PSNN-2014-0867

Safety-Related

Toshiba Project Document No.	Rev. No.
FC51-7012-1004	0

NRW-FPGA-Based I&C System Qualification Project

PSI/ISI Plan, Witness Plan, Test Plan

Title: Software Validation Test Plan for Additional Validation

Document Filing No.	Rev.
RS-5183803	0

Customer Name	None
Project Name	NRW-FPGA-Based I&C System Qualification Project
Item Name	OPRM Equipment
Item Number	C51
Job Number	9P04482
Applicable Plant	None

Project		:NRW-FPGA-Based I&C system :Qualification Project
Contract No.		:---
For Approval	X	For Information
Action		
A		Approved No Further Action
C		Approved with Comment Revised and Resubmit
D		Disapproved Revised and Resubmit
I	X	Accepted for Information Only ☐ Recommendation Included
Group		
Approved by		Reviewed by
T.Ito July14,2014		T. Hayashi Jul. 14, 2014

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TOSHIBA CORPORATION
NED

Initial Issue Date	Issued by	Approved by	Reviewed by	Prepared by	Document filing No.
Feb. 26, 2013	Nuclear Instrumentation & Control Systems Department	H. Kitazono Feb. 26, 2013	H. Kitazono Feb. 26, 2013	K. Kasai Feb.26.2013	5B8K0096

Record of Revisions

Rev No.	Date	Description	Approved by	Reviewed by	Prepared by
0	See Cover Page	Initial Issue	See Cover Page	See Cover Page	See Cover Page

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1. Purpose

The purpose of this Software Validation Test Plan (SVTP) for Additional Validation is to specify test requirements, conditions, and methodologies for software validation test conducted in an additional system validation testing which is performed to supplement the previous system validation testing of the Oscillation Power Range Monitor (OPRM) for the NRW-FPGA-Based I&C System Qualification Project. Test requirements, conditions, and methodologies for the hardware test conducted in the additional system validation testing are described in the System Test Specification for Additional Validation (Reference (12)). The previous system validation testing was performed in accordance with the System Test Specification (Reference (9)) and SVTP (Reference (8)). The test results of the previous system validation testing were recorded in the System Validation Test Record (Reference (10)), and reported in the Software Validation Test Report (Reference (11)).

The purpose of the additional system validation testing is to demonstrate that Cyclic Redundancy Check (CRC) functions added to the OPRM unit are correctly implemented and functions as intended. Another purpose of this test is to demonstrate that the OPRM unit performs its safety functions under specific conditions specified by Nuclear Energy Systems & Services Division (NED) in the procurement specification (Reference (6)) and the System Design Description (Reference (7)) which was revised after the previous system validation testing.

The Nuclear Instrumentation & Control Systems Department (NICSD) Independent Verification and Validation (IV&V) Team prepared this plan in accordance with test documentation requirements prescribed in the NICSD V&V Plan (Reference (1)), Master Test Plan (Reference (2)), Software Test Plan (Reference (3)) and procurement specification (Reference (6)) using NQ-2019 (Reference(13)) and NQ-3016 (Reference (16)) as guides.

2. Scope

The scope of the test specimen subject to the additional system validation testing is the OPRM unit and two Power Factor Correction modules (PFCs), which is enclosed by the bold and dotted line in Figure 2-1 that is a copy of Figure 4-1 of the Equipment Design Specification (EDS) (Reference (4)).

The NICSD IV&V Team is responsible for determining the acceptance methods and criteria for the software validation test conducted in the additional system validation testing. The software validation test requirements are documented in this document.

This plan is used with System Test Specification for Additional Validation (Reference (12)). Section 10 of the System Test Specification for Additional Validation refers to this SVTP for Additional Validation as test item of software validation test for the OPRM unit. Test items for software validation test in this plan were determined based on the OPRM unit functional requirements prescribed in the EDS, the Unit Detailed Design Specification (DDS) (Reference (5)) and the procurement specification (Reference (6)). Test items and features to be tested through the software validation test are listed in Table 9-1.

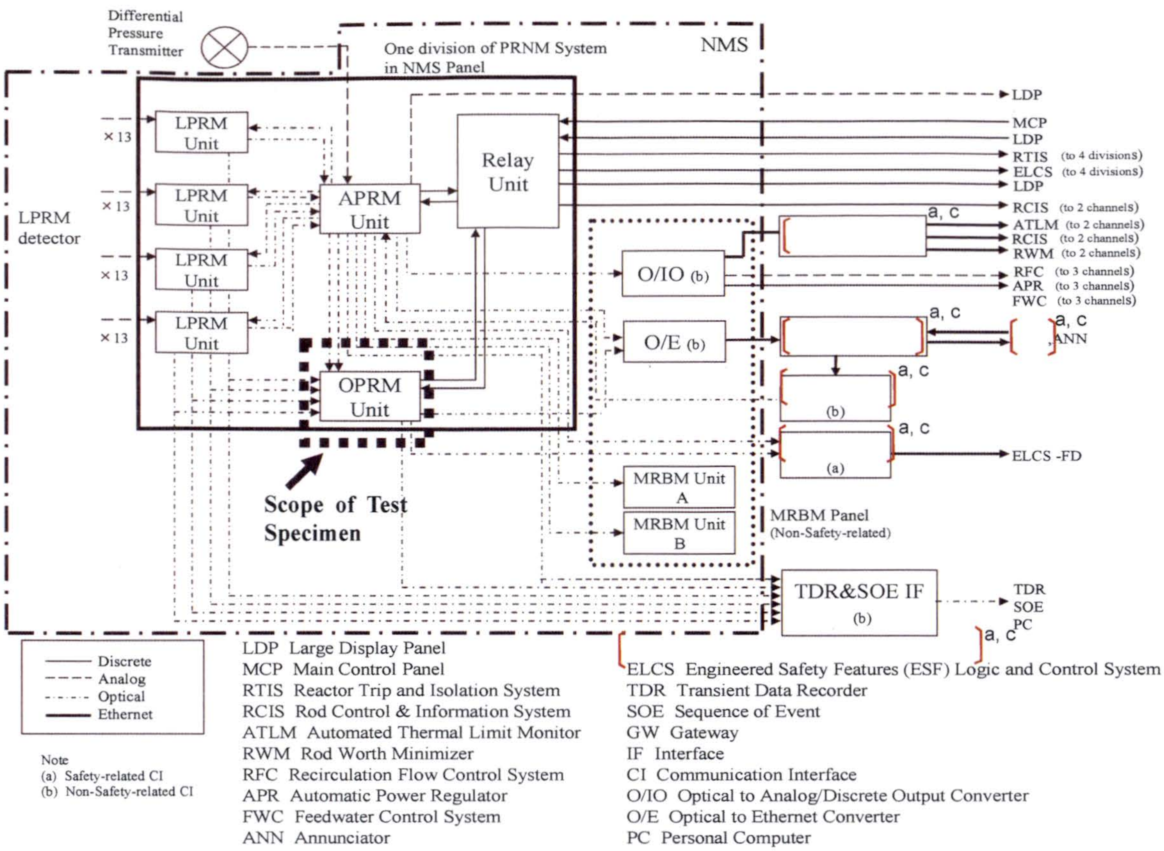

Figure 2-1 Scope of Test Specimen

3. Applicable Documents

(1) Toshiba Project Document Number FA32-3709-1000
"Nuclear Instrumentation & Control Systems Department Verification and Validation Plan for FPGA-based Safety-Related Systems" Rev.5
(2) Toshiba Project Document Number FC51-7021-1000
"Master Test Plan for NRW-FPGA-Based I&C System Qualification Project" Rev.1
(3) Toshiba Project Document Number FA32-3705-1000
"Software Test Plan for FPGA-based Safety-Related Systems" Rev.0
(4) Toshiba Project Document Number FC51-3002-1000
"Equipment Design Specification for Power Range Neutron Monitor" Rev.3
(5) Toshiba Project Document Number FC51-3702-1000
"OPRM Unit Detailed Design Specification for Power Range Neutron Monitor" Rev.4
(6) Toshiba Project Document Number FC51-3601-0001
"Procurement Specification for Equipment Qualification and EMC Qualification of Components of Oscillation Power Range Monitor (OPRM)" Rev.11
(7) Toshiba Project Document Number FC51-1001-0001
"System Design Description for Neutron Monitoring System" Rev.7
(8) Toshiba Project Document Number FC51-7012-1003
"Software Validation Test Plan" Rev.3
(9) Toshiba Project Document Number FC51-7101-1001
"Nuclear Instrumentation & Control Systems Department System Test Specification for Safety-Related Oscillation Power Range Monitor (OPRM)" Rev.6
(10) Toshiba Project Document Number FC51-7501-1001
"System Validation Test Record"
(11) Toshiba Project Document Number FC51-7513-1002
"Software Validation Test Report" Rev.0
(12) Toshiba Project Document Number FC51-7101-1003
"Nuclear Instrumentation & Control Systems Department System Test Specification for Additional Validation for Safety-Related Oscillation Power Range Monitor (OPRM)" Rev.0
(13) Toshiba Nuclear Instrumentation & Control Systems Department NQ-2019
"Preparation Procedure for Test Specification" Rev.4
(14) Toshiba Nuclear Instrumentation & Control Systems Department NQ-3011
"Qualification Procedure of Test Personnel and QC Inspector" Rev.5
(15) Toshiba Nuclear Instrumentation & Control Systems Department NQ-3015
"Test Control Procedure" Rev.4
(16) Toshiba Nuclear Instrumentation & Control Systems Department NQ-3016
"Software Test" Rev.4

4. Abbreviations

ABA	Amplitude Based detection Algorithm
AC	Alternate Current
ANN	Annunciator
APRM	Average Power Range Monitor
BSL	Back Slot
CI	Communication Interface
CRC	Cyclic Redundancy Check
DDS	Detailed Design Specification
EDS	Equipment Design Specification
ELCS	Engineered Safety Features Logic & Control System
EMC	Electromagnetic Compatibility
EQ	Equipment Qualification
ESF	Engineered Safety Features
FD	Flat Display
FPGA	Field Programmable Gate Array
GRA	Growth Rate detection Algorithm
I&C	Instrumentation and Control
IV&V	Independent Verification and Validation
LED	Light Emitting Diode
LPRM	Local Power Range Monitor
M&TE	Measuring and Test Equipment
NED	Nuclear Energy Systems & Services Division
NICSD	Nuclear Instrumentation & Control Systems Department
NICS-QC	Quality Control Group for Nuclear Instrumentation & Control Systems
NOS	Normalized Oscillation Signal
NQ	Nuclear Quality
NRW	Non-Rewritable
OPRM	Oscillation Power Range Monitor
PBDA	Period Based Detection Algorithm
PFC	Power Factor Correction module
[	][a, c]
QC	Quality Control
RPS	Reactor Protection System
SOE	Sequence of Event
SVTP	Software Validation Test Plan
TDR	Transient Data Recorder

5. Test System

The same test system configuration as that used for hardware test is used for the software validation test. Figure 5-1 shows the test system configuration which is a copy of Figure 5-1 of the System Test Specification for Additional Validation (Reference (12)). Refer to Section 5.2 of the System Test Specification for Additional Validation for the explanation of test system. Refer to Section 5.3 of the System Test Specification for Additional Validation for the explanation of test specimen. Refer to Section 5.4 of the System Test Specification for Additional Validation for explanation of test support equipment and Measuring and Test Equipment (M&TE).

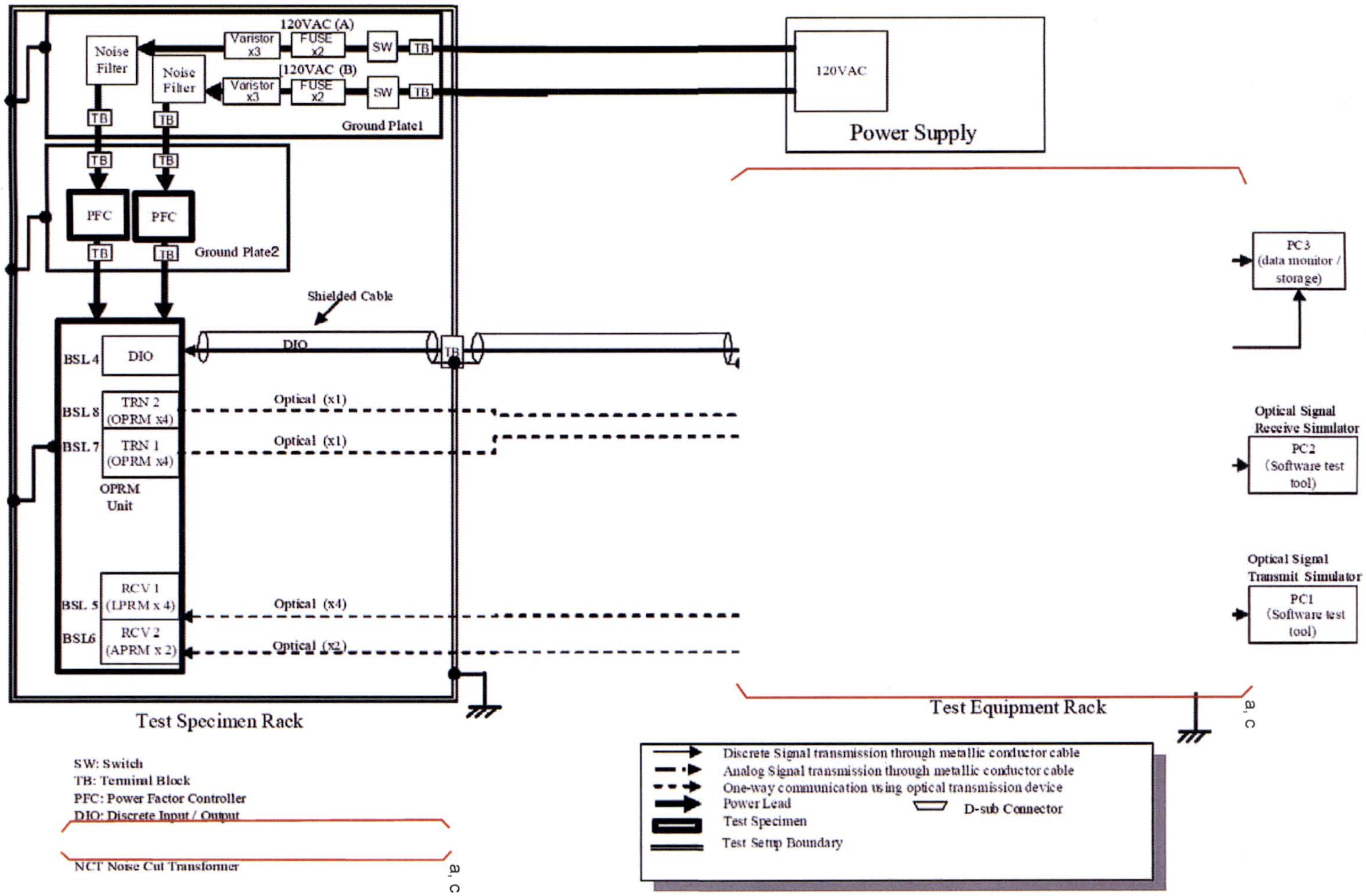

Figure 5-1 Test System

6. Prerequisites

6.1 Standard Settings of OPRM Unit

The same parameter setting for TRN modules and RCV modules, and jumper pin setting as that used for hardware test is used as "Standard Settings" for the software validation test. Refer to Section 6.1 of the System Test Specification for Additional Validation (Reference (12)) for detailed parameter settings for TRN modules and RCV modules, and detailed parameter setting procedure for each module in the OPRM unit. Refer to Section 6.2 of the System Test Specification for Additional Validation for detailed jumper pin settings. The following tables show the "Standard Settings" of OPRM unit parameters and setpoints for the software validation test. If specific parameters for each test item are not specified, the test is performed using the following "Standard Settings."

Table 6-1 Standard Settings for CELL Module

7 Segment LED		Range	Initial Setpoint
PARAMETER1	PARAMETER2		
1	Time Average Filter Cut-off Frequency Setpoint	0.100 to 1.500Hz	0.167
2	LPRM Lower-limit Setpoint	0.0 to 99.9%	5.0
3	Conditioning Filter Cut-off Frequency Setpoint	0.000 to 9.999Hz (effective range: 0.500 to 3.500Hz)	1.000
4	Minimum Number of Active OPRM Cell Setpoint	0 to 99 (effective range: 0 to 44)	32
5	OPRM Region APRM Level Setpoint	0.0 to 99.9%	30.0
6	OPRM Region Core Flow Level Setpoint	0.0 to 99.9%	60.0
7	OPRM Region APRM Level Hysteresis Setpoint	0 to 9%FS	1
8	OPRM Region Core Flow Level Hysteresis Setpoint	0 to 9%FS	1
9	Minimum Number of Active LPRMs	0 to 9 (effective range: 1 to 3)	2

Table 6-2 Standard Settings for AGRD Module

7 Segment LED		Range	Initial Setpoint
PARAMETER1	PARAMETER2		
1	Threshold Setpoint (S1)	1.00 to 1.99	1.20
2	Minimum Threshold Setpoint (S2)	0.50 to 1.99	0.92
3	Growth Rate Factor (DR3)	1.00 to 1.99	1.04
4	Maximum Amplitude Trip Setpoint (Smax)	1.00 to 1.99	1.30
5	Growth Rate Amplitude Setpoint (S3)	1.00 to 1.99	N/A (Calculated value)
6	Time Window for Minimum Threshold Setpoint (Tl)	0.00 to 0.99s	0.31
7	Time Window for Trip Setpoint (Th)	0.00 to 9.99s	2.80
8	ABA and GRA Trip Hold Time Setpoint (Ttph)	0.0 to 9.9s	[ ]a, c
9	Peak and Valley Detection Width Setpoint (a)	0.001 to 0.010 (Note 1)	0.003

Note 1: This parameter is shown as 1 to 10 on the numerical display of the AGRD module.

Table 6-3 Standard Settings for PBD Module

7 Segment LED		Range	Initial Setpoint
PARAMETER1	PARAMETER2		
1	Period Minimum Setpoint (Tmin)	0.00 to 9.99s	1.00
2	Period Maximum Setpoint (Tmax)	0.00 to 9.99s	5.50
3	Period Tolerance Setpoint (Te)	0.000 to 0.999s	0.400
4	Confirmation Count Trip Setpoint (Np)	0 to 99	10
5	PBDA Amplitude Setpoint (Sp)	1.00 to 1.99	1.10
6	PBDA Trip Hold Time Setpoint (Ttph)	0.0 to 9.9s	a, c
7	Peak and Valley Detection Width Setpoint (a)	0.001 to 0.010 (Note 1)	0.003

Note 1: This parameter is shown as 1 to 10 on the numerical display of the PBD module.

6.2 Environmental Conditions

The same environmental conditions as those specified in Section 7.1 of the System Test Specification for Additional Validation (Reference (12)) are applied to the software validation test.

6.3 AC Power Source

AC power sources as those applied to the test specimen are specified in Section 7.2 of the System Test Specification for Additional Validation (Reference (12)).

6.4 Test Sequence

The software validation test should be performed after the hardware test specified in Section 9 of the System Test Specification for Additional Validation (Reference (12)).

The software validation test shall be performed in accordance with Section 10 of this SVTP.

After the software validation test is finished, return to the test sequence specified in the Table 2-1 of the System Test Specification for Additional Validation.

6.5 Test Tool Identification

The following test tools are used for this software validation test.

Table 6-4 Test Tools for Software Validation Test

Tool Type	Software Tool Registration Application Form Number	Version	Remarks
OPRM Test Tool (Optical Signal Receive Simulator, Optical Signal Transmit Simulator)	FDTR-12-0005-KM	NYP134・04-001-C	-
OPRM Test Pattern Files	FDTR-12-0006-KM	NZH002・01-001-C	-

Test pattern files used for the software validation test are listed in Attachment A. The Optical Signal Receive Simulator has two “Transmission Pattern Setting” to transmit LPRM data; that is “Continuous Output” and “Single Output.”

Use the "Continuous Output" unless otherwise instructed in each test item.

The description of each Transmission Pattern Setting is as follows.

Continuous Output

- In this Transmission Pattern Setting, the Optical Signal Transmit Simulator starts transmission of selected test patterns when "Start" for each LPRM or "All Start" for LPRM 1 to 4 is clicked.
- In this Transmission Pattern Setting, the Optical Signal Transmit Simulator transmits selected test patterns continuously until "Stop" for each LPRM or "All Stop" for LPRM 1 to 4 is clicked.
- When "All Stop" for LPRM 1 to 4 is clicked during data transmission, the Optical Signal Transmit Simulator transmits 0% LPRM levels for LPRM CH1 through CH52, and the number of active OPRM Cells becomes "0." Thus, the CELL module generates an OPRM Inoperative signal.

Single Output

- In this Transmission Pattern Setting, the Optical Signal Transmit Simulator transmits selected test patterns once when "Start" for each LPRM or "All Start" for LPRM 1 to 4 is clicked. Click "All Start" for LPRM 1 to 4 to transmit LPRM 1 to 4 data synchronously.
- After "Single Output" of selected test patterns is finished, the Optical Signal Transmit Simulator transmits 0% LPRM levels for LPRM CH1 through CH52 automatically, and the number of active OPRM Cells becomes "0." Thus, the CELL module generates an OPRM Inoperative signal.
- When "All Stop" for LPRM 1 to 4 is clicked during data transmission, the Optical Signal Transmit Simulator transmits 0% LPRM levels for LPRM CH1 through CH52, and the number of active OPRM Cells becomes "0." Thus, the CELL module generates an OPRM Inoperative signal.

6.6 Definition of "Normal Status for Additional Validation" of Test System

The "Normal Status for Additional Validation" used to show the initial status of the test system. In this document, the "Normal Status for Additional Validation" of Test System means the following status. It is not necessarily to check all the following items in each step of test where the "Normal Status for Additional Validation" is referenced. Check items at "Normal Status for Additional Validation" in each step of test should be determined in test procedure as necessary.

- Configure the hardware and cable connections of test system specified in Section 5.2 of the System Test Specification for Additional Validation (Reference (12)) are configured.
- Set the OPRM unit to "Standard Settings" as specified in Section 6.1.
- Turn off the APRM Bypass signal (Aux-Relay Plate).
- Supply the power to the OPRM unit.
- Start up the Optical Signal Transmit Simulator and Optical Signal Receive Simulator.
- Set the key switches of the CELL module, AGRD module, and PBD module to "OP" position.
- Run the following test pattern files on the Optical Signal Transmit Simulator for "Normal Status for Additional Validation".

  "Normal Status for Additional Validation"
  LPRM 1: LPRM_50_R0_LPRM1.csv
  LPRM 2: LPRM_50_R0_LPRM2.csv
  LPRM 3: LPRM_50_R0_LPRM3.csv
  LPRM 4: LPRM_50_R0_LPRM4.csv
  APRM 1: AP_52.0_FL_31.0_R0_Aprm1.csv

APRM 2: AP_52.0_FL_31.0_R0_Aprm2.csv

- Clear the all "FAIL" LEDs and "INOP" LEDs on the CELL module, AGRD module, PBD module, and DAT/ST module by pushing the "RESET" buttons on these modules.

The following table shows the status of displays on the OPRM unit and the Aux-Relay Plate which shows the discrete input and output status of the DIO module.

Table 6-5 Normal Status for Additional Validation of OPRM Unit

LEDs on CELL Module							
INOP	FAIL	BYP	OPRM REGION	St	APRM	FLOW	CELL Count
Off	Off	Off	On	On	Off	Off	Off
Filtered Flux							
UL BYP		UR BYP		LL BYP		LR BYP	
Off		Off		Off		Off	
MODE							
OP	STANDBY	CAL	TEST St	TEST Filtered FLUX	TEST APRM/FLOW	fa	PARAMETER
On	Off	Off	Off	Off	Off	Off	Off

LEDs on AGRD Module									
TRIP	INOP	FAIL	ABA TRIP	GRA TRIP	MODE				
					OP	STANDBY	CAL	Smax	PARAMETER
Off	Off	Off	Off	Off	On	Off	Off	Off	Off

LEDs on PBD Module									
TRIP	INOP	FAIL	PBDA TRIP	MODE					
				OP	STANDBY	CAL	Terror	Np	PARAMETER
Off	Off	Off	Off	On	Off	Off	Off	Off	Off

LEDs on DAT/ST Module										
FAIL	LVPS ALARM		LINE STATUS							
			SEL		FAIL					
	LVPS1	LVPS2	APRM1	APRM2	APRM1	APRM2	LPRM1	LPRM2	LPRM3	LPRM4
Off	Off	Off	On	Off	Off	Off	Off	Off	Off	Off

LEDs on TRN Module (BSL 7: for ELCS[ ]) [a, c]				LEDs on TRN Module (BSL 8: PC)			
LINE STATUS				LINE STATUS			
OUT1	OUT2	OUT3	OUT4	OUT1	OUT2	OUT3	OUT4
On	On	On	On	On	On	On	On

LEDs on RCV Module (BSL 5: LPRM unit 1 to 4 data)				LEDs on RCV Module (BSL 6: APRM data 1, 2)			
LINE STATUS				LINE STATUS			
IN1	IN2	IN3	IN4	IN1	IN2	IN3	IN4
On	On	On	On	On	On	Off	Off

LED on LVPS Module (PSSL 1)	LED on LVPS Module (PSSL 2)
POWER	POWER
On	On

LEDs on Aux-Relay Plate (Discrete Output and Input of DIO Module)				
SCRAM (Pin A)	PBDA_TRIP (Pin B)	COUNT_ST (Pin D)	OPRM_INOP (Pin M)	OPRM_FAIL (Pin N)
Not generated	Not generated	Not generated	Not generated	Not generated
Off	Off	Off	Off	Off

OPRM_AT_BYP (Pin P)	ABA_TRIP (Pin R)	GRA_TRIP (Pin S)	AMP_JUDGE1 (Pin T)	AMP_JUDGE2 (Pin U)	APRM_BYP (Pin JJ)
Not generated	Not generated	Not generated	Not generated	Not generated	Disable
Off	Off	Off	Off	Off	Off

6.7 Documentation and Test Data Storage

The Quality Control Group for Nuclear Instrumentation & Control Systems (NICS-QC) is responsible for preparing a test process schedule, a System Validation Test Procedure for Additional Validation which is based on this System Test Specification for Additional Validation (Reference (12)) and this SVTP for Additional Validation. The NICS-QC is responsible for executing the additional system validation testing and issuing a System Validation Test Record for Additional Validation in accordance with NQ-3015 (Reference (15)). A test personnel assigned by the Manager of NICS-QC in accordance with NQ-3011 (Reference (14)) executes the additional system validation testing as a test engineer of the NICSD IV&V Team. The NICSD IV&V Team is responsible for preparing a Software Validation Test Report after the additional system validation testing.

Test data during test for each test item shall be obtained using following test equipment.

- Scope Corder (DL850) for discrete input/output signals
- Optical Signal Receive Simulator for ELCS/ { }a, c data from Back Slot (BSL) 7 of TRN module and PC data from BSL8 of TRN module.

Store the test data files in write-once media after the testing.

7. Test System Overview

7.1 OPRM Function Overview

The OPRM unit receives 52 Local Power Range Monitor (LPRM) Levels from four LPRM units and forms 44 OPRM Cell configurations to monitor the neutron flux oscillation 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. The OPRM unit generates the alarms and trip signals. The OPRM trip algorithm consists of trip logics depending on signal oscillation amplitude, a signal oscillation period, and signal oscillation growth rate. For each cell, the peak to average value of the Normalized Oscillation Signal is determined to evaluate the amplitude of oscillation and to be used in the setpoint algorithm. The OPRM is a functional subsystem of the Average Power Range Monitor (APRM). There are four OPRM units and each of those units is assigned to a corresponding APRM unit. Bypass of one APRM unit also bypass its corresponding OPRM unit. 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 APRM Level is less than 30% (Initial setpoint) or Core Flow Level is grater than 60% (Initial setpoint). The OPRM unit provides the trip signals to the (Reactor Protection System) RPS via the Relay unit. The OPRM unit provides the signals to Engineered Safety Features Logic & Control System (ELCS)- Flat Display (FD) via Safety-related Communication Interface (CI). Also, the OPRM unit provides the signals to [ ]a,c Annunciator (ANN), Transient Data Recorder (TDR), Sequence of Event (SOE) and PC via Non-Safety-related CI. OPRM Data including internal calculations before 15 minutes and after 5 minutes of OPRM trips are recorded by TDR.

7.2 Signal Processing Flow of OPRM Unit

The OPRM unit generates trip signals with the following steps (See also Figure 7-1, which is a copy of the Figure 5-1 of the OPRM Unit DDS (Reference (5)).

(1) After one of the RCV modules in the OPRM unit receives the optical transmission signals including the 52 LPRM levels by a transmission cycle of 1.016ms from each LPRM unit, the RCV module converts the received optical signals to digital data, and provides the digital data of 52 LPRM levels to the CELL module with a transmission cycle of 1.016ms.

(2) The CELL module selects three or four LPRM levels corresponding to each OPRM Cell from the received digital signals.

(3) The CELL module performs sequential calculation to obtain a Normalized Oscillation Signal for CELL 1 thorough 44 per a processing cycle of [ ]a,c ms (i.e. the CELL module has 25 ms sampling interval).

(4) The obtained Normalized Oscillation Signal is provided to the AGRD module and the PBD module via the same serial bus.

(5) The AGRD module sequentially determines a trip generation for CELL 1 thorough 44 per a processing cycle of [ ]a,c ms using the Amplitude Based detection Algorithm (ABA) and Growth Rate detection Algorithm (GRA). In parallel with processing in the AGRD module, the PBD module sequentially determines a trip generation for CELL 1 thorough 44 per a processing cycle of [ ]a,c ms using the Period Based Detection Algorithm (PBDA).

These sequential processing and parallel processing features in the OPRM unit were taken into account when deciding test patterns and acceptance criteria for software validation test.

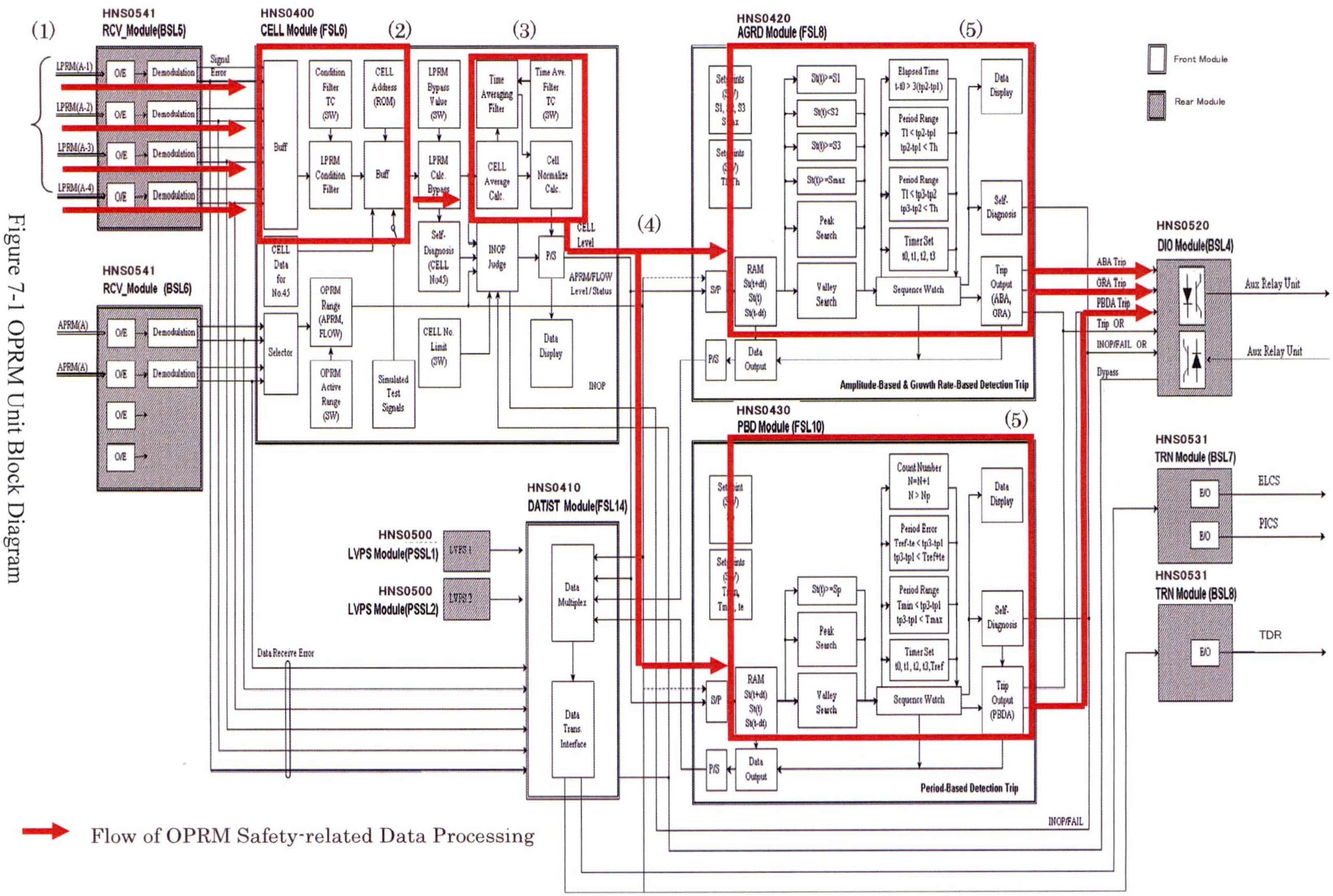

Figure 7-1 OPRM Unit Block Diagram

8. Validation Approach

This section describes approaches to determine input test patterns and expected outputs.

8.1 Generation of LPRM Levels for Input Test Pattern

A LPRM level input is simulated with the following basic equation.

a, c

Based on the above basic equation, four LPRM levels comprising an OPRM Cell (i.e., y_A: LPRM A, y_B: LPRM B, y_C: LPRM C, and y_D: LPRM D) can be further defined as follows.

a, c

The NICSD IV&V Team generated input test patterns of LPRM levels using above equations with test pattern generation tool. This equation can simulate various types of oscillation signals by changing the parameters. The input test pattern files used for software validation test are listed in Attachment A.

8.2 Determination of Expected Output

If all the LPRM levels in a Cell synchronize, the Normalized Oscillation Signal (St) simulated by the theoretical formula may be simplified with a filtered single LPRM level except noise as follows.

Normalized Oscillation Signal (St):

a, c

$$St =$$

a, c

The NICSD IV&V Team simulated the Normalized Oscillation Signal (St) based on above theoretical formula. The NICSD IV&V Team compared the simulated Normalized Oscillation Signal (St) with Normalized Oscillation Signal (St) output from the OPRM unit, and checked that the input test patterns generated by test pattern were acceptable for use in software validation test. Based on the functionality of the OPRM unit, the NICSD IV&V Team determined expected output for each input test pattern as responses of OPRM unit to the simulated Normalized Oscillation Signal (St) and other input parameter conditions.

9. Features to be Tested

The software validation test in the additional system validation testing is performed:

- To demonstrate that CRC functions added to the OPRM unit are correctly implemented and functions as intended.
- To demonstrate that the OPRM unit performs its safety functions under specific conditions specified by NED with additional performance requirements for the OPRM Trip response time of the OPRM unit.

Test items are configured based on the CRC functions and additional requirements stated in the EDS (Reference (4)), Unit DDS (Reference (5)) and the procurement specification (Reference (6)). Table 9-1 shows a list of test items showing relationship between test items and related EDS section, and Unit DDS section. Other requirements specified in the EDS and the Unit DDS not listed in Table 9-1 have already been evaluated and verified through the previous system validation testing as appropriate. Refer to Table 9-1 of the SVTP (Reference (8)) showing the test items which were tested in the previous system validation testing.

The NICSD IV&V Team evaluated the impact of the design change regarding addition of CRC functions on the test items in the previous system validation testing. Addition of the CRC functions are accomplished by the TRN module which adds a CRC code in the end of each frame of optical transmission data, and by the RCV module which receives the optical transmission data from the TRN module, and calculates a CRC code, compares it with the received CRC code to check integrity of frame the received data. The RCV module removes the CRC code from the received data without changing the original frame of received data, sends the received data to other modules for calculation and operation in the OPRM unit. It is confirmed that the addition of the CRC functions does not affect calculations and operations performed by the CELL module, PBD module, AGRD module, DAT/ST module, and DIO module in the OPRM unit as long as the functions of the TRN modules and RCV modules are validated in the Module Validation Testing. Thus, the NICSD IV&V Team determined that re-test of the OPRM functions confirmed in the previous system validation testing is not necessary.

The NICSD IV&V Team determined the detailed test cases for CRC function check in Section 10.2 based on the considerations described blow. The OPRM unit contains two RCV modules to receive optical transmission data from the LPRM unit and the APRM unit. The RCV module mounted on BSL5 is used for receiving optical transmission data from the four LPRM units. The RCV module mounted on BSL6 is used for receiving optical transmission data from the APRM unit. Although the CRC functions allocated to all the ports of those RCV modules have already been validated in the Module Validation Testing, the NICSD IV&V Team determined that the verification of the CRC function generating an OPRM Minor Failure signal as a combinational function by the modules in the OPRM unit when the OPRM unit detects unmatched CRC codes in received data is necessary. The OPRM unit contains two TRN modules to send optical transmission data to external system. The TRN module mounted on BSL7 is used for sending optical transmission data to ELCS. The TRN module mounted on BSL8 is used for sending optical transmission data to [.][a, c] The CRC functions allocated to all the ports of those TRN modules have already been validated in the Module Validation Testing, thus the NICSD IV&V Team determined that duplicating the verification of the CRC function of those TRN modules at system level testing is not necessary.

The NICSD IV&V Team determined the detailed test cases for additional validation of trip algorithms in Section 10.3 based on the conditions and parameters specified in Section 2.8 (3) of the procurement specification (Reference (6)). In Section 10.3, the OPRM trip function based on the Period Based Detection Algorithm (PBDA), Amplitude Based Algorithm (ABA), and Growth Rate Algorithm (GRA) is tested changing the parameters of input signal with different phase lag between four LPRM Levels comprising an OPRM Cell, and the different frequency of oscillation.

The NCISD IV&V Team determined the method to evaluate the response time of the OPRM unit applied in Section 10.3 based on the following considerations.

- In the EDS (Reference (4)) and the Unit DDS (Reference (5)), the OPRM trip response time of the OPRM unit is required as "the OPRM trip response time of the OPRM unit from when the core oscillation initiation detected by LPRM detector is input to the OPRM unit to when the OPRM trip function initiation from the OPRM unit shall not exceed [ ][a, c] ms."

- The PBDA trip is subject to the OPRM trip response time verification based on discussion with NED engineers.
- The OPRM unit determines a trip generation based on the Normalized Oscillation Signals calculated in the CELL module. The Normalized Oscillation Signals are conditioned and averaged by the conditioning and averaging filters in the CELL module, and there is time lag between the Normalized Oscillation Signal and input LPRM Levels. Thus, to determine the starting point when measuring the response of the OPRM unit, it is necessary to postulate an ideal Normalized Oscillation Signal which does not affected by the filtering processing, and can be calculated theoretically.
- It is difficult to accurately analyze the LPRM Levels input to the OPRM unit which are Manchester coded optical signals, and to match the timing between the optical signals and measuring equipment connected to the discrete output signal for the OPRM Trip output. Meanwhile, time difference between a PBDA Trip signal in the optical output signal from the TRN module and the discrete output signal for the OPRM Trip output is technically known. Thus, the NICSD IV&V Team determined that it is reasonable to evaluate the response time using the optical output signal which contains the LPRM Levels, the Normalized Oscillation Signals, and the PBDA Trip signals.
- The NICSD IV&V Team defined the acceptance criteria for the response time verification to as [ ] ms [a, c] considering the sampling interval of the CELL module discussed in Section 7.2.

Based on the above considerations, the NCISD IV&V Team defined the acceptance criterion for the response time verification in the additional system validation testing as follows.

Response time (α) shall not exceed [ ] ms [a, c], where

$$\alpha = X - \beta$$

β : Theoretically calculated time lag between the peak of ideal Normalized Oscillation Signal and the peak of LPRM A. LPRM A is an LPRM Level simulating input from the bottom LPRM detector, which has maximum amplitude of oscillation within the four LPRM Levels in an OPRM Cell that is dominant factor when calculating the Normalized Oscillation Signal.

X = A - B (s)

A: The time when the first PBDA Trip is generated observed in the optical signal output.

B: The time when the LPRM A reaches to peak position right before the first PBDA Trip observed in the optical signal output.

Table 9-1 List of Test Items

Test Item		Remarks	Related EDS Section	Related Unit DDS Section
Section No. of SVTP	Title			
10.1	Standard Setting Check (Initial Setpoint)	-	5.1.3 5.2.2.3.9 5.12	5.1.8 5.2.1 5.2.2 5.2.3
10.2	CRC Function		5.1.8.6 B)	9 (4) I), J)
10.3	Additional Validation of Trip Algorithms	Requirements for additional functional testing are specified in the procurement specification (Reference (6)).	5.1.4.6 B)	7.1

10. Software Validation Test

The following subsections specify test specifications and conditions for each test item.

10.1 Standard Setting Check (Initial Setpoint)

The same parameter setting and jumper pin setting as those specified in Section 6 of the System Test Specification for Additional Validation (Reference (12)) are used as "Standard Settings" for the software validation test. In this check, check that the parameters displayed on the module front panel are consistent with the values specified in "Standard Settings."

In this test, correct indication of parameters is checked only. In the subsequent test items, parameters specified in each test item will be varied to demonstrated functionality subject to test as necessary.

(1) Test Patterns and Procedures

- Check that setting of digital switches on the CELL module in accordance with Table 6-1 of System Test Specification for Additional Validation was finished.
- Check that setting of digital switches on the AGRD module in accordance with Table 6-2 of System Test Specification for Additional Validation was finished.
- Check that setting of digital switches on the PBD module in accordance with Table 6-3 of System Test Specification for Additional Validation was finished.
- Check that setting of digital switches on the TRN modules in accordance with Table 6-4 of System Test Specification for Additional Validation was finished.
- Check that setting of digital switches on the RCV modules in accordance with Table 6-5 of System Test Specification for Additional Validation was finished.
- Check that setting of jumper pins on the modules in accordance with Table 6-6 of System Test Specification for Additional Validation was finished.
- Turn the power of the OPRM unit on.
- Set the "Time Average Filter Cut-off Frequency Setpoint" of CELL module to "0.167" in accordance with the procedures described in Note 1 of Table 6-1 of System Test Specification for Additional Validation.
- Set the "Maximum Amplitude Trip Setpoint (Smax)" of AGRD module to "1.30" in accordance with the procedures described in Note 3 of Table 6-2 of System Test Specification for Additional Validation.
- Set the "Period Tolerance Setpoint (Te)" of PBD module to "0.400" in accordance with the procedures described in Note 5 of Table 6-3 of System Test Specification for Additional Validation.
- Set the "Confirmation Count Trip Setpoint (Np)" of PBD module to "10" in accordance with the procedures described in Note 6 of Table 6-3 of System Test Specification for Additional Validation.
- Set the OPRM unit to the "Normal Status for Additional Validation" as described in Section 6.6.

(2) Acceptance Criteria

- Check that the status of displays on the OPRM unit and the Aux-Relay Plate is consistent with Table 6-5.
- Check that displayed setpoints on the front panel of CELL module are consistent with the "Initial Setpoint" values specified in Table 6-1.
- Check that displayed setpoints on the front panel of AGRD module are consistent with the "Initial Setpoint" values specified in Table 6-2.

- Check that displayed setpoints on the front panel of PBD module are consistent with the "Initial Setpoint" values specified in Table 6-3.
- Check the numerical display "Amp/%/Count" of CELL module. Select "St" to show the Normalized Oscillation Signal values. The displayed Normalization Oscillation Signal (St) values for CELL 1 through 45 on the numerical display of the CELL module are as follows.

  After 60 seconds elapsed from being set to "Normal Status for Additional Validation," Normalized Oscillation Signal values for CELL 1 to 45 are within 1.000 +/- 0.001.
- Check the numerical display "Amp/%/Count" of CELL module. Select "CELL Count" to show the Number of Active OPRM Cells. The displayed Number of Active OPRM Cells "CELL Count" on the numerical display of the CELL module is 44.

10.2 CRC Function

The purpose of this test item is to check the CRC function of the OPRM unit. The CRC errors are simulated by switches of the [.][a, c]

(1) Test Patterns and Procedures

- Step 1: LPRM Unit 1 Data transmission failure is detected
  Set the switch [ ][a, c] in accordance with Table 10-1.
- Step 2: LPRM Unit 1 Data transmission failure is restored
  Set the switch [ ][a, c] in accordance with Table 10-1
  Push the "RESET" buttons on the CELL, AGRD, PBD and DAT/ST modules.
- Step 3: LPRM Unit 2 Data transmission failure is detected
  Set the switch [ ][a, c] in accordance with Table 10-1.
- Step 4: LPRM Unit 2 Data transmission failure is restored
  Set the switch [ ][a, c] in accordance with Table 10-1.
  Push the "RESET" buttons on the CELL, AGRD, PBD and DAT/ST modules.
- Step 5: LPRM Unit 3 Data transmission failure is detected
  Set the switch [ ][a, c] in accordance with Table 10-1.
- Step 6: LPRM Unit 3 Data transmission failure is restored
  Set the switch [ ][a, c] in accordance with Table 10-1.
  Push the "RESET" buttons on the CELL, AGRD, PBD and DAT/ST modules.
- Step 7: LPRM Unit 4 Data transmission failure is detected
  Set the switch [ ][a, c] in accordance with Table 10-1.
- Step 8: LPRM Unit 4 Data transmission failure is restored
  Set the switch [ ][a, c] in accordance with Table 10-1.
  Push the "RESET" buttons on the CELL, AGRD, PBD and DAT/ST modules.
- Step 9: APRM Unit Data 1 transmission failure is detected
  Set the switch [ ][a, c] in accordance with Table 10-1.
- Step 10: APRM Unit Data 1 transmission failure is restored
  Set the switch [ ][a, c] in accordance with Table 10-1.
  Push the "RESET" buttons on the CELL, AGRD, PBD and DAT/ST modules.
- Step 11: APRM Unit Data 2 transmission failure is detected

Set the switch [ ] a, c in accordance with Table 10-1.

- Step 12: APRM Unit Data 2 transmission failure is restored
  Set the switch [ ] a, c in accordance with Table 10-1.
  Push the "RESET" buttons on the CELL, AGRD, PBD and DAT/ST modules.

(2) Acceptance Criteria

- In each step, check that the discrete outputs, module displays and ELCS/[ ] a, c data outpts change as expected specified in Table 10-1.

Table 10-1 Test Pattern and Expected Output

Step	Test Pattern		Acceptance Criteria (Expected Output)					
			Displays on modules				Discrete Outputs and Optical Signal Receive Simulator Viewer (ELCS) a, c	
	Optical Signal Transmit Simulator	Module Operations a, c	CELL module (FAIL)	DAT/ST module (FAIL)	DAT/ST module (LINE STATUS)	DAT/ST module (LVPS ALARM)	OPRM Minor Failure Signal	OPRM Inoperative ABA Trip GRA Trip PBDA Trip OPRM Trip
1		N/A	ON	ON	FAIL/APRM 1: OFF FAIL/APRM 2: OFF FAIL/LPRM 1: ON FAIL/LPRM 2: OFF FAIL/LPRM 3: OFF FAIL/LPRM 4: OFF	LVPS 1: OFF LVPS 2: OFF	ON	OFF
2		Push the "RESET" buttons on the CELL, AGRD, PBD and DAT/ST modules	OFF	OFF	FAIL/APRM 1: OFF FAIL/APRM 2: OFF FAIL/LPRM 1: OFF FAIL/LPRM 2: OFF FAIL/LPRM 3: OFF FAIL/LPRM 4: OFF	LVPS 1: OFF LVPS 2: OFF	OFF	OFF
3		N/A	ON	ON	FAIL/APRM 1: OFF FAIL/APRM 2: OFF FAIL/LPRM 1: OFF FAIL/LPRM 2: ON FAIL/LPRM 3: OFF FAIL/LPRM 4: OFF	LVPS 1: OFF LVPS 2: OFF	ON	OFF
4		Push the "RESET" buttons on the CELL, AGRD, PBD and DAT/ST modules	OFF	OFF	FAIL/APRM 1: OFF FAIL/APRM 2: OFF FAIL/LPRM 1: OFF FAIL/LPRM 2: OFF FAIL/LPRM 3: OFF FAIL/LPRM 4: OFF	LVPS 1: OFF LVPS 2: OFF	OFF	OFF
5		N/A	ON	ON	FAIL/APRM 1: OFF FAIL/APRM 2: OFF FAIL/LPRM 1: OFF FAIL/LPRM 2: OFF FAIL/LPRM 3: ON FAIL/LPRM 4: OFF	LVPS 1: OFF LVPS 2: OFF	ON	OFF
6		Push the "RESET" buttons on the CELL, AGRD, PBD and DAT/ST modules	OFF	OFF	FAIL/APRM 1: OFF FAIL/APRM 2: OFF FAIL/LPRM 1: OFF FAIL/LPRM 2: OFF FAIL/LPRM 3: OFF FAIL/LPRM 4: OFF	LVPS 1: OFF LVPS 2: OFF	OFF	OFF
7		N/A	ON	ON	FAIL/APRM 1: OFF FAIL/APRM 2: OFF FAIL/LPRM 1: OFF FAIL/LPRM 2: OFF FAIL/LPRM 3: OFF FAIL/LPRM 4: ON	LVPS 1: OFF LVPS 2: OFF	ON	OFF

Step	Test Pattern		Acceptance Criteria (Expected Output)					
			Displays on modules				Discrete Outputs and Optical Signal Receive Simulator Viewer (ELCS) a, c	
	Optical Signal Transmit Simulator	Module Operations a, c	CELL module (FAIL)	DAT/ST module (FAIL)	DAT/ST module (LINE STATUS)	DAT/ST module (LVPS ALARM)	OPRM Minor Failure Signal	OPRM Inoperative ABA Trip GRA Trip PBDA Trip OPRM Trip
8		Push the "RESET" buttons on the CELL, AGRD, PBD and DAT/ST modules	OFF	OFF	FAIL/APRM 1: OFF FAIL/APRM 2: OFF FAIL/LPRM 1: OFF FAIL/LPRM 2: OFF FAIL/LPRM 3: OFF FAIL/LPRM 4: OFF	LVPS 1: OFF LVPS 2: OFF	OFF	OFF
9		N/A	ON	ON	FAIL/APRM 1: ON FAIL/APRM 2: OFF FAIL/LPRM 1: OFF FAIL/LPRM 2: OFF FAIL/LPRM 3: OFF FAIL/LPRM 4: OFF	LVPS 1: OFF LVPS 2: OFF	ON	OFF
10		Push the "RESET" buttons on the CELL, AGRD, PBD and DAT/ST modules	OFF	OFF	FAIL/APRM 1: OFF FAIL/APRM 2: OFF FAIL/LPRM 1: OFF FAIL/LPRM 2: OFF FAIL/LPRM 3: OFF FAIL/LPRM 4: OFF	LVPS 1: OFF LVPS 2: OFF	OFF	OFF
11		N/A	ON	ON	FAIL/APRM 1: OFF FAIL/APRM 2: ON FAIL/LPRM 1: OFF FAIL/LPRM 2: OFF FAIL/LPRM 3: OFF FAIL/LPRM 4: OFF	LVPS 1: OFF LVPS 2: OFF	ON	OFF
12		Push the "RESET" buttons on the CELL, AGRD, PBD and DAT/ST modules	OFF	OFF	FAIL/APRM 1: OFF FAIL/APRM 2: OFF FAIL/LPRM 1: OFF FAIL/LPRM 2: OFF FAIL/LPRM 3: OFF FAIL/LPRM 4: OFF	LVPS 1: OFF LVPS 2: OFF	OFF	OFF

10.3 Additional Validation of Trip Algorithms

The purpose of this test item is to demonstrate that the OPRM unit performs its safety functions under specific conditions specified by NED with additional performance requirements for the OPRM Trip response time of the OPRM unit.

(1) Test Patterns and Procedures

1. Test Pattern 1

Signals that oscillate at a frequency of [ ]a, c Hz are input as LPRM Levels (i.e., LPRM A through LPRM D) that make up Cell 2. Based on the LPRM A, the [ ]a, c -degree phase lag is set to LPRM B first, next the [ ]a, c -degree phase lag is set to LPRM C, and then finally the [ ]a, c -degree phase lag is set to LPRM D. This test pattern comes with the four oscillating LPRM Levels without phase lags in the former part of this test pattern, and then the four oscillating LPRM Levels with phase lags follow.

- Step 1
  Set the OPRM unit to the "Normal Status for Additional Validation."

- Step 2
  Click "All Stop" for LPRM 1 to 4.
  Run ("All Start") the following test pattern files on the Optical Signal Transmit Simulator.
  LPRM 1: [ ]a, c (Single Output)
  LPRM 2: (Single Output)
  LPRM 3: (Single Output)
  LPRM 4: (Single Output)

  Note: After "Single Output" of selected test patterns is finished, the Optical Signal Transmit Simulator transmits 0% LPRM levels for LPRM CH1 through CH52 automatically, and the number of active OPRM Cells becomes "0." Thus, the CELL module generates an OPRM Inoperative signal.

- Step 3

  Check that status of discrete outputs, ELCS [ ]a, c data outputs and PC data outputs on the Optical Signal Receive Simulator is as expected in Table 10-2.

2. Test Pattern 2

Signals that oscillate at a frequency of [ ]a, c Hz are input as LPRM Levels (i.e., LPRM A through D) that make up Cell 20. Based on the LPRM CH of LPRM A, the [ ]a, c -degree phase lag is set to LPRM B first, next the [ ]a, c -degree phase lag is set to LPRM C, and then finally the [ ]a, c -degree phase lag is set to LPRM D. This test pattern comes with the four oscillating LPRM Levels without phase lags in the former part of this test pattern, and then the four oscillating LPRM Levels with phase lags follow.

- Step 1
  Click "All Stop" for LPRM 1 to 4.
  Run ("All Start") the following test pattern files on the Optical Signal Transmit Simulator.
  LPRM 1: [ ]a, c (Single Output)
  LPRM 2: (Single Output)
  LPRM 3: (Single Output)
  LPRM 4: (Single Output)

- Step 2

  Check that status of discrete outputs, ELCS [ ]a, c data outputs and PC data outputs on the Optical Signal Receive Simulator is as expected in Table 10-2.

- Step 3

  Determine the duration when the first PBDA Trip is generated on the Optical Signal Receive Simulator (PC data).

- Step 4

  Determine the duration when the LPRM A (LPRM CH 33) reaches to peak position right before the first PBDA Trip on the Optical Signal Receive Simulator (PC data).

  Note: Determine peak and valley positions by cursor operation. When the same values continue at the peak area, the peak position is to be determined by visually picking up a central point of those continuous values in the line graph.

- Step 5

  Calculate the response time of the first PBDA Trip generation as described in Table 10-3.

3. Test Pattern 3

Signals that oscillate at a frequency of [a, c] Hz are input as LPRM Levels (i.e., LPRM A through D) that make up Cell 22. Based on the LPRM A, the [a, c] -degree phase lag is set to LPRM B first, next the [a, c] -degree phase lag is set to LPRM C, and then finally the [a, c] -degree phase lag is set to LPRM D. This test pattern comes with the four oscillating LPRM Levels without phase lags in the former part of this test pattern, and then the four oscillating LPRM Levels with phase lags follow.

- Step 1
  Click "All Stop" for LPRM 1 to 4.
  Run ("All Start") the following test pattern files on the Optical Signal Transmit Simulator.
  [a, c]
  LPRM 1: (Single Output)
  LPRM 2: (Single Output)
  LPRM 3: (Single Output)
  LPRM 4: (Single Output)

- Step 2

  Check that status of discrete outputs, ELCS [a, c] data outputs and PC data outputs on the Optical Signal Receive Simulator is as expected in Table 10-2.

- Step 3

  Determine the duration when the first PBDA Trip is generated on the Optical Signal Receive Simulator (PC data).

- Step 4

  Determine the duration when the LPRM A (LPRM CH 32) reaches to peak position right before the first PBDA Trip on the Optical Signal Receive Simulator (PC data).

- Step 5

  Calculate the response time of the first PBDA Trip generation as described in Table 10-3.

4. Test Pattern 4

Signals that oscillate at a frequency of [a, c] Hz are input as LPRM Levels (i.e., LPRM A through D) that make up Cell 24. Based on the LPRM A, the [a, c] -degree phase lag is set to LPRM B first, next the [a, c] -degree phase lag is

set to LPRM C, and then finally the [ ] [a, c]-degree phase lag is set to LPRM D. This test pattern comes with the four oscillating LPRM Levels without phase lags in the former part of this test pattern, and then the four oscillating LPRM Levels with phase lags follow.

- Step 1
  Click "All Stop" for LPRM 1 to 4.
  Run ("All Start") the following test pattern files on the Optical Signal Transmit Simulator. [a, c]
  LPRM 1: [ ] (Single Output)
  LPRM 2: [ ] (Single Output)
  LPRM 3: [ ] (Single Output)
  LPRM 4: [ ] (Single Output)

- Step 2
  Check that status of discrete outputs, ELCS/ [ ] [a, c] data outputs and PC data outputs on the Optical Signal Receive Simulator is as expected in Table 10-2.

- Step 3

  Determine the duration when the first PBDA Trip is generated on the Optical Signal Receive Simulator (PC data).

- Step 4

  Determine the duration when the LPRM A (LPRM CH 7) reaches to peak position right before the first PBDA Trip on the Optical Signal Receive Simulator (PC data).

- Step 5

  Calculate the response time of the first PBDA Trip generation as described in Table 10-3.

5. Test Pattern 5

Signals that oscillate at a frequency of [ ] [a, c] Hz are input as LPRM Levels (i.e., LPRM A through D) that make up Cell 35. Based on the LPRM A, the [ ] [a, c]-degree phase lag is set to LPRM B first, next the [ ] [a, c]-degree phase lag is set to LPRM C, and then finally the [ ] [a, c]-degree phase lag is set to LPRM D. This test pattern comes with the four oscillating LPRM Levels without phase lags in the former part of this test pattern, and then the four oscillating LPRM Levels with phase lags follow.

- Step 1
  Click "All Stop" for LPRM 1 to 4.
  Run ("All Start") the following test pattern files on the Optical Signal Transmit Simulator. [a, c]
  LPRM 1: [ ] (Single Output)
  LPRM 2: [ ] (Single Output)
  LPRM 3: [ ] (Single Output)
  LPRM 4: [ ] (Single Output)

- Step 2
  Check that status of discrete outputs, ELCS/ [ ] [a, c] data outputs and PC data outputs on the Optical Signal Receive Simulator is as expected in Table 10-2.

- Step 3

  Determine the duration when the first PBDA Trip is generated on the Optical Signal Receive Simulator (PC data).

- Step 4

  Determine the duration when the LPRM A (LPRM CH 49) reaches to peak position right before the first PBDA Trip on the Optical Signal Receive Simulator (PC data).

- Step 5

  Calculate the response time of the first PBDA Trip generation as described in Table 10-3.

6. Test Pattern 6

Signals that oscillate at a frequency of [ ]a, c Hz are input as LPRM Levels (i.e., LPRM A through D) that make up Cell 38. Based on the LPRM A, the [ ]a, c -degree phase lag is set to LPRM B first, next the [ ]a, c -degree phase lag is set to LPRM C, and then finally the [ ]a, c -degree phase lag is set to LPRM D. It should be noted in this test pattern that <u>simulated random noise is given to LPRM Levels</u> at the frequency band from 3 to 33 Hz with maximum amplitude of 1.5 %. This test pattern comes with the four oscillating LPRM Levels without phase lags in the former part of this test pattern, and then the four oscillating LPRM Levels with phase lags follow.

- Step 1
  Click "All Stop" for LPRM 1 to 4.
  Run ("All Start") the following test pattern files on the Optical Signal Transmit Simulator.
  LPRM 1: [ ]a, c (Single Output)
  LPRM 2: [ ] (Single Output)
  LPRM 3: [ ] (Single Output)
  LPRM 4: [ ] (Single Output)

- Step 2

  Check that status of discrete outputs, ELCS/[ ]a, c data outputs and PC data outputs on the Optical Signal Receive Simulator is as expected in Table 10-2.

7. Test Pattern 7

The same test pattern files as that used for Test Pattern 1 (Cell2, frequency [ ]a, c Hz) are used. To check trip algorithms when signals of LPRM A and LPRM B are bypassed, transmission of LPRM unit 1 data and LPRM unit 4 data is stopped manually. This test pattern comes with the four oscillating LPRM Levels without phase lags in the former part of this test pattern, and then the four oscillating LPRM Levels with phase lags follow.

- Step 1
  Click "All Stop" for LPRM 1 to 4.
  Run ("All Start") the following test pattern files on the Optical Signal Transmit Simulator.
  LPRM 1: [ ]a, c (Single Output)
  LPRM 2: [ ] (Single Output)
  LPRM 3: [ ] (Single Output)
  LPRM 4: [ ] (Single Output)

- Step 2

  After the four oscillating LPRM Levels without phase lags in the former part of this test pattern finished,
  click "Stop" for <u>LPRM 1</u> to bypass LPRM B, and
  click "Stop" for <u>LPRM 4</u> to bypass LPRM A.

- Step 3

  Check that status of discrete outputs, ELCS[ ]a, c data outputs and PC data outputs on the Optical Signal Receive Simulator is as expected in Table 10-2.

8. Test Pattern 8

The same test pattern files as that used for Test Pattern 2 (Cell20, frequency [ ]a, c Hz) are used. To check trip algorithms when signals of LPRM A and LPRM B are bypassed, transmission of LPRM unit 2 data and LPRM unit 3 data is stopped manually. This test pattern comes with the four oscillating LPRM Levels without phase lags in the former part of this test pattern, and then the four oscillating LPRM Levels with phase lags follow.

- Step 1
  Click “All Stop” for LPRM 1 to 4.
  Run (“All Start”) the following test pattern files on the Optical Signal Transmit Simulator. [ ]a, c
  LPRM 1: (Single Output)
  LPRM 2: (Single Output)
  LPRM 3: (Single Output)
  LPRM 4: (Single Output)

- Step 2

  After the four oscillating LPRM Levels without phase lags in the former part of this test pattern finished,
  click “Stop” for <u>LPRM 2</u> to bypass LPRM B, and
  click “Stop” for <u>LPRM 3</u> to bypass LPRM A.

- Step 3

  Check that status of discrete outputs, ELCS/ [ ]a, c data outputs and PC data outputs on the Optical Signal Receive Simulator is as expected in Table 10-2.

9. Test Pattern 9

The same test pattern files as that used for Test Pattern 3 (Cell22, frequency [ ]a, c Hz) are used. To check trip algorithms when signals of LPRM A and LPRM B are bypassed, transmission of LPRM unit 1 data and LPRM unit 3 data is stopped manually. This test pattern comes with the four oscillating LPRM Levels without phase lags in the former part of this test pattern, and then the four oscillating LPRM Levels with phase lags follow.

- Step 1
  Click “All Stop” for LPRM 1 to 4.
  Run (“All Start”) the following test pattern files on the Optical Signal Transmit Simulator. [ ]a, c
  LPRM 1: (Single Output)
  LPRM 2: (Single Output)
  LPRM 3: (Single Output)
  LPRM 4: (Single Output)

- Step 2

  After the four oscillating LPRM Levels without phase lags in the former part of this test pattern finished,
  click “Stop” for <u>LPRM 1</u> to bypass LPRM B, and
  click “Stop” for <u>LPRM 3</u> to bypass LPRM A.

- Step 3

  Check that status of discrete outputs, ELCS/ [ ]a, c data outputs and PC data outputs on the Optical Signal Receive Simulator is as expected in Table 10-2.

10. Test Pattern 10

The same test pattern files as that used for Test Pattern 1 (Cell2, frequency [ ]a, c Hz) are used. It is checked that trip signals are not generated when the setpoints of Th and Tmax are changed from the "Standard Settings" as follows.

- Time Window for Trip Setpoint (Th) : 2.20
- Period Maximum Setpoint (Tmax) : 3.50

- Step 1
  Set the parameter "Th" of the AGRD module to 2.20.

- Step 2
  Set the parameter "Tmax" of the PBD module to 3.50.

- Step 3
  Click "All Stop" for LPRM 1 to 4.
  Run ("All Start") the following test pattern files on the Optical Signal Transmit Simulator.
  LPRM 1: [ ]a, c (Single Output)
  LPRM 2: (Single Output)
  LPRM 3: (Single Output)
  LPRM 4: (Single Output)

- Step 4
  Check that status of discrete outputs, ELCS/[ ]a, c data outputs and PC data outputs on the Optical Signal Receive Simulator is as expected in Table 10-2.

(2) Acceptance Criteria

- In each Test Pattern, check that the discrete outputs and optical outputs (ELCS[ ]a, c and PC) are expected specified in Table 10-2
- .In Test Pattern 2 through 5, check the response time is expected specified in Table 10-3.

Table 10-2 Acceptance Criteria and Expected Outputs

Test Pattern No.	Items to be checked		Acceptance Criteria	Reference Figure
	Type of signal/display	Signal name/displayed item		
Test Pattern 1 through 9	Optical Signal Receive Simulator Viewer (ELCS/ [ ] a, c data and PC data)	OPRM Trip	The "OPRM Trip" signal is generated.	N/A
		PBDA Trip	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Figure 10-1
		GRA Trip	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Figure 10-2
		ABA Trip	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time..	Figure 10-3
	Discrete Outputs	SCRAM	First "SCRAM" signal (Discrete) is generated within +/- 2 s of "OPRM Trip" signal (ELCS/ [ ] a, c data).	N/A
		PBDA_TRIP	First "PBDA_TRIP" signal (Discrete) is generated within +/- 2s of "PBDA Trip" signal (ELCS/ [ ] a, c data).	N/A
		GRA_TRIP	First "GRA_TRIP" signal (Discrete) is generated within +/- 2s of "GRA Trip" signal (ELCS/ [ ] a, c data).	N/A
		ABA_TRIP	First "ABA_TRIP" signal (Discrete) is generated within +/- 2s of "ABA Trip" signal (ELCS/ [ ] a, c data).	N/A
Test Pattern 10	Optical Signal Receive Simulator Viewer (ELCS/ [ ] a, c data and PC data)	OPRM Trip	"OPRM Trip" signal is not generated.	N/A
		PBDA Trip	"PBDA Trip" signal is not generated.	N/A
		ABA Trip	"ABA Trip" signal is not generated.	N/A
		GRA Trip	"GRA Trip" signal is not generated.	N/A
	Discrete Outputs	OPRM_TRIP	"OPRM_TRIP" signal is not generated.	N/A
		PBDA_TRIP	"PBDA_TRIP" signal is not generated.	N/A
		ABA_TRIP	"ABA_TRIP" signal is not generated.	N/A
		GRA_TRIP	"GRA_TRIP" signal is not generated.	N/A

Table 10-3 Acceptance Criteria of Response Time

Test Pattern No.	Items to be checked		Acceptance Criteria	Reference Figure
	Type of signal/display	Response time(α)		
Test Pattern 2	Optical Signal Receive Simulator Viewer (PC data)	$\alpha = X - \beta$ β is [ ] a, c s (calculated value)	[ ] a, c s or less	Figure 10-4
Test Pattern 3	Optical Signal Receive Simulator Viewer (PC data)	$\alpha = X - \beta$ β is [ ] a, c s (calculated value)	[ ] a, c s or less	Figure 10-5
Test Pattern 4	Optical Signal Receive Simulator Viewer (PC data)	$\alpha = X - \beta$ β is [ ] a, c s (calculated value)	[ ] a, c s or less	Figure 10-6
Test Pattern 5	Optical Signal Receive Simulator Viewer (PC data)	$\alpha = X - \beta$ β is [ ] a, c s (calculated value)	[ ] a, c s or less	Figure 10-7

Note

X = A- B (s)

A: The duration when the first PBDA Trip is generated.

B: The duration when the LPRM A reaches to peak position right before the first PBDA Trip.

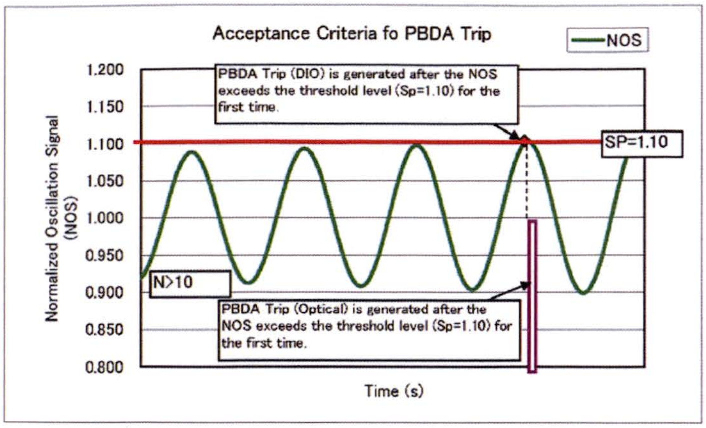

Figure 10-1 Acceptance Criteria of PBDA Trip

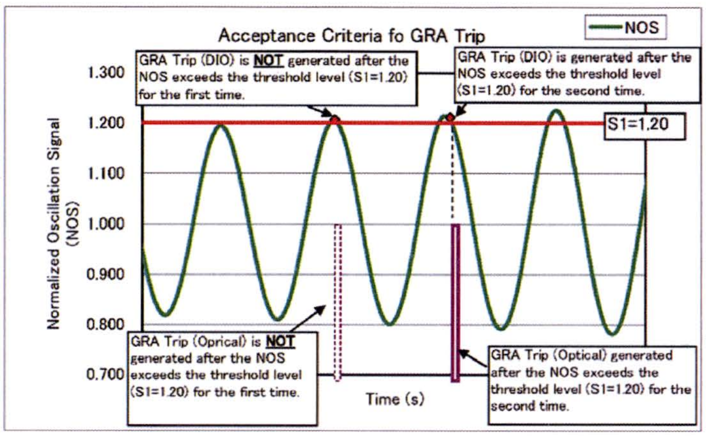

Figure 10-2 Acceptance Criteria of GRA Trip

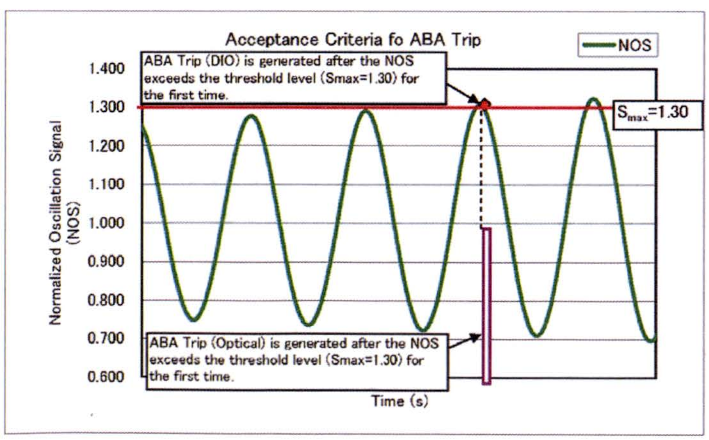

Figure 10-3 Acceptance Criteria of ABA Trip

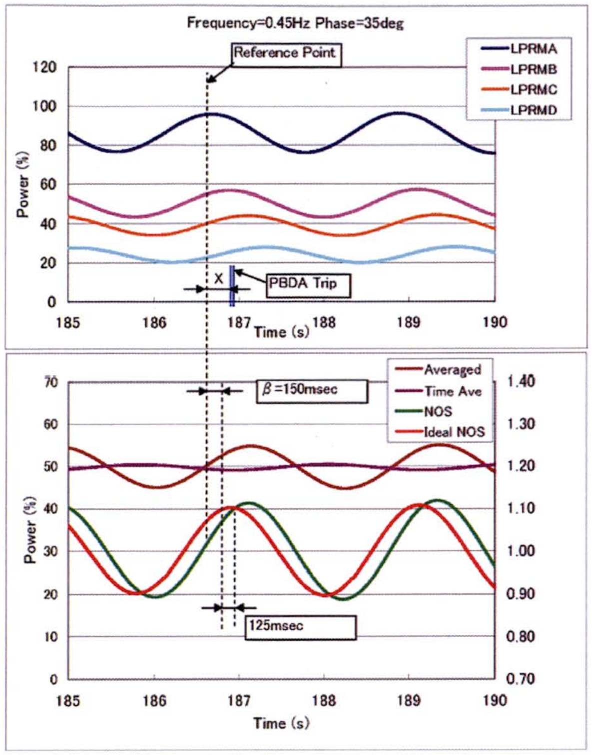

Figure 10-4 Wave Form and Expected Output for Test Pattern 2

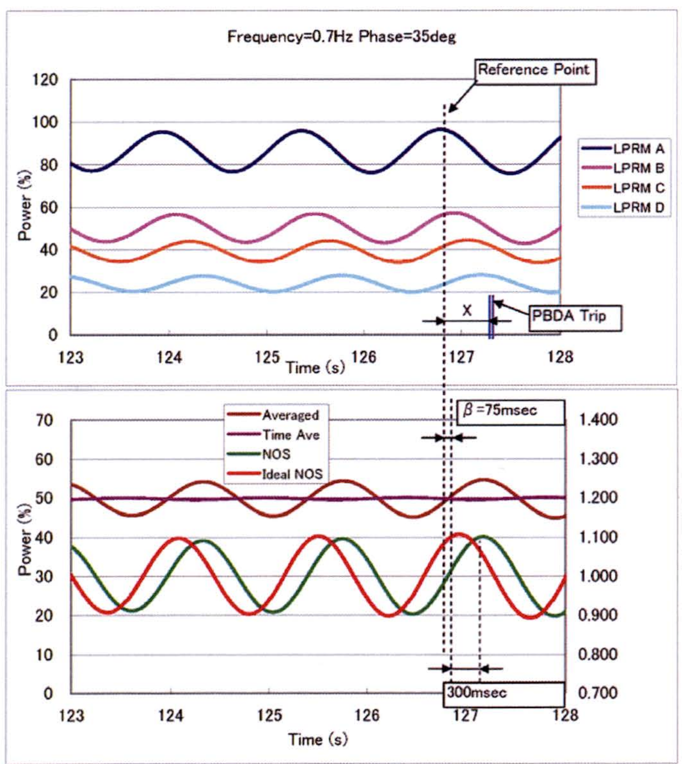

Figure 10-5 Wave Form and Expected Output for Test Pattern 3

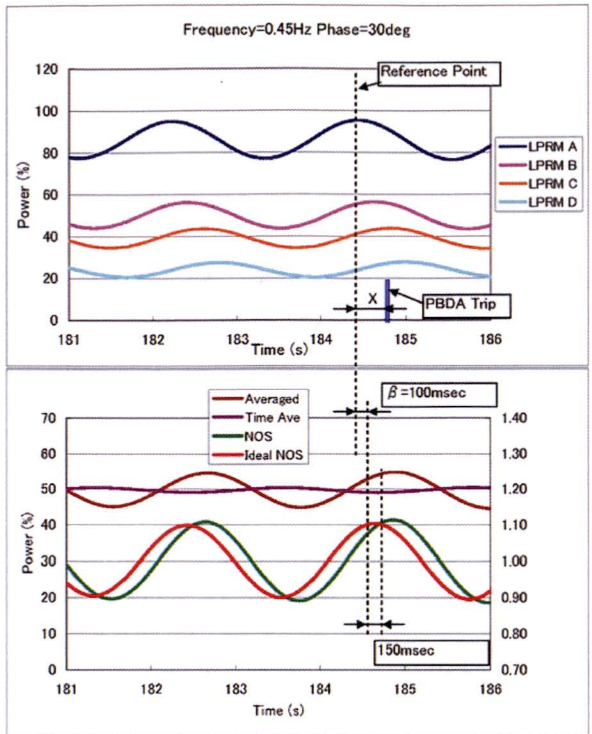

Figure 10-6 Wave Form and Expected Output for Test Pattern 4

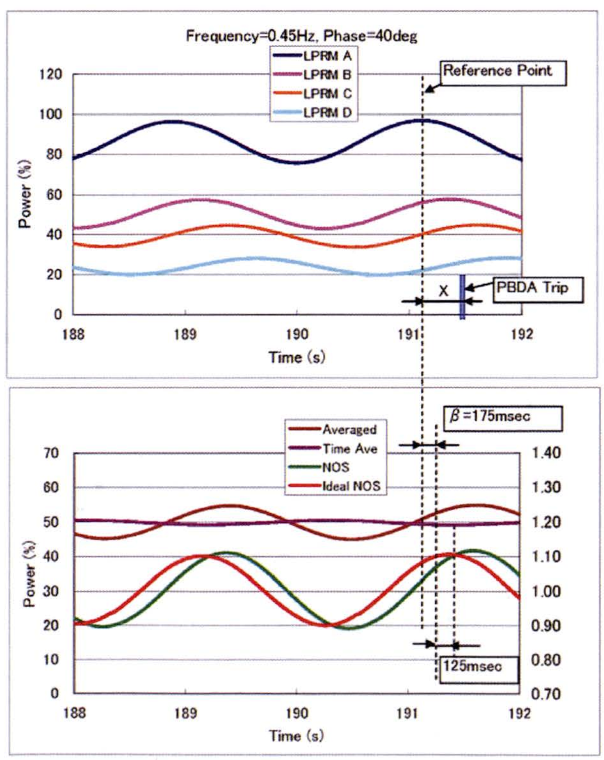

Figure 10-7 Wave Form and Expected Output for Test Pattern 5

Attachment A List of Test Pattern Files

List of LPRM Data Files

Section No. of SVTP	Test Pattern No.	File Name	Remarks
10.1, 10.2	Common	LPRM_50_R0_LPRM1.csv	All LPRM Levels are 50%.
		LPRM_50_R0_LPRM2.csv	All LPRM Levels are 50%.
		LPRM_50_R0_LPRM3.csv	All LPRM Levels are 50%.
		LPRM_50_R0_LPRM4.csv	a, c All LPRM Levels are 50%.
10.3	1, 7, 10		The purpose of this test pattern is to check response of the OPRM unit assuming actual plant condition. LPRM Signals which make up CELL2 are set to: a, c -Frequency is Hz. -Phase lag is a, c degrees.
	2, 8		The purpose of this test pattern is to check response of the OPRM unit assuming actual plant condition. LPRM Signals which make up CELL20 are set to: a, c -Frequency is Hz. -Phase lag is a, c degrees.
	3, 9		The purpose of this test pattern is to check response of the OPRM unit assuming actual plant condition. LPRM Signals which make up CELL22 are set to: a, c -Frequency is Hz. -Phase lag is a, c degrees.
	4		The purpose of this test pattern is to check response of the OPRM unit assuming actual plant condition. LPRM Signals which make up CELL24 are set to: a, c -Frequency is Hz. -Phase lag is a, c degrees.
	5		The purpose of this test pattern is to check response of the OPRM unit assuming actual plant condition. LPRM Signals which make up CELL35 are set to: a, c -Frequency is Hz. -Phase lag is a, c degrees.
	6		The purpose of this test pattern is to check response of the OPRM unit assuming actual plant condition. LPRM Signals which make up CELL38 are set to: a, c -Frequency is Hz. -Phase lag is a, c degrees. -Noise Peak is 1.5% -Noise Frequency is 3 - 33Hz.

List of APRM Data Files

Section No. of SVTP	Test Pattern No.	File Name	Remarks
10.1 through 10.3	Common	AP_52.0_FL_31.0_R0_Aprm1.csv	APRM 52.0%, Flow 52.0% (OPRM Region)
		AP_52.0_FL_31.0_R0_Aprm2.csv	

Attachment B Run Time of Test Pattern

Anticipated run time of each test pattern file used with "Single Output" mode is provided in the following table as a test supporting information.

Section No. of SVTP	Test Pattern No.	Run Time (sec.)
10.3	Test Pattern 1, 7, 10	510
	Test Pattern 2, 8	250
	Test Pattern 3, 9	180
	Test Pattern 4	250
	Test Pattern 5	250
	Test Pattern 6	250