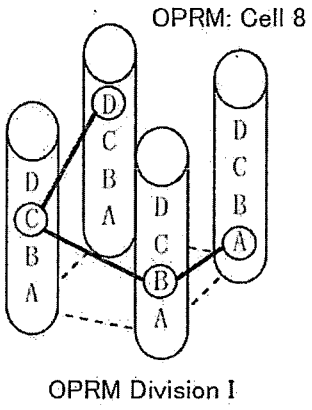


Figure 5.1 Core Map and OPRM Cell

Table 5.1-1 Assignment of LPRM Detectors to OPRM Unit

		Division	I	II	III	IV			Division	I	II	III	IV
		LPRM	A1	B1	C1	D1			LPRM	A2	B2	C2	D2
Detector		LPRM Detector Location	Axial Position				Detector		LPRM Detector Location	Axial Position			
Unit Input Connector	CH1	20-61	B	C	D	A	Unit Input Connector	CH14	28-61	C	D	A	B
	CH2	52-61	B	C	D	A		CH15	36-53	A	B	C	D
	CH3	12-53	D	A	B	C		CH16	20-45	B	C	D	A
	CH4	44-53	D	A	B	C		CH17	52-45	B	C	D	A
	CH5	28-45	C	D	A	B		CH18	04-37	A	B	C	D
	CH6	60-45	C	D	A	B		CH19	12-37	D	A	B	C
	CH7	36-37	A	B	C	D		CH20	44-37	D	A	B	C
	CH8	20-29	B	C	D	A		CH21	28-29	C	D	A	B
	CH9	52-29	B	C	D	A		CH22	60-29	C	D	A	B
	CH10	12-21	D	A	B	C		CH23	36-21	A	B	C	D
	CH11	44-21	D	A	B	C		CH24	20-13	B	C	D	A
	CH12	28-13	C	D	A	B		CH25	52-13	B	C	D	A
	CH13	36-05	A	B	C	D		CH26	44-05	D	A	B	C

		Division	I	II	III	IV			Division	I	II	III	IV
		LPRM	A3	B3	C3	D3			LPRM	A4	B4	C4	D4
Detector		LPRM Detector Location	Axial Position				Detector		LPRM Detector Location	Axial Position			
Unit Input Connector	CH27	36-61	B	C	D	A	Unit Input Connector	CH40	44-61	C	D	A	B
	CH28	28-53	D	A	B	C		CH41	20-53	A	B	C	D
	CH29	60-53	D	A	B	C		CH42	52-53	A	B	C	D
	CH30	12-45	C	D	A	B		CH43	04-45	B	C	D	A
	CH31	44-45	C	D	A	B		CH44	36-45	B	C	D	A
	CH32	20-37	A	B	C	D		CH45	28-37	D	A	B	C
	CH33	52-37	A	B	C	D		CH46	60-37	D	A	B	C
	CH34	04-29	B	C	D	A		CH47	12-29	C	D	A	B
	CH35	36-29	B	C	D	A		CH48	44-29	C	D	A	B
	CH36	28-21	D	A	B	C		CH49	20-21	A	B	C	D
	CH37	60-21	D	A	B	C		CH50	52-21	A	B	C	D
	CH38	12-13	C	D	A	B		CH51	36-13	B	C	D	A
	CH39	44-13	C	D	A	B		CH52	28-05	D	A	B	C

Table 5.1-2 Assignment of LPRM CH to OPRM Cell

Cell No.	UL*	UR*	LL*	LR*	Cell No.	UL*	UR*	LL*	LR*
	LPRM CH in Division**					LPRM CH in Division**			
1	–	1	3	41	23	32	45	8	21
2	1	14	41	28	24	45	7	21	35
3	14	27	28	15	25	7	20	35	48
4	27	40	15	4	26	20	33	48	9
5	40	2	4	42	27	33	46	9	22
6	2	–	42	29	28	34	47	–	10
7	–	3	43	30	29	47	8	10	49
8	3	41	30	16	30	8	21	49	36
9	41	28	16	5	31	21	35	36	23
10	28	15	5	44	32	35	48	23	11
11	15	4	44	31	33	48	9	11	50
12	4	42	31	17	34	9	22	50	37
13	42	29	17	6	35	10	49	38	24
14	43	30	18	19	36	49	36	24	12
15	30	16	19	32	37	36	23	12	51
16	16	5	32	45	38	23	11	51	39
17	5	44	45	7	39	11	50	39	25
18	44	31	7	20	40	50	37	25	–
19	31	17	20	33	41	24	12	–	52
20	17	6	33	46	42	12	51	52	13
21	18	19	34	47	43	51	39	13	26
22	19	32	47	8	44	39	25	26	–

* Refer to Figure 5.1

** Refer to Figure 5.1-1

5.2 OPRM Automatic Bypass Function

The OPRM unit performs its intended safety functions in the OPRM Region when the both of the following conditions are satisfied.

1. APRM Level ≥ OPRM Region APRM Level setpoint
2. Core Flow Level ≤ OPRM Region FLOW Level setpoint

Otherwise, the OPRM unit enters the "OPRM Auto Bypass" state and the "BYP" LED on the CELL module turns on.

There is a hysteresis for each setpoint for stable judgment processing preventing unexpected generation and recovery of bypass function in a short period of time.

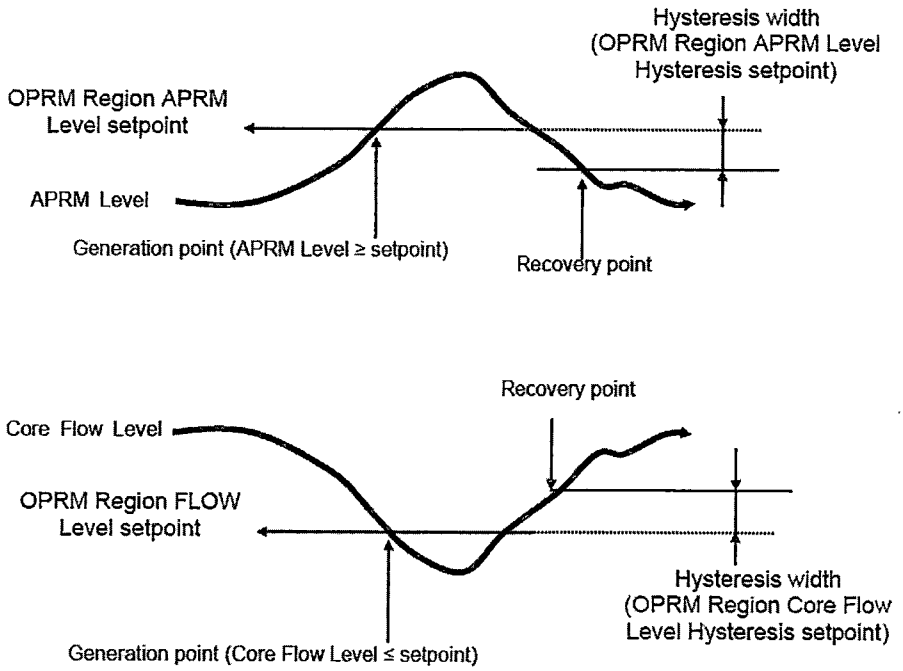


Figure 5.2 Outline of OPRM Region and Automatic OPRM Bypass Function

5.3 Trip Judgment Function

5.3.1 ABA Trip Judgment

Figure 5.3.1 shows an illustrative outline of Amplitude-Based Maximum Trip (ABA Trip) judgment.

In ABA Trip calculation, when the peak value of the "Normalized Oscillation Signal (St)" exceeds the "Threshold Setpoint (S1)," the valley value of the St is compared with the "Minimum Threshold Setpoint (S2)" as the next step. If the valley value of the St decreases below S2 within a specified time period (greater than the "Time Window for Minimum Threshold (Tℓ)" and less than the "Time Window for Trip Setpoint (Th)"), the next peak value of St is compared with the "Maximum Amplitude Trip Setpoint (Smax)." If the St exceeds Smax within a specified time period (greater than the Tℓ and less than the Th), ABA Trip signal is generated. ABA Trip judgment is continued even after the first trip generation.

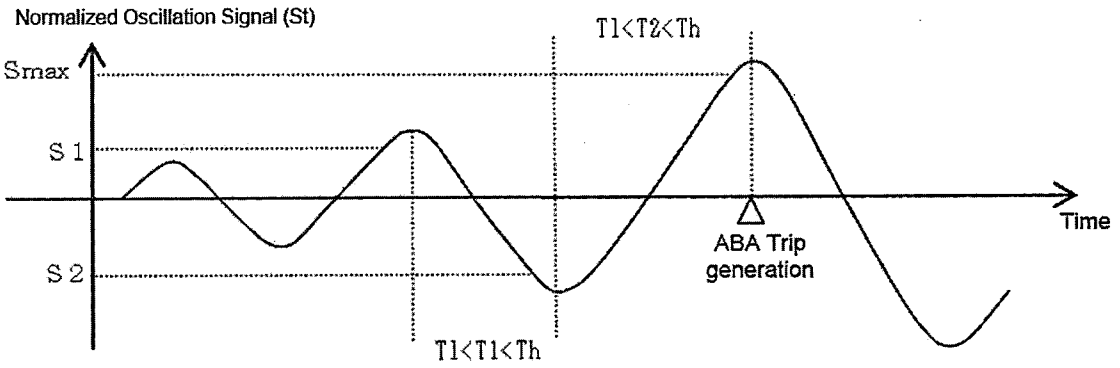


Figure 5.3.1 Outline of ABA Trip

5.3.2 GRA Trip Judgment

Figure 5.3.2 shows an illustrative outline of Growth Rate-Based Trip (GRA Trip) judgment.

GRA Trip is judged by the growth rate of the oscillation of the "Normalized Oscillation Signal (St)." Its algorithm is similar to that of ABA Trip and is performed in the same process. After oscillation is confirmed by comparison with the "Minimum Threshold Setpoint (S2)" in ABA Trip judgment process, the "Growth Rate Amplitude Setpoint (S3)" is calculated from the peak value of the previous cycle of the St ("First Peak Value (P1)") and the "Growth Rate Factor (DR3)" according to the below formula.

$$\text{Growth Rate Amplitude Setpoint (S3)} = (\text{P1}-1.0) \times \text{DR3} + 1.0$$

GRA Trip signal is generated when the "Normalized Oscillation Signal (St)" exceeds the S3. GRA Trip judgment is continued even after the first trip generation.

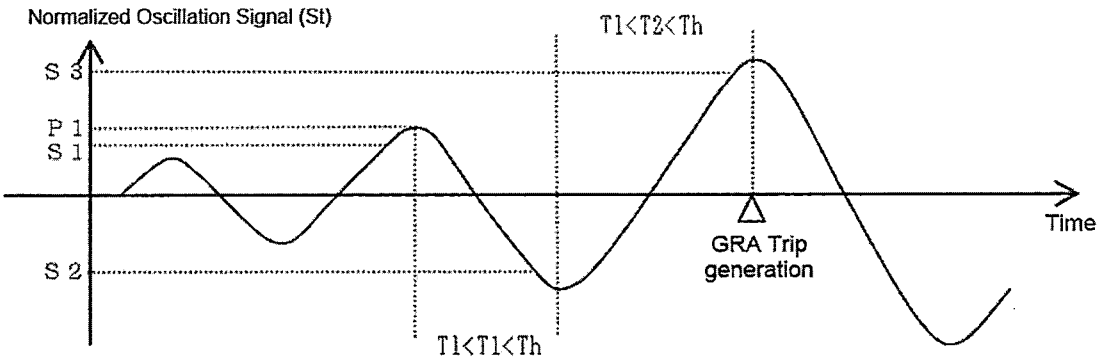


Figure 5.3.2 Outline of GRA Trip

5.3.3 PBDA Trip Judgment

Figure 5.3.3 shows an illustrative outline of Period-Based Trip (PBDA Trip) judgment when the Confirmation Count Trip Setpoint (Np) is set to 10.

The PBDA Trip is an algorithm that detects the oscillation of the "Normalized Oscillation Signal (St)" with a specific cycle. The "Confirmation Count (N)" is used together with the "PBDA Amplitude Trip Setpoint (Sp)" for PBDA Trip judgment. A PBDA Trip is generated if both of the following conditions are satisfied. The cycle count and the PBDA Trip judgment are continued even after the first trip generation.

1. Successive oscillation of Normalized Oscillation Signal (St) in a specific period range (longer than "Period Minimum Setpoint (Tmin)" and shorter than "Period Maximum Setpoint (Tmax)") continues for more than the "Confirmation Count Trip Setpoint (Np)." (i.e. Confirmation Count (N) ≥ Confirmation Count Trip Setpoint (Np))
2. Normalized Oscillation Signal (St) exceeds the "PBDA Amplitude Trip Setpoint (Sp)."

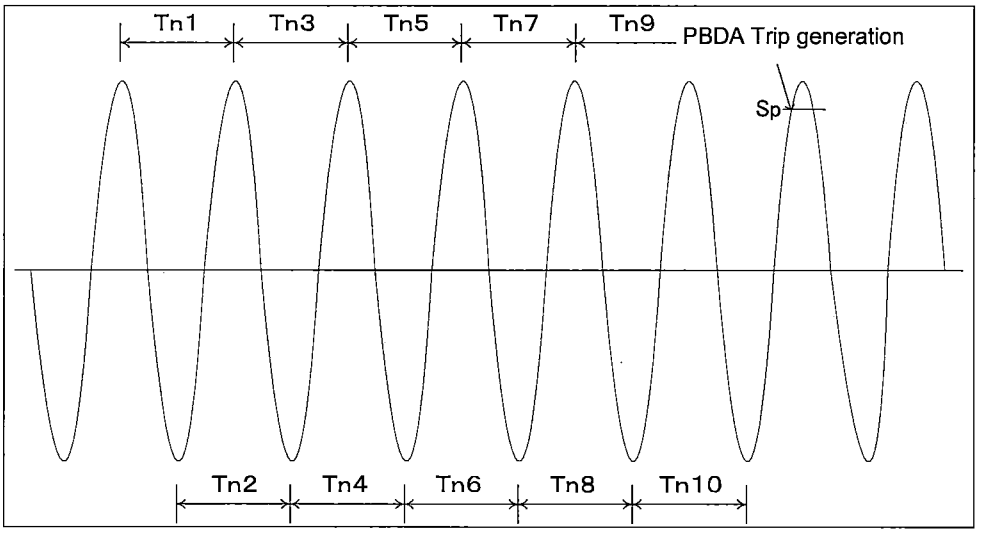


Figure 5.3.3 Outline of PBDA Trip

5.4 Discrete Input/Output Function

The OPRM unit has a DIO module that has electrically insulated interfaces (Photo couplers) to receive discrete input signals from external system, and transmit discrete output signals to external system as described in Sections 1.3.1.3 and 1.3.2.3.

The "OPRM Inoperative signal," "Trip (Scram) signal," and "OPRM Minor Failure signal" are generated as logical sum of alarm signals from relevant modules as shown in Figure 5.4. The conditions for "OPRM Inoperative signal" and "OPRM Minor Failure signal" generation from each module are shown in the "Assumed Cause" column of Table 6.4.

Figure 5.4 Circuit for Logical Sum of OPRM Inoperative, Trip (Scram), and OPRM Minor Failure signals

5.5 Optical Signal Transmitter

The TRN modules receive multiplexed serial data from other modules in the OPRM unit, and convert the serial data into Manchester Code, and transmit the code as optical signal. Two TRN modules are mounted, and there are four output ports on each module.

Two output ports on the TRN module (Slot ID: BSL7, See Figure 1.2.2) are used to send optical signals to ELCS and [ ]^{a,c}

One output port on the TRN module (Slot ID: BSL8, See Figure 1.2.2) is used to send optical signals to TDR.

5.6 Optical Signal Receiver

The RCV module (Slot ID: BSL5, See Figure 1.2.2) receives Manchester coded optical serial signals from four LPRM units in the same division (See Section 1.3.1.1 for detailed port allocation).

The RCV module (Slot ID: BSL6, See Figure 1.2.2) receives Manchester coded optical serial signals from the APRM unit (two input ports are used for redundancy, See Section 1.3.1.2 for detailed port allocation).

These RCV modules convert received signals into electrical serial signals and send the serial signals to the CELL module.

5.7 Unit Status Display of DAT/ST Module

The "FAIL" LED on the DAT/ST module turns on under the circuit logics shown in Figure 5.4 to indicate the failures of the LVPS module 1 and 2, minor failure of the modules in the OPRM unit, and data input errors. See Section 1.3.3.4 for more detailed indication items on the DAT/ST module. The conditions for "OPRM Minor Failure signal" generation from each module are shown in the "Assumed Cause" column of Table 6.4.

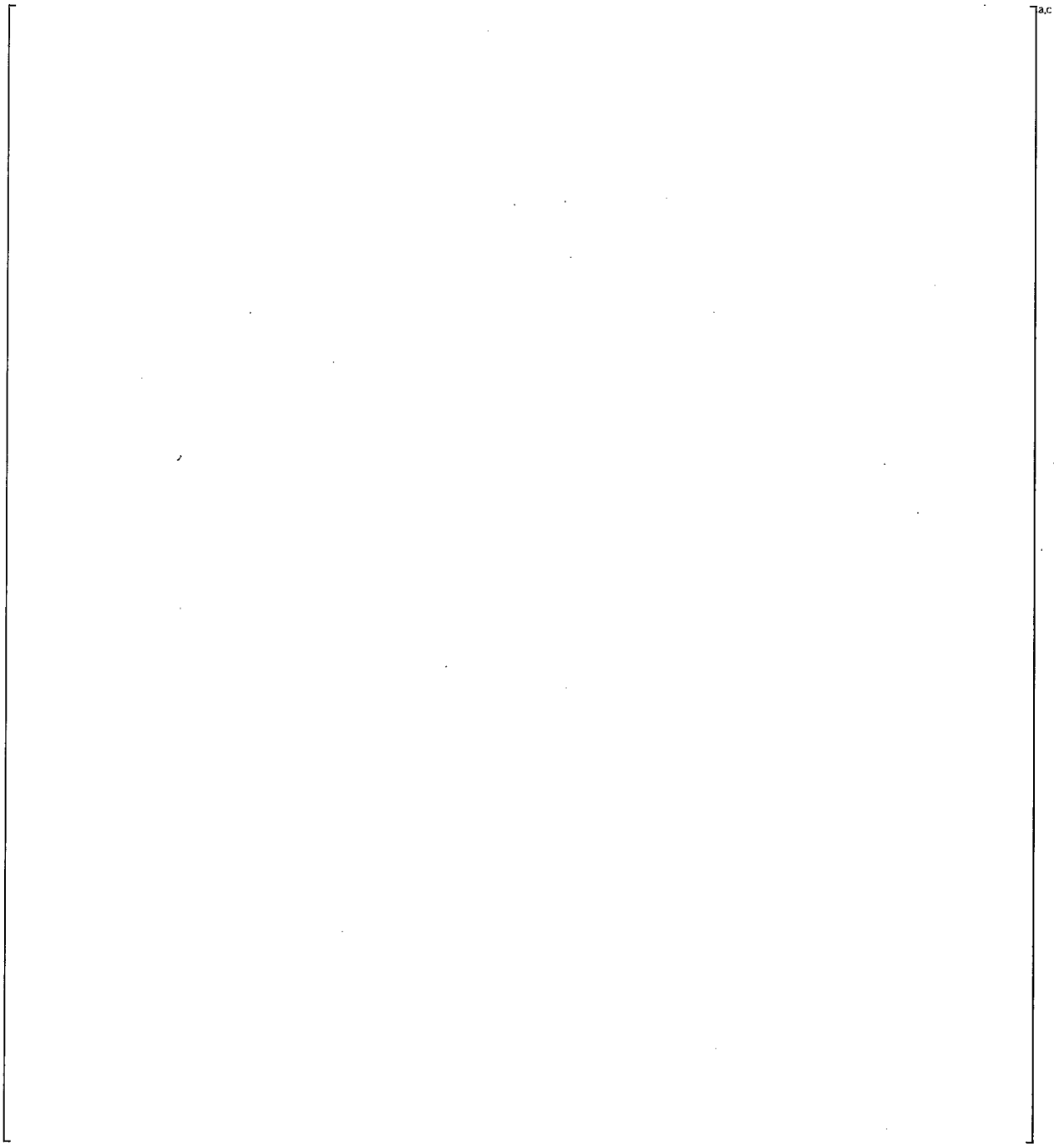


Figure 5.7 Conditions for OPRM Minor Failure Display (FAIL) on DAT/ST Module

6 Maintenance and Inspection

⚠ CAUTION	
 Power off	■ **Be sure to turn the power off when removing modules or plugging/unplugging connectors for maintenance and inspection.**
	■ **In order to prevent false trips and alarms, make sure to take safety measures (such as bypass or isolation) before inspecting.**
 No disassembly/ modification	■ **Do not modify this unit.**
 Contact us	■ **Please contact our service representative for parts replacement.**

6.1 Adjustment

Perform inspection and adjustment before using this unit and on a regular basis during use. For details on how to adjust each module, see the instruction manual of corresponding module.

6.1.1 Voltage Adjustment of LVPS Module

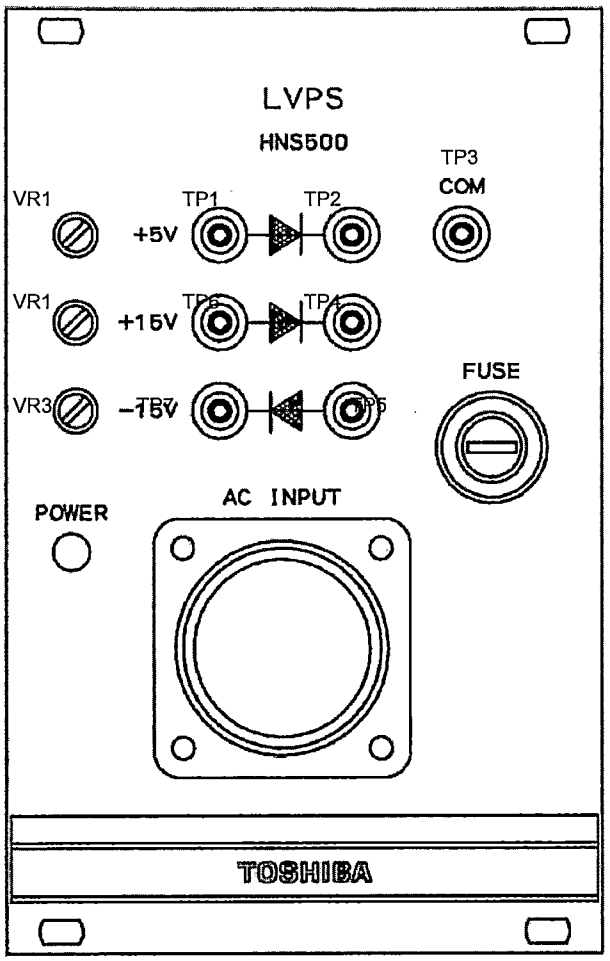
Two LVPS modules are contained (for parallel operation) in the unit. Two LVPS modules feed DC power to other modules in the unit simultaneously through the redundant diodes, so turn off the circuit breaker installed in the NMS Panel that is connected to the LVPS module which is not subjected to voltage adjustment.

Measurement points and adjustment ranges are shown in Table 6.1.1.

Table 6.1.1 Voltage Adjustment of LVPS Module

Power Voltage	Measurement Point	Adjustment Trimmer	Adjustment Voltage Range
+5 V	Between TP2 and TP3	VR1	[ ]^{a,c}V to [ ]^{a,c}V
+15 V	Between TP4 and TP3	VR2	[ ]^{a,c}V to [ ]^{a,c}V
-15 V	Between TP5 and TP3	VR3	[ ]^{a,c}V to [ ]^{a,c}V

When the voltage is checked at points TP1, TP6, and TP7, its output is higher because of the voltage drop due to the redundant diodes.



[a,c

]a,c

Figure 6.1.1 Measurement Points and Trimmers on LVPS Module

6.2 Unit Operation Test

An internal test circuit allows checking the algorithm operation of LPRM Bypass, OPRM Cell Bypass, OPRM Automatic Bypass, and ABA, GRA, PBDA Trips. A method to check the soundness of Normalized Oscillation Signal calculation function by inputting a specific input signals to the OPRM unit using a dedicated maintenance tool is provide in Section 6.2.4.

6.2.1 ABA/GRA/PBDA Trip Test using Test Data

a. Turn the key switch of the CELL module to "CAL" position.

   Press the "SELECT3" button on the right side of the key switch to turn on the "TEST St" LED (yellow). A test number is displayed in the numerical display of "fa/FLOW/St TEST No./CAL/PARAMETER2." Press the "+" button to increment a test number. Press the "-" button to decrement the test number. Press the "SET" button to start a trip test.
   Test number 1: Test data for ABA Trip /AGRD module
   Test number 2: Test data for GRA Trip /AGRD module
   Test number 3: Test data for PBDA Trip /PBD module

   (Note: Pressing the "SET" button triggers test data transmission to the internal test circuit of related modules. During data transmission, the test number in the numerical display remains lit. After the data transmission is complete and the "SET" button is pressed again, the test number in the numerical display starts blinking, indicating that the CELL module is ready for the next test number selection.)

b. Check if the "TRIP" and "ABA TRIP" LEDs (both red) of the AGRD module turn on when test number 1 is selected and the "SET" button is pressed.
   Check if the "TRIP" and "GRA TRIP" LEDs (both red) of the AGRD module turn on when test number 2 is selected and the "SET" button is pressed.
   Check if the "TRIP" and "PBDA TRIP" LEDs (both red) of the PBD module turn on and the "Confirmation Count (N)" display starts counting up when test number 3 is selected and the "SET" button is pressed.

6.2.2 LPRM Bypass Test using Filtered Flux Calibration Input

a. Turn the key switch of the CELL module to "CAL" position.

b. Press the "SELECT3" button on the right side of the key switch twice to turn on the "TEST Filtered Flux" LED (yellow).

c. Filtered Flux calibration input (input range: 0.0 – 125.0 (%)) setting is as follows.

Press the "SELECT2" button to select a numerical display (UL, UR, LL, or LR) in "Filtered Flux" area of the CELL module (all digits of the selected numerical display will blink). The input value to be replaced with is displayed on the "PARAMETER2" display.
Enter 4 digits of Filtered Flux calibration value as follows.

- Press the "▶" button to select a digit position to set a value. The selected digit starts blinking.
- Press the "+" button to increment the value.
- Press the "-" button to decrement the value.

d. After the 4 digits of input value are entered, press the "SET" button. Note that set a value greater than the "LPRM Lower-limit Setpoint" (see Table 4.1.2-1) at first and gradually lower the value until a LPRM bypass generation is confirmed.

e. To confirm corresponding LPRM bypass generation, check if the "BYP" LED located on the right side of the numerical display (UL, UR, LL, or LR) turns on.

6.2.3 OPRM Automatic Bypass Test using APRM/Flow Level Calibration Input

a. Turn the key switch of the CELL module to "CAL" position.

b. Press the "SELECT3" button three times to turn on the "TEST APRM/FLOW" LED (yellow).

c. APRM Level calibration input (input range: 0.0 – 125.0 (%)) setting is as follows.

The numerical display "APRM/PARAMETER1" of the CELL module is already selected when the "TEST APRM/FLOW" LED is turned on above.

- Press the "▶" button to select a digit position to set a value. The selected digit starts blinking.
- Press the "+" button to increment the value.
- Press the "-" button to decrement the value.

d. After the 4 digits of input value are entered, press the "SET" button. The "Amp/%/Count" display is updated. Note that set a value greater than the "OPRM Region APRM Level setpoint" at first and gradually lower the value until an OPRM Automatic Bypass signal is generated.

e. Flow Level calibration input (input range: 0.0 – 200.0 (%)) setting is as follows.

Press the "SELECT2" button to select the numerical display "fa/FLOW/St TEST No./CAL/PARAMETER2" of the CELL module.

- Press the "▶" button to select a digit position to set a value. The selected digit starts blinking.
- Press the "+" button to increment the value.
- Press the "-" button to decrement the value.

f. After the 4 digits of input value are entered, press the "SET" button. If the input value is out of the input range, the "BYP" LED (yellow) turns on. Note that set a value smaller than the "OPRM Region Core Flow Level setpoint" at first and gradually increase the value until an OPRM Automatic Bypass signal is generated.

g. Check if the OPRM Automatic Bypass ("BYP" LED (Yellow)) is turn on.
Check if the OPRM Region ("OPRM REGION" LED (Green)) is turn off.

6.2.4 Normalized Oscillation Signal Calculation Check

The OPRM unit calculates Normalized Oscillation Signal for each OPRM Cell. To calculate the Normalized Oscillation Signal, a filtering, averaging, and normalizing are applied to the LPRM Levels as explained in Section 5.1. This section provides a method to check the soundness of Normalized Oscillation Signal calculation function by inputting a specific input signals to the OPRM unit using a dedicated maintenance tool.

⚠ CAUTION	
	■ **Take safety measures (Bypass the corresponding OPRM channel) first and then change the mode of each module. For OPRM channel bypass method, see system O&M manual.** An inoperative alarm is generated if the mode is changed by the key switch from "OP" mode to "CAL" or "STANDBY" mode during the corresponding OPRM channel not bypassed. The OPRM is a functional subsystem of the Average Power Range Monitor (APRM). There are four OPRM channels, with each OPRM as part of the each APRM channel. Bypass of one APRM channel also bypass one corresponding OPRM channel. Refer to System O&M Manual to bypass the corresponding OPRM channel.

Make sure to bypass the OPRM channel before taking the following procedure. See "CAUTION" above.

a. Turn off the two circuit breakers installed in the NMS Panel that are connected to redundant power supply lines to the OPRM unit.

b. Connect a maintenance tool to the OPRM unit in accordance with System O&M Manual.

c. Input test signals to the OPRM unit, and check that the Normalized Oscillation Signal calculation function works correctly in accordance with System O&M Manual.

d. Disconnect the maintenance tool from the OPRM unit, and check that all the connections are correct in accordance with Section 2.3.2.

e. Turn on the power to the OPRM unit in accordance with Section 4.1.3.

6.3 Maintenance

6.3.1 Periodic Replacement Parts

The following parts in this unit require periodic replacement.

Table 6.3.1 Daily Checklist of Periodic Replacement Parts

Parts	Inspection Method	Inspection Frequency	Replacement Cycle	Remarks
Fuse (LVPS module)	Visual inspection (Check discoloration and/or tarnish inside the tube)	As needed	[][a,c] years	Fuse type: MF61 NR10
LVPS module	Voltage measurement (Refer to Section 6.1.1)	As needed	[][a,c] years	LVPS module type: HNS500

6.3.2 Replacement of Equipment

If any events occur which indicate failure of this unit (e.g. large fluctuation in indication, OPRM Inoperative/OPRM Minor Failure signal generation), follow the procedures in Section 6.4 "Failure Diagnosis and Measures" and replace the equipment as necessary. Before replacement please contact our service representative.

6.3.3 Cleaning

Check if the unit and modules are clean during maintenance and inspection. If there is persistent dirt on them, clean them in order to avoid decrease of isolation performance between the internal circuits.

6.4 Failure Diagnosis and Measures

As the diagnosis process includes measurement of electric circuits, special care must be taken in handling measuring instruments. If you have any questions or concerns about measurement of electric circuits, please contact our service representative.

⚠ CAUTION	
 Only qualified personnel	■ **Use only qualified personnel who have received safety training for, maintenance, inspection and calibration.**
 CAUTION Electric Shock	■ **Be careful of electric shocks, short circuit, and improper connections.**
 Power off	■ **Turn off the power before mounting/dismounting modules, plugging/unplugging connectors and connecting the equipment.** Failure to follow the instruction could result in electric shock and equipment failure.

See Table 6.4 "Failure Diagnosis," Figure 6.4 "Failure Diagnosis Flow," and the manuals of each module before performing failure diagnosis and replacing the equipment.

A failure event may not be duplicated once the power is turned off and then turned on again. When performing diagnosis, try to maintain the failure state as much as possible.

If any alert or event occur which indicates failure, perform an initial diagnosis in accordance with the steps described in Figure 6.4 with reference to Table 6.4, and identify failed module or equipment.

After the initial diagnosis is completed, contact our service representative. If you have any questions or concerns about measurement of electric circuits, please contact our service representative.

Turn off the two circuit breakers installed in the NMS Panel that are connected to redundant power supply lines to the OPRM unit when replacing the failed module or equipment.

Table 6.4 Failure Diagnosis

Alarm Name (Alarm Display LED)	Module name where alarm display LED turns on	Assumed Cause
OPRM Minor Failure (FAIL)	AGRD module PBD module	Front panel control operation stop
		EEPROM data error is detected
	CELL module	Front panel control operation stop
		LPRM Unit 1-4 Data Input Error APRM Unit Data 1 or 2 Input Error
	DAT/ST module	OPRM Cell Data Input Error
		OPRM Calculation Data Input Error
		AGRD Calculation Data Input Error
		PBD Calculation Data Input Error
		Signal processor operation stop
		Both LVPS modules fail
	None	DIO module failure or Relay unit failure
		Module failure (all displays and LEDs turn off)
OPRM Inoperative (INOP)	CELL module	Number of active OPRM Cell is lower than the setpoint (Minimum Number of Active OPRM Cell Setpoint)
		Calculation circuit failure in the CELL module
		Data transmission error occurs in both APRM Unit Data 1 and 2 from APRM unit (both of redundant optical transmission signals from APRM unit are not available)
		The OPRM unit receives "APRM Inoperative" signal from APRM unit.
	AGRD module PBD module	Signal processor operation stop. Key switch is not in "OP" position. SRAM data error
		OPRM Cell Data Input Error

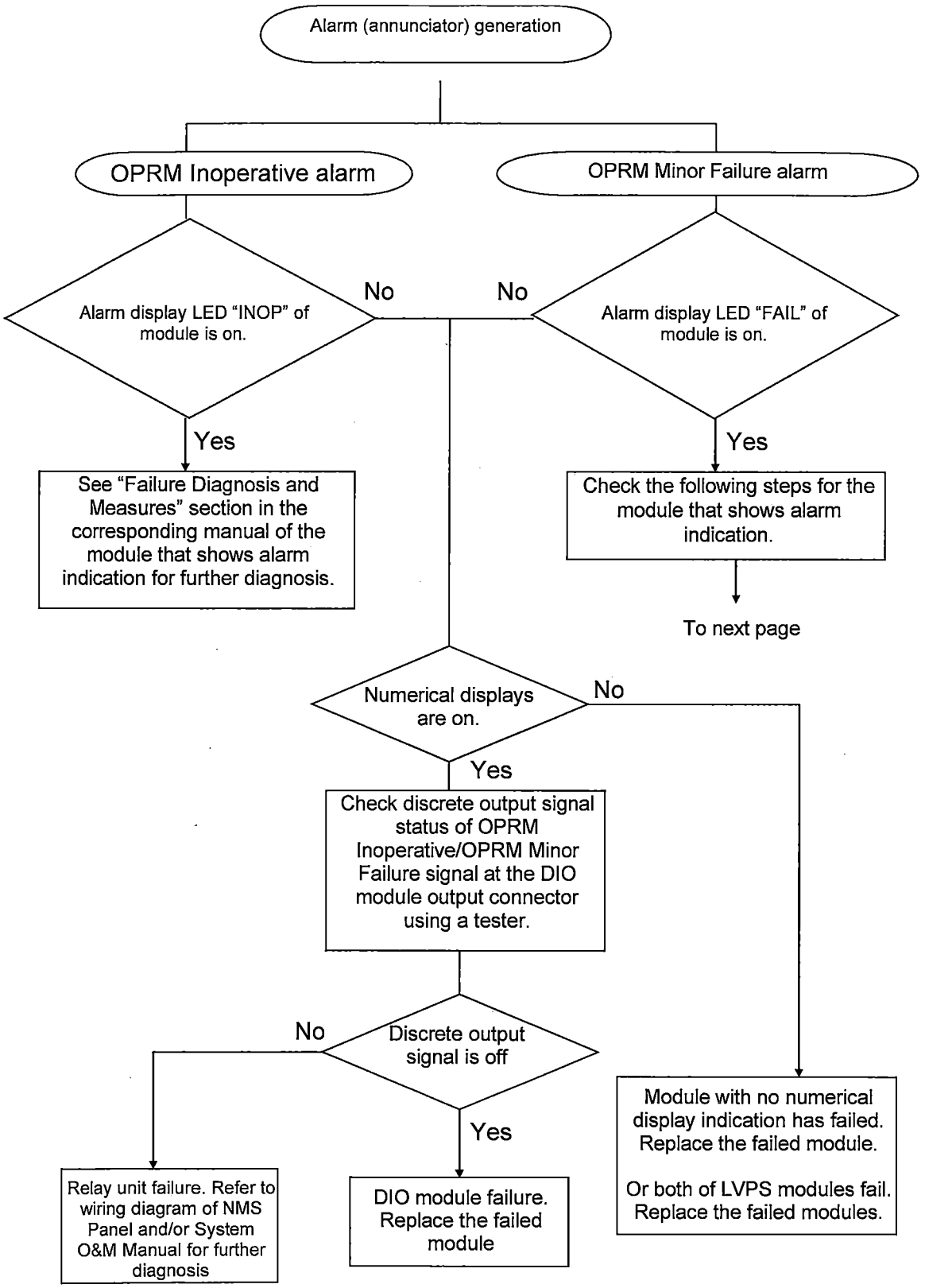


Figure 6.4 Failure Diagnosis Flow (1/2)

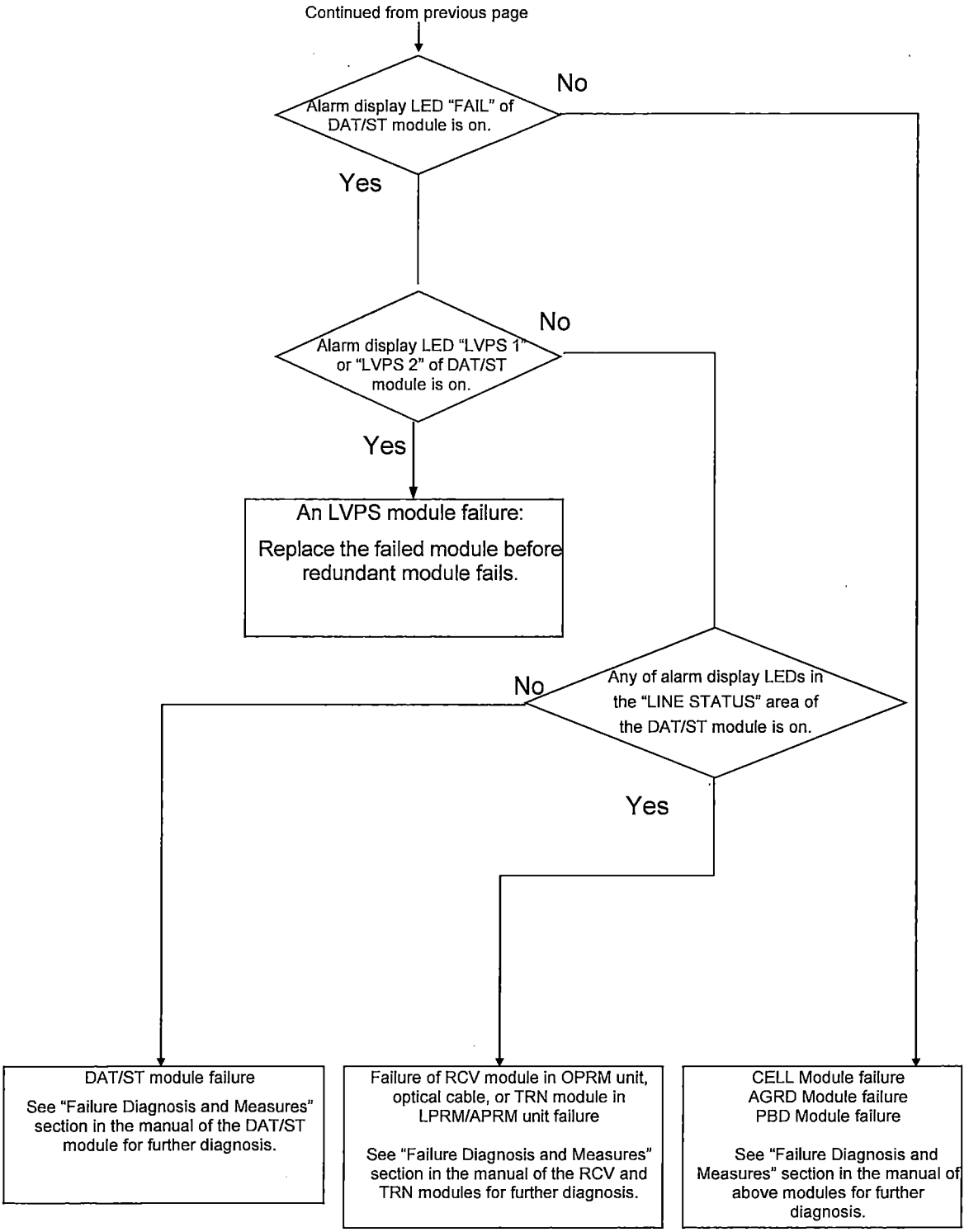


Figure 6.4 Failure Diagnosis Flow (2/2)

7 Abbreviations

ABA Trip	Amplitude-Based Maximum Trip
ABWR	Advanced Boiling Water Reactor
AC	Alternate Current
APRM	Average Power Range Monitor
BSL	Back Slot
CRC	Cyclic Redundancy Check
DC	Direct Current
ELCS	Engineered Safety Features Logic & Control System
FD	Flat Display
FG	Frame Ground
FS	Full Scale
FSL	Front Slot
GRA Trip	Growth Rate-Based Trip
HMI	Human-Machine Interface
LL	Lower Left
LPRM	Local Power Range Monitor
LR	Lower Right
MOS	Metal-Oxide Semiconductor
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
NMS	Neutron Monitoring System
O&M	Operations and Maintenance
OPRM	Oscillation Power Range Monitor
PBDA Trip	Period-Based Trip
PCB	Printed Circuit Board
PFC	Power Factor Correction module
[	]a,c
PRNM	Power Range Neutron Monitor
PSSL	Power Supply Slot
TDR	Transient Data Recorder
UL	Upper Left
UR	Upper Right