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■ **Safety-Related**
☐ **Non-Safety-Related**
☐ **ASME CODE**
☐ **Others**

NRW-FPGA-Based I&C System Qualification Project

Equipment Design Specification

Title: Equipment Design Specification for Power Range Neutron Monitor

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

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Open Items

No.	Document Section	Description	Measures / Solutions	Responsible Group	Due Date	Status
1	General	RTM for EDS have not been issued.	NICSD issued RTM (FC51-3704-1004 Rev.0).	NISCD	Jan.13.2011	Close
2	General	Deviation items described in ECS-JHS-015387 are open item.	NED revised SDD (FC51-1001-0001-02 Rev.2).	NED	Mar.31.2012	Close
3	General	Deviation items described in ECS-JHS-017052 are open item.	NED revised IBD (FC51-2205-0001 Rev.2) and NED RTM (FC51-3704-0002 Rev.3)	NED NICSD	Mar.31.2012	Close

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Acronyms

ABA	Amplitude Based Detection Algorithm
ADS	Automatic Depressurization System
ANN	Annunciator
ANSI	American National Standard Institute
APR	Automatic Power Regulator
APRM	Average Power Range Monitor
ATLM	Automated Thermal Limit Monitor
ATWS	Anticipated Transient Without Scram
BYP	Bypass
CAL	Calibration
CI	Communication Interface
EDS	Equipment Design Specification
EFT/B	Electrical Fast Transient / Burst
ELCS	Engineered Safety Features Logic & Control System
EMC	Electromagnetic Capability
EMI/RFI	Electromagnetic Interference/ Radio Frequency Interference
EPRI	Electric Power Research Institute
ESD	Electrostatic Discharge
ESF	Engineered Safety Features
FD	Flat Display
FPGA	Field Programmable Gate Array
FS	Full Scale
FWC	Feedwater Control System
GAF	Gain Adjustment Factor
GRA	Growth Rate-Based Detection Algorithm
HMI	Human Machine Interface
I&C	Instrumentation and Control
IBD	Interlock Block Diagram
IEEE	Institute of Electrical and Electronics Engineers
IED	Instrument Equipment Diagram
LDP	Large Display Panel
LPRM	Local Power Range Monitor
MCR	Main Control Room
MDS	Material Data Sheets
MIL	Military specifications
MRBM	Multichannel Rod Block Monitor
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
NED	Nuclear Energy Systems and Services Division
NICSD	Nuclear Instrumentation and Control Systems Department
NMS	Neutron Monitoring System
NRW	Non-Rewritable
O/E	Optical to Ethernet

OP	Operation
OPRM	Oscillation Power Range Monitor
O/IO	Optical to Analog/Discrete Output
PBDA	Period Based Detection Algorithm
PC	Personnel Computer
PFC	Power Factor Correction
[	][a,c]
PSM	Power Systems Manufacturing Section
PRNM	Power Range Neutron Monitor
RCIS	Rod Control & Information System
RFC	Recirculation Flow Control System
RG	Regulatory Guide
RMS	Root Mean Square
RPS	Reactor Protection System
RTIS	Reactor Trip and Isolation System
RRS	Required Response Spectra
RWM	Rod Worth Minimizer
SCMP	Software Configuration Management Plan
SDD	System Design Description
SIL	Software Integrity Levels
SMP	Software Management Plan
SOE	Sequence of Event
SQAP	Software Quality Assurance Plan
SRNM	Startup Range Neutron Monitor
SSE	Safe Shutdown Earthquake
STANDBY	Standby
TDR	Transient Data Recorder
TR	Topical Report
V&V	Verification and Validation
VVP	Verification and Validation Plan

1. Scope

The scope of this Equipment Design Specification (EDS) is to specify requirements for the equipment design of the Local Power Range Monitor (LPRM), Average Power Range Monitor (APRM) and Oscillation Power Range Monitor (OPRM) comprising the Power Range Neutron Monitor (PRNM), which is a part of the Neutron Monitoring System (NMS).

Detector, external cable, and connector outside the Safety Related NMS Panel are out of scope of this specification.

The EDS is written to meet the requirements specified in the System Design Description for Neutron Monitoring System (SDD) (Reference 3 (1)), Neutron Monitoring System Interlock Block Diagram (IBD) (Reference 3 (6)), and Neutron Monitoring System Instrument Equipment Diagram (IED) (Reference 3 (2), (3), (4), (5)).

The scope of the EDS includes the applicable regulations, codes and standards, reference documents, functions and boundaries, design specifications, fabrication requirements, inspection and test requirements, painting and coating requirements, cleaning, packaging, shipping and transportation requirements and spare and replacement parts of the OPRM system.

The PRNM is classified as Category I for seismic category, Class 1E for electrical equipment, and Safety Class 3 (SC-3) according to "Procurement Specification for Equipment Qualification and EMC Qualification of Components of Oscillation Power Range Monitor" (Reference 3 (32)).

This EDS is used for the Non-Rewritable (NRW)-Field Programmable Gate Array (FPGA)-Based Instrumentation and Control (I&C) System Qualification Project. Scope of this project is Equipment Qualification (EQ) and Electromagnetic Compatibility (EMC) qualification of components of the OPRM in accordance with "Procurement Specification for Equipment Qualification and EMC Qualification of Components of Oscillation Power Range Monitor" (Reference 3 (32)). Scope of Test Specimen to be qualified through qualification tests is an OPRM unit specified in following sections of this EDS.

- Section 1
- Section 2
- Section 3
- Section 4.1.1.1, 4.1.1.3, 4.1.1.5, 4.1.2.2, 4.2 to 4.4
- Section 5.1.1 to 5.1.3, 5.1.4, 5.1.6 to 5.1.13, 5.2.1.3, 5.2.2.3, 5.2.2.4.2, 5.2.3.2, 5.2.3.7, 5.2.3.14, 5.3 to 5.12
- Section 6
- Section 7
- Section 8
- Section 9
- Section 10

2. Applicable Regulations, Codes and Standards

Following codes and standards are applicable to NMS to the extent specified herein.

(1) 10CFR50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants
(2) Regulatory Guide 1.22 Rev.0, Periodic Testing of Protection System Actuation-Functions
(3) Regulatory Guide 1.47 Rev.0, Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems
(4) Regulatory Guide 1.53 Rev.2, Application of the Single-Failure Criterion to Nuclear Power Plant Safety System
(5) Regulatory Guide 1.152 Rev.3, Criteria for use of computers in safety systems of Nuclear Power Plants
(6) Regulatory Guide 1.180 Rev.1, Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems
(7) IEEE Std 7-4.3.2-2003 IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations
(8) IEEE Std 323-2003 Qualifying of Class 1E Equipment for Nuclear Power Generating Stations
(9) IEEE Std 338-1987 Criteria for the Periodic Testing of Nuclear Power Generating Stations Safety Systems
(10)IEEE Std 344-1987 Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations
(11)IEEE Std 352-1987 Guide for General Principles of Reliability Analysis of Nuclear Power Generating Stations
(12)IEEE Std 379-2000 Standard Application of the Single-Failure Criterion to Nuclear Power Generating Stations Safety Systems
(13)IEEE Std 384-1992 Standard Criteria for Independence of Class 1E Equipment and Circuits
(14)IEEE Std 603-1991 IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations
(15)IEEE Std 1012-1998 IEEE Standard for Software Verification and Validation Plans
(16)IEEE Std 1050-1996 Guide for Instrumentation Control Equipment Grounding in Generating Stations
(17)MIL-HDBK 217F Reliability Prediction of Electronic Equipment
(18)ISA-S67.04-1994 Setpoints for Nuclear Safety related Instrumentation Used in Nuclear Power Plants
(19)EPRI TR-107330 Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety related Applications in Nuclear Power Plants, December 1996
(20)Deleted
(21)Regulatory Guide 1.75 Rev.3, Physical Independence of Electric Systems
(22)Regulatory Guide 1.29 Rev.4, Seismic Design Classification
(23)MIL-STD-461E Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
(24)EPRI TR-102323 Rev.2, Guidelines for Electromagnetic Interference Testing in Power Plant Equipment, November 2000
(25)Regulatory Guide 1.209 Guidelines for Environmental Qualification of Safety-Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants," March 2007

3. Reference Documents

(1) RS-5155709 Rev.8 (FC51-1001-0001 Rev.8), System Design Description for Neutron Monitoring System
(2) NP-5101426 Rev.1 (FC51-2202-0001-00001 Rev.1), Neutron Monitoring System IED (Sheet 1)
(3) NP-5101426 Rev.0 (FC51-2202-0001-00002 Rev.0), Neutron Monitoring System IED (Sheet 2)
(4) NP-5101426 Rev.0 (FC51-2202-0001-00003 Rev.0), Neutron Monitoring System IED (Sheet 3)
(5) NP-5101426 Rev.1 (FC51-2202-0001-00004 Rev.1), Neutron Monitoring System IED (Sheet 4)
(6) NM-5106817 Rev.2 (FC51-2205-0001 Rev.2), Neutron Monitor System IBD
(7) [Deleted]
(8) [Deleted]
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(20)TOSHIBA NICSD NQ-2004 Preparation Procedure for Equipment Design Specification (*1)
(21)TOSHIBA NICSD NQ-2030 Procedural Standard for FPGA Products Development (*1)
(22)TOSHIBA NICSD NQ-2036 Procedure for Design Control (*1)
(23)TOSHIBA NICSD NQ-2037 Cyber Security Procedure of Safety-Related Digital System (*1)
(24)TOSHIBA NICSD NQ-5001 Preparation and Operational Procedure of Traveler (*1)
(25)TOSHIBA NICSD NQ-5003 Identification and Control of items (*1)
(26)TOSHIBA NICSD NQ-5004 Manufacturing Process Procedure (*1)
(27)[Deleted]
(28)TOSHIBA NICSD 5B8K0037 Rev.1 (FA32-3701-1001 Rev.1), NICSD Software Quality Assurance Plan for FPGA-Based Safety-Related I&C Systems
(29)TOSHIBA NICSD 5B8K0038 Rev.5 (FA32-3709-1000 Rev.5), NICSD Verification and Validation Plan for FPGA-Based Safety-Related I&C Systems
(30)TOSHIBA NICSD 5B8K0035 Rev.2 (FA32-3702-1000 Rev.2), NICSD Software Management Plan for FPGA-Based Safety-Related I&C Systems
(31)TOSHIBA NICSD 5B8K0036 Rev.1 (FA32-3708-1000 Rev.1), NICSD Software Configuration Management Plan for FPGA-Based Safety-Related I&C Systems
(32)RS-5155431 Rev.11 (FC51-3601-0001, Rev.11), Procurement Specification for Equipment Qualification and EMC Qualification of Component of Oscillation Power Range Monitor (OPRM)
(33)TOSHIBA NED AS-500A007 General Requirements for packaging, shipping, receiving, storage, and handling (*1)
(34)RS-5154609 Rev.2 (FA70-3602-0001, Rev.2), The Common Quality Assurance Specification for NRW-FPGA-Based I&C System Qualification Project
(35)RS-5073918 Rev.6 (FPG-RQS-C51-0001, Rev.6), Equipment Requirement Specification of FPGA based Units

Note:
*1: This project shall use the latest edition of NQ and AS Standards.

4. Functions and Boundaries

This section describes the requirements of functions and boundaries of the PRNM system.

4.1. Functions

The PRNM system is divided into safety-related and non-safety-related portions. The functions of safety-related and non-safety-related systems are determined according to System Design Description for NMS (SDD) (Reference 3 (1)), and described in the following sections 4.1.1 and 4.1.2.

4.1.1. Safety-Related Functions

The PRNM system provides the following safety-related signals:

4.1.1.1. Generate the following signals:

- LPRM Level, which represents a local neutron flux
- APRM Level, which represents an average neutron flux
- Simulated Thermal Power
- Core Flow Level
- Neutron flux oscillation

4.1.1.2. Generate the following trip signals, as the APRM and Core Flow measurement functions and provide to the Reactor Protection System (RPS):

- APRM Upscale Flux Trip
- Simulated Thermal Power Upscale Trip
- APRM Inoperative
- Core Flow Rapid Coastdown (bypassed when thermal power is less than specific value)

4.1.1.3. Generate the following trip signals, as OPRM functions and provide to the Reactor Protection System (RPS):

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

4.1.1.4. Generate the APRM Anticipated Transient Without Scram (ATWS) Permissive signals and provide to identical division of Engineered Safety Features (ESF) Logic and Control System (ELCS) for Automatic Depressurization System (ADS) inhibit.

4.1.1.5. Provide the data signals, bypass state, trip state, annunciator and operation state to the ELCS Flat Display (FD).

4.1.2. Non-Safety-Related Functions

The PRNM system provides the following non-safety-related signals:

4.1.2.1. Generate the following rod block signals to the Rod Control & Information System (RCIS).

- APRM Upscale Flux Alarm
- APRM Inoperative
- APRM Downscale (only in RUN)
- Core Flow Upscale Alarm
- Core Flow Downscale

4.1.2.2. Provide the data signal to the following external systems via Non-Safety-related Interface as described in Section 5.2.1:

- [ ]a,c
- Automatic Power Regulator (APR)
- Recirculation Flow Control System (RFC)
- Automated Thermal Limit Monitor (ATLM)

4.1.2.3. Provide the signals to the Multichannel Rod Block Monitor (MRBM) as described in Section 5.2.1.

4.1.2.4. Download the Gain Adjustment Factors (GAFs) from [ ]a,c via the Non-Safety-Related Communication Interface (CI), in order to adjust the LPRM Icals, which are the LPRM detector currents at 100% power. In order to obtain exact LPRM Level, an Ical value can be changed and an LPRM Level is calibrated. GAF is a factor to compensate a previous Ical value. For example, when the previous Ical is 1,100μA and GAF is 1.1, then the new Ical becomes 1,000μA.

4.2. Summary Description

This section gives an overview of the PRNM configuration, and functional allocation.

The definition of the PRNM system in this EDS is specified in Section 3.2.1 of the SDD for NMS (Reference 3 (1)). The PRNM system does not include the LPRM detectors.

The PRNM system consists of four equivalent divisions.

A rectangle block drawn in solid line in Figure 4-1 shows the configuration for one division of the PRNM system. One division of the PRNM system consists of four LPRM units, one APRM unit, one OPRM unit, one Relay unit. All the PRNM divisions are independent one another and redundant. The LPRM units, APRM unit, OPRM unit, and Relay unit are included in the NMS Panel per division and installed in the main control room (MCR) back panel area. The PRNM system shares the NMS Panel with Startup Range Neutron Monitor (SRNM). They are classified as Class 1E safety-related.

The PRNM system is connected to Safety-related CI and Non-Safety-related CI. The Safety-related CI consists of the [ ][a,c] Non-Safety-related CI consists of the Optical to Analog/Discrete Output (O/IO) converter, the Optical to Ethernet (O/E) converter, the Transient Data Recorder (TDR) & Sequence of Event (SOE) Interface (IF), and the [ ][a,c]

The PRNM system receives current signals from 208 LPRM detectors distributed in the whole core. These detectors are grouped into four divisions: A, B, C and D, as shown in the Neutron Monitor System IED (Reference 3 (2)), therefore one division has 52 detectors. The signals from these 52 detectors are divided into four groups, which are assigned to respective four LPRM units.

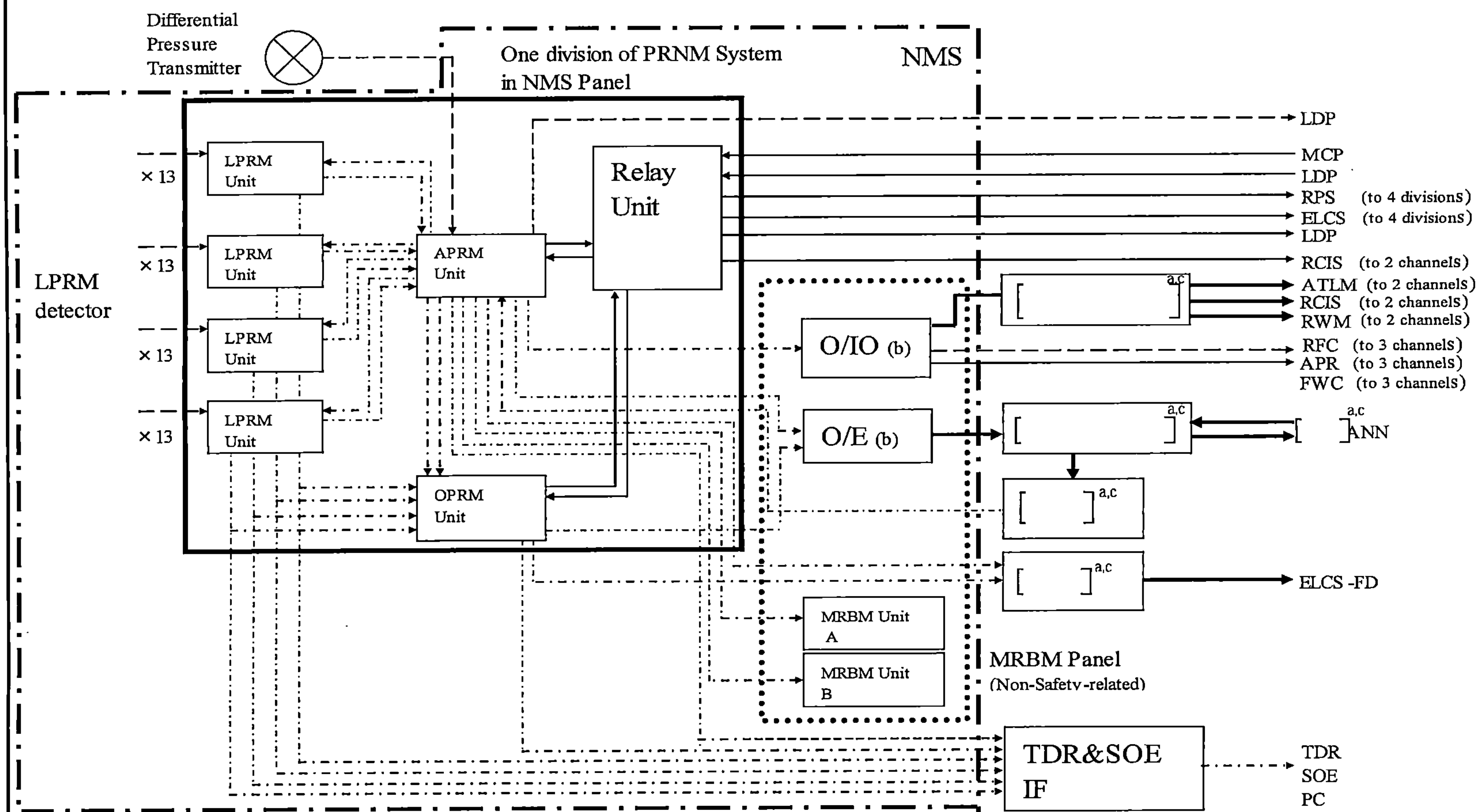
Receiving the current signals from LPRM detectors, the LPRM units provide the LPRM Levels to the APRM unit and OPRM unit. The LPRM unit generates an alarm when one of the LPRM Level exceeds an upper or lower setpoint. In order to obtain exact LPRM Level, an Ical value can be changed and an LPRM Level is calibrated. The GAF download function is provided to calibrate the Ical value. The LPRM unit provides the LPRM Level to TDR via TDR & SOE IF.

The APRM unit averages the 52 LPRM Levels received from four LPRM units, to generate an APRM Level. The APRM unit measures 0 to 125% of the rated reactor power. The lower part of this range overlaps the measurement range of the Startup Range Neutron Monitor (SRNM). The APRM unit generates a Simulated Thermal Power Level using low pass filter on the APRM Level. The APRM unit also processes the Core Support Plate Differential Pressure value received from the core support plate, to generate the Core Flow Level. The APRM unit provides APRM Unit Data and LPRM Unit Data to the OPRM unit and MRBM unit. The APRM unit provides signals described in Section 5.2.1.2 to ELCS-FD via Safety-related CI. Also, the APRM unit provides signals described in Section 5.2.1.2 to ATLM, RCIS, Rod Worth Minimizer (RWM), Recirculation Flow Control System (RFC), Feedwater Control System (FWC), Annunciator (ANN), [ ][a,c] APR,TDR and SOE via Non-Safety-related CI. The APRM unit generates the alarm and trip signals listed in Section 5.2.1.2 and sends to RPS and RCIS via Relay unit. The APRM unit sends to APRM ATWS Permissive signal to ELCS via Relay unit for ADS inhibit. One APRM unit is bypassed by the APRM Bypass switch on Large Display Panel (LDP). The APRM unit receives the GAF value from [ ][a,c] via Non-Safety-related CI, and provides to LPRM units.

The OPRM unit receives 52 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 as shown in Figure 5-4. The OPRM unit generates the alarms and trip signals described in Section 5.2.1.3. 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 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 greater than 60% (Initial setpoint). The OPRM unit provides the trip signals described in Section 4.1.1.3 to the RPS via the Relay unit. The OPRM unit provides the signals described in Section 5.2.1.3 to ELCS-FD via Safety-related CI. Also, the OPRM unit provides the signals described in Section 5.2.1.3 to [ ][a,c] ANN, TDR, 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 Transient Data Recorder (TDR).

The Relay unit and optical cables are provided to interface the APRM unit and OPRM unit to, and also isolate those units from external systems.



- Discrete
- Analog
- Optical
- Ethernet

Note:
(a): Safety-related CI
(b): Non-Safety-related CI

LDP: Large Display Panel
MCP: Main Control Panel
RPS: Reactor Protection System
RCIS: Rod Control & Information System
ATLM: Automated Thermal Limit Monitor
RWM: Rod Worth Minimizer
RFC: Recirculation Flow Control System
APR: Automatic Power Regulator
FWC: Feedwater Control System
ANN: Annunciator

[ ]a,c
ELCS: Engineered Safety Features (ESF) Logic and Control System
TDR: Transient Data Recorder
SOE: Sequence of Event
GW: Gateway
IF: Interface
CI: Communication Interface
O/IO: Optical to Analog/Discrete Output Converter
O/E: Optical to Ethernet Converter
PC: Personal Computer

Figure 4-1 System Configuration

4.3. System Features

4.3.1. Design Criteria

The following design criteria are applied for the safety-related part of the PRNM system:

1. The PRNM system shall adopt modular design and support module replacement as described in Section 2 of IEEE Std 603 (Reference 2 (14)).

2. Single failure criterion shall be applied in the design of the PRNM system in conformance with Section 5.1 of IEEE Std 603 (Reference 2 (14)) and IEEE Std 379 (Reference 2 (12)) endorsed by RG 1.53 (Reference 2 (4))
   (a) The safety-related systems shall perform all required safety-related functions for a design basis event in the presence of any single detectable failure within the safety systems concurrent with all identifiable, but non-detectable failures.
   (b) The safety-related systems shall perform all required safety-related functions for a design basis event in the presence of all failures caused by the single failure.
   (c) The safety-related systems shall perform all required safety-related functions for a design basis event in the presence of all failures and spurious system actions that cause, or are caused by, the design basis event requiring the safety function.

3. Each division shall be independent in design, and isolated in conformance with section 5.6 of IEEE Std 603 (Reference 2 (14)) and IEEE Std 384 (Reference 2 (13)) functionally.

4. For interconnection between safety-related parts and other systems, Section 5.6.3.1 of IEEE Std 603 (Reference 2 (14)) shall be applied.
   (a) Equipment that is used for both safety and non-safety functions shall be classified as part of the safety systems.
   (b) Isolation devices used to be a safety system boundary shall be classified as part of the safety system.
   (c) No credible failure on the non-safety side of an isolation device shall prevent any portion of a safety system from meeting its minimum performance requirements during and following any design basis event requiring that safety function.
   (d) A failure in an isolation device shall be evaluated in the same manner as a failure of other equipment in a safety system.

5. The PRNM system shall be designed so that its portions of the execute features with a degree of redundancy of one allow a portion placed in maintenance bypass during plant operation, in conformance with Section 7.5 of IEEE Std 603 (Reference 2 (14)).

6. All auxiliary supporting features that are required by the PRNM system to accomplish its safety-related functions shall meet the requirements imposed on the safety portions of the PRNM system, in conformance with IEEE Std 603 (Reference 2 (14)).

7. The PRNM system is safety-related and, thus, shall be qualified for Class 1E applications per the requirements of IEEE Std 323(Reference 2 (8)) and IEEE Std 344(Reference 2 (10)).

8. IEEE Std 1012(Reference 2 (15)) defines Software Integrity Levels (SIL).
   The SIL shall be defined for all software used in development of the PRNM system.
   The safety-related logic embedded in the PRNM system shall be dealt with as SIL 4 software.
   The SIL is defined in the Software Quality Assurance Plan (SQAP) (Reference 3 (28)).

9. The logic of PRNM system shall be verified and validated in accordance with the method provided in IEEE 1012 (Reference 2 (15)).

10. The PRNM system shall be designed so that it could be protected against power supply fluctuation.

A loss of power supply or an equipment failure shall generate an inoperative trip as fail-safe.
The power supply shall be a Class-1E power supply for each division in accordance with IEEE Std 384 (Reference 2 (13)).

11. The communications from the unit are designed adhering to the following criteria:
Communication path from safety-related to non-safety-related systems shall be logically and physically isolated.
Communication path from safety-related to non-safety-related systems shall meet all the separation criteria in accordance with IEEE Std 384 (Reference 2 (13)).
Each unit of PRNM system shall be so designed that any communication does not interfere its safety-related functions automatically and change settings or calibrations without operator approval.
Each unit of PRNM system shall be so designed to use a pre-determined data format and identify and dispose of unrecognized data.
Each unit of PRNM system shall be so designed that any communication fault does not interfere its safety-related signal processing.
Each unit of PRNM system shall communicate point-to-point.
Each unit of PRNM system shall be so designed that it communicates a set of fixed data (called "state") at regular interval.

These criteria conform to the requirements in Section 5.6 of IEEE Std 7-4.3.2 (Reference 2 (7)).

12. The PRNM system shall be designed so that any errors in the test circuit or the self-diagnosis circuit do not affect it operation.
This criteria conform to the requirements in Section 5.5.3 of IEEE Std 7-4.3.2 (Reference 2 (7))

13. The control logic of the PRNM system shall be designed to be "fail-safe." This is to generate a trip signal when a control logic function fails or does not work properly due to a loss of power.

14. The PRNM system shall have one or more outputs that can be used to indicate its bypassed and inoperative status indication in conformity with RG.1.47 (Reference 2 (3)).

15. The PRNM system shall be protected from electric power transients and disturbances by using fuses, analog isolators, optical couplers and, fiber optic cables in conformance with RG.1.180 (Reference 2 (6)). Detail description of isolation is described in EDS Section 5.5.7.

16. All safety-related PRNM equipment has the ability to operate under the normal and accident conditions specified in EPRI TR-107330 (Reference 2 (19)).

17. The PRNM system shall be designed to minimize susceptibility to, and generation of, electromagnetic interference (EMI) and radio frequency interference (RFI).

18. The PRNM system seismic requirement shall be designed in accordance with EPRI TR-107330 (Reference 2 (19)).

19. The allowance for uncertainties between the process analytical limit and the device setpoints is determined according to the setpoint calculation in the bases for the Plant Technical specification or in accordance with ISA-S67.04 (Reference 2 (18)). Design of multiple setpoints for adequate protection for a particular mode of operation or set of operating conditions provides positive means of ensuring that the more restrictive setpoint is used when required.

20. The PRNM system shall be designed so that calibration settings are specifically acknowledged, approved and download by qualified personnel with strict access control (e.g., key lock or closely controlled password).

21. The PRNM monitoring function shall be able to be maintained even in the event of a loss of single failure of

redundant power supply of each equipment conformance with SDD for NMS, FC51-1001-0001 (Reference 3 (1))

22. Digital equipment shall be designed in accordance with IEEE Std 7-4.3.2 (Reference 2 (7)).

4.3.2. System Availability

The PRNM system is designed to support the overall required plant availability more than 95%.

4.4. Operation

4.4.1. Operation Modes

The PRNM system is designed to have operation modes. The operation modes are described in section 5.2.2.1.4, 5.2.2.2.4 and 5.2.2.3.4. The operation (OP) mode is provided for normal measurement, the other modes are provided for maintenance. The LPRM unit receives 13 LPRM detector signals, and is designed to allow operation mode selection for each signal processing on the LPRM detector signal. The LPRM unit, APRM unit and OPRM unit are designed to allow operation mode selection during signal processing from a key switch in front panel.
For further detail, see Section 5.2.2.1.4, 5.2.2.2.4 and 5.2.2.3.4.

4.4.2. Operating Bypass

The OPRM function is bypassed, if one or more of the following conditions occur:

A) When the APRM Level is less than the OPRM Region APRM Level Setpoint.
B) When the Core Flow Level is more than the OPRM Region Core Flow Level Setpoint.

Nominal setpoint of the OPRM Region APRM Level Setpoint is 30%.
Nominal setpoint of the OPRM Region Core Flow Level Setpoint is 60%.

4.4.3. Maintenance Bypass

The one division of the PRNM system is bypassed by APRM Bypass switch on LDP without causing a plant shutdown or scram while plant is in operation for maintenance, and allows maintenance of the LPRM unit, the OPRM unit, and the APRM unit included in the bypassed division of the PRNM system. At one time, only one division of the PRNM system can be bypassed.

Each LPRM signal processing path can be bypassed individually for calibration and alarm testing, as describe in Section 4.4.4. The bypassed LPRM signal processing path is marked as inoperative, and ignored in the APRM calculation. To retain the PRNM safety-related function, the APRM unit generates an APRM Inoperative signal if one or more of the following conditions occur:

A) When the Number of Active LPRMs is less than Minimum Number of Operating LPRMs
B) When the Number of Active LPRMs on the same plane orthogonal to the core axial direction is less than Minimum Number of Operating LPRMs on same plane.

Nominal setpoint of the Minimum Number of Operating LPRMs is 32.
Nominal setpoint of the Minimum Number of Operating LPRMs on same plane is 6.

4.4.4. Calibration and Test

The PRNM system is tested periodically in accordance with IEEE Std 338 (Reference 2 (9)) and RG 1.22 (Reference 2 (2)).
The PRNM system has the following Calibration and Test functions:

1. Gain Calibration

    1) LPRM Gain Calibration

    Each LPRM signal processing can be bypassed to calibrate its gain individually. The LPRM unit provides the following two methods for gain calibration.

    A) Manual Calibration

    The LPRM signal processing can be bypassed to calibrate its gain.
    The LPRM unit is designed to calibrate the LPRM gain by generating internal calibration signal by pressing

button in the LPRM unit.

B) GAF download
The LPRM signal processing can be bypassed to calibrate its gain.
The LPRM unit is designed to calibrate the LPRM gain by Gain Adjustment signal that receives from [ ][a,c]

2) APRM Gain Calibration
The APRM signal processing can be bypassed to calibrate its gain.
The APRM unit is designed to change the APRM Gain by pressing button in the APRM unit.

2. Setpoint Calibration Analysis
An analysis is prepared to provide the information needed to support an application specific setpoint analysis per ISA-S 67.04 (Reference 2 (18)). The analysis includes:
A) Calibrated accuracy, including hysteresis and non-linearity, of the analog inputs.
B) Repeatability of the analog inputs.
C) Temperature sensitivity of the analog inputs.
D) Drift with time of the analog inputs.
E) Power supply voltage fluctuation effects on the analog inputs.

3. Trip and Alarm Test
Trip and Alarm output can be checked by the button operation on LPRM unit, APRM unit and OPRM unit.

4. Circuit Test
For LPRM and Core Flow measurements, internal current sources are provided to test the signal processing circuits.

4.4.5. Other Feature

The PRNM system has the following the other functions:
1. Trip and Alarm Latch
The PRNM system is designed to latch the trip and alarm signals listed in Table 5-11-2, Table 5-15-2 and Table 5-20-2, and allow the operator to reset the trip and alarm signals (The Core Flow Rapid Coastdown Bypass signal, the APRM ATWS Permissive OFF signal, the APRM Bypass signal, and the Reactor Mode signal are reset automatically).

2. Self-Diagnostic
The PRNM system has self-diagnostic functions, which are described in the Section 5.1.8.
Failures detected by self-diagnosis are indicated.

5. Design Specifications

This section specifies the design specifications for the PRNM system.

5.1. System Functional Specifications

5.1.1. System Configuration Specifications

The followings are basic specifications for the PRNM system:

1. The PRNM system shall adopt unit design.
2. The PRNM system shall consist of four equivalent divisions.
3. The one division of PRNM system shall be designed to perform the PRNM system functions by combination of four LPRM units, one OPRM unit, one APRM unit, the interconnecting cables and the Relay unit as described Figure 4-1.
4. The NMS panels shall be designed to contain the LPRM units, the APRM units, the OPRM units, the Relay units and the DC power supplies for Relay units.
5. All the PRNM divisions shall be independent one another.
6. All the PRNM divisions shall be redundant.
7. The NMS panels shall be installed in the MCR area.

The followings are described about one division of PRNM system. These descriptions are same for other division.

5.1.2. System Initialize Specification

The followings are system initialization specification for the PRNM system:

1. The units used in the PRNM system shall initialize by power on reset function, when power is supplied to the units.
2. The units used in the PRNM system shall generate all trip and alarm outputs during the initialization.

5.1.3. Nominal Setpoint

The LPRM, the OPRM, and the APRM units have setpoints for their trip and alarm generations. Figure 5-1 illustrated the APRM Upscale Flux Trip, Simulated Thermal Power Upscale Trip, APRM Upscale Flux Alarm, and APRM Downscale setpoints against the core flow.

The PRNM system shall have trip and alarm setpoints listed in Table 5-1, Table 5-2, and Table 5-3.
The PRNM system shall have adjustable setpoints with its measurement range.
The setpoint shall be designed to be adjustable manually (except the Core Flow Downscale Setpoint and Minimum Number of Operating LPRMs on same plane).
The setpoint shall be able to be checked.

Table 5-1 Nominal LPRM Setpoints

Conditions	Action	Tentative Setpoint	Setpoint Range
LPRM Upscale Alarm	annunciator	≥100%	5.0 to 125.0 %
LPRM Downscale	annunciator	≤5%	0.0 to 10.0 %

Table 5-2 Nominal APRM Setpoints

Conditions	Action	Tentative Setpoint	Setpoint Range
APRM Upscale Flux Trip (only in RUN) (a)	Scram	≥118%	60.0 to 125.0 %
APRM Upscale Flux Trip (not in RUN) (b)	Scram	≥13%	6.0 to 20.0 %
Simulated Thermal Power Upccale Trip	Scram	≥0.68W+52.0% (maximum 113.0%) (c)	Clamp (d): 60.0 to 125.0 % Slope: 0.40 to 1.50 Intercept: 20.0 to 125.0%
APRM Upscale Flux Alarm (only in RUN) (a)	Rod block	≥0.68W+47.0% (maximum 108.0%) (c)	Clamp (d): 60.0 to 125.0 % Slope: 0.40 to 1.50 Intercept: 20.0 to 125.0%
APRM Upscale Flux Alarm (not in RUN (b)	Rod block	≥10.0%	0.0 to 10.0 %
APRM Downscale	Rod block (only in RUN)	≤5%	2.0 to 20.0%
Core Flow Upscale Alarm	Rod block	≥120.0%	100.0 to 125.0%
Core Flow Rapid Coastdown	Scram	Z≤0% (e)	0.0 to 15.0%
Core Flow Rapid Coastdown Bypass	Core Flow Rapid Coastdown signal Bypass	≤75.0% (Simulated Thermal Power during past 3 seconds)	60.0 to 85.0%
Core Flow Downscale	Rod block	Input current ≤2mA	2.0mA (fixed)
Core Flow Low-Cut	Core Flow value =0	≤25%	0.0 to 40.0%
APRM Inoperative (Minimum Number of Operating LPRMs)	Scram and Rod block	<32 detectors	32 to 52
APRM Inoperative (Minimum Number of Operating LPRMs on same plane)	Scram and Rod block	<6 detector s	6 detectors (fixed)
APRM ATWS permissive	ATWS permissive	≥6.0%	0.0 to 99.9%

Note:

(a): When the reactor mode is at "RUN."

(b): When the reactor mode is not at "RUN."

(c): W is the Core Flow Level measured in percent, which biases the setpoint.

(d): Clamp determines the maximum value of the setpoint.

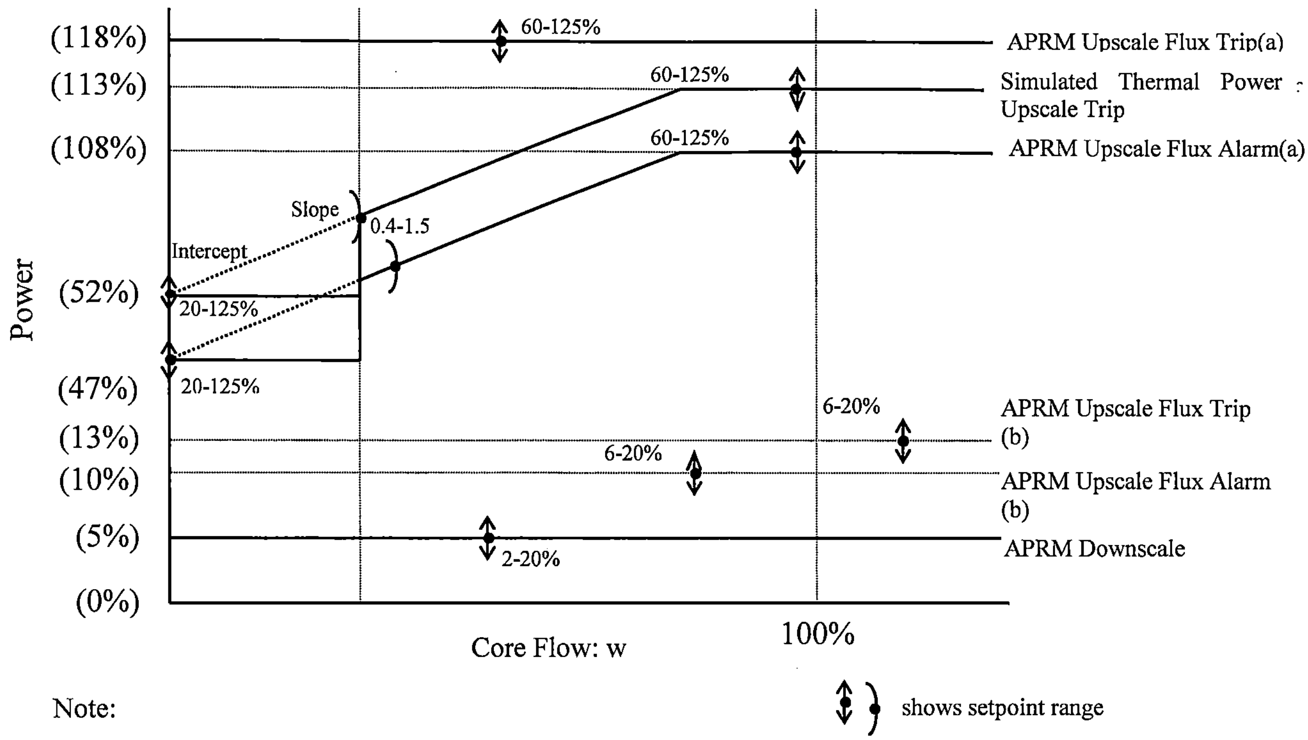
(e): The explanation of "Z" is described in Section 5.2.2.2.5-9.

Table 5-3 Nominal OPRM Setpoints

Conditions	Action	Tentative Setpoint	Setpoint Range
Growth Rate-Based Trip (S3)	Scram (a)	S≥S3=(P1-1.0) x DR3+1.0 (b) DR3=1.30	DR3:1.00 to 1.99
Amplitude-Based Maximum Trip (Smax)	Scram (a)	S ≥ Smax =1.30 (c)	1.00 to 1.99
Period-Based Trip (Sp)	Scram (a)	S ≥Sp=1.10 (c)	1.00 to 1.99

S: Normalized Oscillation Signal.
S3: Growth Rate Amplitude Setpoint.
DR3: Growth Rate Factor.
Smax: Maximum Amplitude Trip Setpoint (ABA).
Sp: Maximum Amplitude Trip Setpoint (PBDA).

Note:
(a): Automatically bypassed if APRM Level is less than 30 % or Core Flow Level is more than 60 %
(b): P1 is the latest peak reading measured after the signal S (Normalized Oscillation Signal) exceeds the Threshold Setpoint. Other Pre-Trip Condition parameters of the algorithm are described in Table 5-20.
(c): Other Pre-Trip Condition parameters of the algorithm are described in Table 5-20.



Note:

(a): When the reactor mode is at "RUN."

(b): When the reactor mode is not at "RUN."

Figure 5-1 APRM Upscale Flux Trip, Simulated Thermal Power Upscale Trip, APRM Upscale Flux Alarm and APRM Downscale setpoints

5.1.4. Response Time

The APRM trip response time are defined as specified in the SDD for NMS (Reference 3 (1)) as the delay time from an input signal change to the corresponding output signal change.

1. APRM Upscale Flux Trip
   The APRM Upscale Flux Trip response time from the change of the LPRM input signal to the occurrence of trip from Relay unit shall not exceed 40 milliseconds.

2. Simulated Thermal Power Upscale Trip
   The Simulated Thermal Power Upscale Trip response time from the change of the LPRM input signal to the occurrence of trip from Relay unit shall not exceed 40 milliseconds
   Note: The response time does not include time constant (6 seconds).

3. Core Flow Rapid Coastdown
   The Core Flow Rapid Coastdown response time from the step change of Core Support Plate Differential Pressure input signal to the occurrence of trip from Relay unit shall not exceed 1100 milliseconds at the following conditions.
   - Filter time constant (analog filter of the transmitter and digital filter of signal processing):
     1000 milliseconds or less
   - Delay time due to signal processing:
     100 milliseconds or less

   Note: The response time does not include a delay in RPS logic and a response time of a transmitter.

4. APRM ATWS Permissive
   The APRM ATWS Permissive signal response time from the change of the LPRM input signal to the occurrence of trip from Relay unit shall not exceed 40 milliseconds.

5. Rod Block signal which transmits to RCIS
   The response time from the LPRM input signal which is received by LPRM unit to an alarm output to RCIS shall not exceed 250 milliseconds.

6. OPRM Trip
   A) The OPRM trip response time of the PRNM system from the core oscillation initiation detected by LPRM detector through LPRM subsystem to the OPRM trip function initiation from Relay unit shall not exceed [ ][a,c] ms.
   B) 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.

   Note:
   - Typical LPRM Level signals and conditions that satisfy the requirements specified in Section 2.8 (3) of "Procurement Specification for Equipment Qualification and EMC Qualification of Components of Oscillation Power Range Monitor" (Reference 3 (32)) are used for response time verification.
   - The OPRM Trip signal response time of the OPRM unit was determined based on the following design consideration.
     - The OPRM trip generation function of the PRNM system is accomplished with the combination of the LPRM unit, OPRM unit, and the Relay unit as shown in Figure 4-1. Thus, a criterion for the OPRM Trip signal response time of the OPRM unit can be determined by assuming the time allocated for the LPRM unit and the Relay, and subtracting it from [ ][a,c] ms which is allowed for the OPRM trip response time of the PRNM system.
     - The assumed response time of the LPRM unit is [ ][a,c] ms according the Equipment

Requirements Specification (Reference 3 (35)) used for the NRW-FPGA-Based PRM System Qualification Project. Then, [ ]^{a,c}ms with a margin is allocated to the LPRM unit in the OPRM response time of the PRNM system.

- The assumed response time of the Relay unit is [ ]^{a,c}ms at a maximum. Because it is easy to choose a qualified relay that works below [ ]^{a,c}ms response time, this assumption is reasonable. Then, [ ]^{a,c}ms is allocated to the Relay unit in the OPRM response time of the PRNM system.
- Thus, the OPRM Trip signal response time of the OPRM unit was determined to be less than [ ]^{a,c}ms with margin based on the following calculation. The [ ]^{a,c}ms response time for the OPRM Trip signal provides [ ]^{a,c}ms margin for LPRM signal processing time in the LPRM Unit when the Relay with [ ]^{a,c}ms response time is used.
- [ ]^{a,c}ms (OPRM trip response time allowed for PRNM system) – [ ]^{a,c}ms (LPRM unit) – [ ]^{a,c}ms (Relay unit) = [ ]^{a,c}ms.

5.1.5. Drift and Accuracy Requirements

5.1.5.1. LPRM unit

The drift and accuracy requirements are described in SDD for NMS (Reference 3 (1)) for the LPRM unit.

1. The output accuracy of LPRM unit depending on a sampling frequency, A/D conversion, and signal processing shall be less than +/- 2.0 % of the full scale.
2. In order to meet the accuracy requirements for APRM unit, the drift of LPRM equipment shall be less than +/- 1.0 % of the full scale in 700 hours.

Note:

- Full Scale is defined as the LPRM Level of 0 to 125%, which represents the reactor core power.
- The LPRM drift and linearity are measured from the LPRM input current to the LPRM output through the analog output.
- LPRM indication in 100 % (flux region from 2.8 x 10^{13} ($cm^{-2}s^{-1}$) to 2.8 x 10^{14} ($cm^{-2}s^{-1}$)) is periodically calibrated to be within +/- 1 % from the value calculated by reactor core performance. The calibration is done by gain adjustment. The LPRM gain is able to be adjusted so as to satisfy this requirement. The detail description of LPRM Calibration Function is described in section 5.2.2.1.7.

5.1.5.2. APRM Unit

The following drift and accuracy requirements are required for the APRM unit.

1. APRM function

A) The analog output accuracy of APRM functions shall be equal to or less than +/- 2.0% of the full scale.

B) The trip accuracy of APRM functions shall be less than +/- 2.0% of full scale, at MCR area environmental conditions.

C) The drift of signal processing sections shall be equal to or less than +/- 1.0 % of full scale in 700 hours.

Note:

- Full Scale is defined as the APRM Level of 0 to 125%, which represents the reactor core power.
- The APRM drift and accuracy is measured from the LPRM input current to the APRM output through the analog output.
- The APRM drift and trip accuracy is measured from the LPRM input current to APRM discrete outputs.

2. Core Flow measurement function

A) The trip accuracy of Core Flow measurement function shall be within +/- 7.5% of full scale, at MCR area environmental conditions.(expect Core Flow Rapid Coastdown and Core Flow Downscale)

B) The Core Flow Rapid Coastdown accuracy shall be within +/- 1.0% of full scale.

C) The Core Flow Downscale accuracy shall within +/- 0.05 mA.

D) The drift of the Core Flow measurement function shall be less than +/- 1.0 % of full scale in 700 hours.

Note:

Full Scale is defined as the Core Flow Level of 0 to 125.0%, which represents the reactor core power.

5.1.5.3. OPRM Unit

Not required.

Note: The function of the OPRM setpoint is to trip the reactor during a core instability event before the critical power ratio drops below the fuel safety analysis limit anywhere in the core.
To determine core instability, the OPRM is comprised of multiple cells which receive input from adjacent LPRMs.
Each LPRM signal is processed through a conditioning filter followed by an averaging filter in order to generate a Normalized Oscillation Signal to the OPRM Cells.
Because of the filtering process and generation of the Normalized Oscillation Signal, the LPRM sensor and process uncertainties that are used in other Neutron Monitoring functions (e.g. APRM) are indiscernible for the OPRM system.
The Normalized Oscillation Signal is then sent to three detection algorithms.
Of the three detection algorithms used by the OPRM system, only the Period Based Detection Algorithm (PBDA) is applied in the protection of the safety limit.
Since the OPRM PBDA algorithm uses the Normalized Oscillation Signal for trip determination and a digital rack contact for the trip, the uncertainties are effectively zero for this trip function.

5.1.6. Operating Bypass

1. The OPRM function of PRNM system shall be bypassed automatically if APRM Level is less than the OPRM Region APRM Level Setpoint or Core Flow Level is more than the OPRM Region Core Flow Level Setpoint.

5.1.7. Maintenance Bypass

1. The one division of PRNM system shall be manually bypassed by bypass switch in LDP without causing a plant shutdown or scram while plant is in operation for maintenance.
2. Each LPRM signal processing path shall be bypassed individually for calibration and alarm testing.
3. APRM Inoperative signal to RPS is bypassed by manual switch on NMS panel for RTIS surveillance test. During APRM Inoperative signal is bypassed by the manual switch, APRM Inoperative Bypass alarm signal is provided to ANN.
4. OPRM Inoperative signal to RPS is bypassed by manual switch on NMS panel for RTIS surveillance test. During OPRM Inoperative signal is bypassed by the manual switch, OPRM Inoperative Bypass alarm signal is provided to ANN.

5.1.8. Failure Detection and Self Test Requirements

The PRNM system shall have the following diagnostic functions:

1. <u>Monitoring of the Low Voltage Power Supply</u>

A) The PRNM system monitors their internal power supplies.
B) If their voltage becomes out of range of the setpoint, the PRNM system provides an indication on the unit front panel.

2. <u>Monitoring Low Voltage Supply to modules</u>

A) Adopting modular design, the PRNM system is decomposed into modules.
B) Each module monitors the input voltage from the Low Voltage Power Supply.
C) If the input voltage becomes lower than the setpoint, the module is reset.

3. <u>Monitoring of the FPGAs with a watchdog timer</u>

A) The watchdog timer shall monitor FPGAs operating periodically.
[ ][a,c] watchdog timer may monitor a group of FPGAs that operates serially as long as the timer can detect [ ][a,c] [ ][a,c].
If a [ ][a,c], the module containing the FPGA generates an inoperative signal.
The failure of the [ ][a,c] does not generate an inoperative signal.

The failure of the[ ]a,c generates an alarm indicating minor failure.

4. External Watchdog Timer
A) The watchdog timers are external, and not built into the FPGA logic.

5. Independence of Watchdog Timer on Clock
A) The watchdog timer does not depend on the clock signal used by the FPGAs

6. Data Transmission Error
A) The PRNM system monitors data transmission error within itself.
B) The PRNM system detects multi-bit errors of data transmission between the units within the PRNM system, and data transmission between the PRNM system and external system.

7. Checking constants stored in field modifiable memories
A) The constants (e.g., setpoints or Core Flow Factor) stored in field modifiable memories shall be checked.
B) If a constant is saved in a field modifiable memory, the constant is protected by appropriate measures, such as parity bits or dual storage.
C) If an error is detected, a minor failure alarm is generated.

8. Checking the voltage of the LPRM High Voltage Power Supply
A) The LPRM unit shall monitor the voltage of the High Voltage Power Supplies for the LPRM detectors.

9. OPRM Calculation Monitoring
A) [ ]a,c
[ ]a,c

5.1.9. Availability/Reliability Requirements

Reliability analysis is performed based on IEEE Std. 352 (Reference 2 (11)) but detail methods are performed based on EPRI TR-107330 (Reference 2 (19)).

1. The PRNM system shall be designed to support the overall required plant availability more than 95% to SDD for NMS (Reference 3 (1)).
2. The availability of the PRNM system is calculated for the combination of four PRNM divisions, which are shown in Figure 4-1.
3. Each unit of PRNM system shall have an availability goal of 99% on the condition that Mean Time To Repair (MTTR) is 24 hours.
4. Availability is calculated by MTTR and Mean Time Between Failures (MTBF). MTTR is assumed as 24 hours. Reliability is calculated by MTBF.
5. The mean time between failure (MTBF) of each subcomponent (electronic component) is calculated using the reference given in MIL-HDBK 217F (Reference 2 (17)).

5.1.10. Test Circuit Requirements

The PRNM equipment or FPGAs may include built-in internal diagnosis circuits, as long as the circuits do not have adverse effects on the safety-related functions of the PRNM system.

5.1.11. Function boundary of Hardware and Logic

FPGA-based PRNM system does not use application software.
However, the logic for FPGA-based components is designed and manufactured by a process, which is similar to generating software.
The function boundary of software and hardware is whether the function is included in FPGA or not.
The example of hardware function (not in FPGA) is following:

- Analog signal processing
- Watchdog timer
- Check the input voltage

The example of software function (in FPGA) is following:

- Digital signal processing
- Comparing setpoint
- Detecting data error

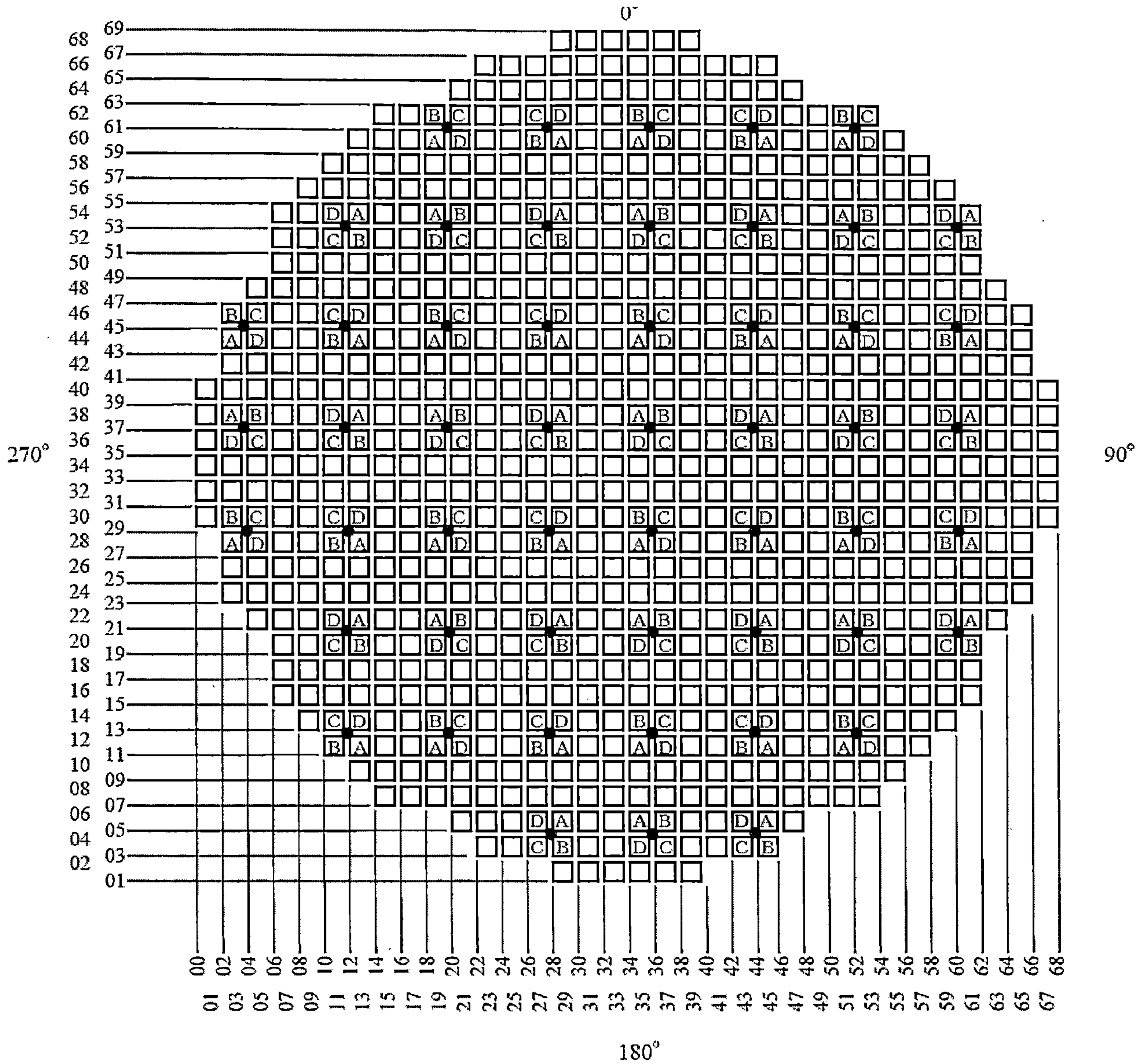
Integrity of software function should be verified through V&V activities.

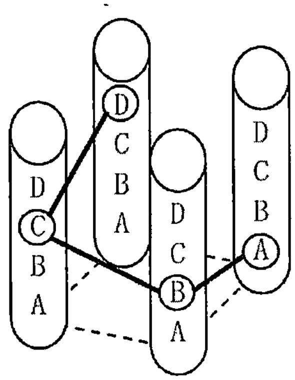
5.1.12. Data Retention Capability Requirements

Field modifiable constants shall be stored in EEPROM which shall be capable of at least 100,000 write cycles. EEPROM is electrically erasable PROM.

5.1.13. Assignment of LPRM Detectors

The assignment of LPRM detectors for LPRM unit complies with Figure 5-2 and Table 5-4.





Axial position of LPRM detector

Figure 5-2 Assignment of LPRM Detector

Table 5-4 Assignment of LPRM Detectors to LPRM Unit

Assognments of LPRM detectors to LPRM unit																	
Location	LPRM Unit ID*	LPRM CH in Unit**	LPRM CH in Division***	Division				Location	LPRM Unit ID*	LPRM CH in Unit**	LPRM CH in Division***	Division			
				I	II	III	IV					I	II	III	IV
20-61	1	1	1	B	C	D	A	04-29	3	8	34	B	C	D	A
28-61	2	1	14	C	D	A	B	12-29	4	8	47	C	D	A	B
36-61	3	1	27	B	C	D	A	20-29	1	8	8	B	C	D	A
44-61	4	1	40	C	D	A	B	28-29	2	8	21	C	D	A	B
52-61	1	2	2	B	C	D	A	36-29	3	9	35	B	C	D	A
12-53	1	3	3	D	A	B	C	44-29	4	9	48	C	D	A	B
20-53	4	2	41	A	B	C	D	52-29	1	9	9	B	C	D	A
28-53	3	2	28	D	A	B	C	60-29	2	9	22	C	D	A	B
36-53	2	2	15	A	B	C	D	12-21	1	10	10	D	A	B	C
44-53	1	4	4	D	A	B	C	20-21	4	10	49	A	B	C	D
52-53	4	3	42	A	B	C	D	28-21	3	10	36	D	A	B	C
60-53	3	3	29	D	A	B	C	36-21	2	10	23	A	B	C	D
04-45	4	4	43	B	C	D	A	44-21	1	11	11	D	A	B	C
12-45	3	4	30	C	D	A	B	52-21	4	11	50	A	B	C	D
20-45	2	3	16	B	C	D	A	60-21	3	11	37	D	A	B	C
28-45	1	5	5	C	D	A	B	12-13	3	12	38	C	D	A	B
36-45	4	5	44	B	C	D	A	20-13	2	11	24	B	C	D	A
44-45	3	5	31	C	D	A	B	28-13	1	12	12	C	D	A	B
52-45	2	4	17	B	C	D	A	36-13	4	12	51	B	C	D	A
60-45	1	6	6	C	D	A	B	44-13	3	13	39	C	D	A	B
04-37	2	5	18	A	B	C	D	52-13	2	12	25	B	C	D	A
12-37	2	6	19	D	A	B	C	28-05	4	13	52	D	A	B	C
20-37	3	6	32	A	B	C	D	36-05	1	13	13	A	B	C	D
28-37	4	6	45	D	A	B	C	44-05	2	13	26	D	A	B	C
36-37	1	7	7	A	B	C	D								
44-37	2	7	20	D	A	B	C								
52-37	3	7	33	A	B	C	D								
60-37	4	7	46	D	A	B	C								

*: Identification number for LPRM units in one division.
**: Identification number for LPRM detector signal in one unit.
***: Identification number for LPRM detector signal in one division.

5.2. Hardware Specification

5.2.1. Unit Input/Output Specifications

The each unit shall have interfaces that can connect metal wires or optical fiber cables. Metal wires are used for discrete I/O signal and analog I/O signal. Optical fiber cables are used for Optical transmission I/O signal.

5.2.1.1. LPRM Unit.

Analog Input Interface

The LPRM unit shall have analog input interface to receive analog signal.
Current range of the analog input shall be 0 to -3mA

Optical Transmission Input Interface

The LPRM unit shall have optical transmission input interface to generate optical serial signal.
Transmission cycle of the optical transmission input interface shall be [ ][a,c] msec.

Optical Transmission Output Interface

The LPRM unit shall have optical transmission output interface to generate optical serial signal.
Transmission cycle of the optical transmission output interface shall be [ ][a,c] msec.

1. Input

The LPRM unit shall receive signals listed in Table 5-5-1.

Table 5-5-1 LPRM unit Input List

Input type	From	Signal Name	Number of cables	Safety-Related (S) or Non-Safety-Related (N)
Analog	LPRM detector	-LPRM detector signal	13	S
Optical Transmission	APRM unit	-GAF value	1	N

2. Output
The LPRM unit shall provide signals and data listed in Table 5-5-2.

Table 5-5-2 LPRM unit output List

Output type	To	Signal Name	Number of cables	Safety-Related (S)or Non-Safety-Related (N)
Optical Transmission	TDR (via TDR & SOE	-LPRM Level	13 (To TDR & SOE	N
Optical Transmission	APRM unit OPRM unit	-LPRM Level -LPRM Upscale Alarm -LPRM Downscale -LPRM Bypass -LPRM Minor Failure	1 (To APRM unit) 1 (To OPRM unit)	S

5.2.1.2. APRM Unit

Analog Input Interface
The APRM unit shall have analog input interface to receive analog signal.
Current range of analog input shall be 4 to 20mA

Analog Output Interface
The APRM unit shall have analog output interface to generate analog signal.
Voltage range of the analog output shall be 1 to 5V.

Discrete Input Interface
The APRM unit shall have discrete input interface to receive digital signal.
Input voltage of the discrete input shall be 24VDC when input signal is ON.
Input voltage of the discrete input shall be 0VDC when it's OFF.

Discrete Output Interface
The APRM unit shall have discrete output interface to generate digital signal.
Discrete output interface shall be non-voltage contact.
Contact of discrete output interface shall open when output signal is OFF.
Contact of discrete output interface shall short when output signal is ON.

Optical Transmission Input Interface
The APRM unit shall have optical transmission input interface to generate optical serial signal.
Transmission cycle of the optical transmission input interface shall be[ ][a,c] msec.

Optical Transmission Output Interface
The APRM unit shall have optical transmission output interface to generate optical serial signal.
Transmission cycle of the optical transmission output interface shall be[ ][a,c] msec. (not including LPRM unit)
Transmission cycle of the optical transmission output interface to LPRM unit shall be[ ][a,c] msec.

1. Input

The APRM unit shall receive signals listed in Table 5-6-1.

Table 5-6-1 APRM unit Input List

Input type	From	Signal Name	Number of cables	Safety-Related (S)or Non-Safety-Related (N)
Analog	Differential Pressure Transmitter	-Core Support Plate Differential Pressure	1	S
Optical Transmission	LPRM unit	-LPRM Level -LPRM Upscale Alarm -LPRM Downscale -LPRM Bypass -LPRM Minor failure	4	S
	[ ]a,c (via[ ]a,c and[ ]a,c	-GAF value	1 (From[ ]a,c)	N
Discrete	Relay unit	-Reactor mode signal -APRM Bypass	1	S

2. Output

The APRM unit shall provide signals and data listed in Table 5-6-2.

Table 5-6-2 APRM unit Output List (1/2)

Output type	To	Signal Name	Number of cables	Safety-Related (S)or Non-Safety-Related (N)
Analog	LDP	-APRM Level	1	N
Optical Transmission	LPRM unit	-GAF value	4	N
	OPRM unit, ELCS-FD(via [ ]a,c, MRBM, [ ]a,c and ANN (via O/E converter)	-LPRM Level -LPRM Upscale Alarm -LPRM Downscale -LPRM Bypass -LPRM Inoperative -LPRM Minor failure -APRM Upscale Flux Trip Setpoint (only in Run) -APRM Upscale Flux Trip Setpoint (not in Run) -APRM Upscale Flux Alarm Setpoint (only in Run) -APRM Upscale Flux Alarm Setpoint (not in Run) -APRM Downscale Setpoint -APRM Level -Simulated Thermal Power Level -APRM Gain -Simulated Thermal Power Upscale Trip Setpoint -APRM Inoperative -APRM Minor failure -Simulated Thermal Power Upscale Trip -Reactor mode signal -APRM Bypass -Core Flow Downscale Alarm Setpoint -Core Flow Rapid Coastdown Trip bypass Setpoint -Core Flow Low-Cut Setpoint -Core Flow Upscale Alarm Setpoint -Core Flow Level -Z value -RC value -Core support plate differential pressure -Core Flow Rapid Coastdown Trip -Core Flow Upscale Alarm -Core Flow Downscale	2 (To OPRM unit/ two per one OPRM unit) 2 (To MRBM units/ one per one MRBM unit) 1 (To [ ]a,c) 1 (To O/E converter)	S (OPRM unit, ELCS-FD) N (MRBM[ ]a,c and ANN)

Table 5-6-2 APRM unit Output List (2/2)

Output type	To	Signal Name	Number of cables	Safety-Related (S)or Non-Safety-Related (N)
Optical Transmission	ATLM, RCIS, RWM, (via O/IO converter and [ ][a,c] RFC, APR, FWC	-LPRM Level -APRM Level -Simulated Thermal Power -Core Flow Level -APRM Bypass -LPRM Bypass	1 (To O/IO converter)	N
	TDR, SOE (via TDR & SOE IF)	-Simulated Thermal Power Upscale Trip -APRM Upscale Flux Trip -APRM Inoperative -Core Flow Rapid Coastdown Trip -APRM Level -Simulated Thermal Power -Core Flow Level -APRM Bypass	1 (To TDR & SOE IF)	N
Discrete	Relay unit	-Reactor Mode signal -APRM Bypass -APRM Upscale Flux Trip -Simulated Thermal Power Upscale Trip -APRM Inoperative -Core Flow Rapid Coastdown Trip -APRM ATWS Permissive -APRM Upscale Flux Alarm -APRM Downscale -APRM Minor Failure -Core Flow Upscale Alarm -Core Flow Downscale	1	S

5.2.1.3. OPRM Unit

Discrete Input Interface

The OPRM unit shall have discrete input interface to receive digital signal.
Input voltage of the discrete input shall be 24VDC when input signal is ON.
Input voltage of the discrete input shall be 0VDC when it's OFF.

Discrete Output Interface

The OPRM unit shall have discrete output interface to generate digital signal.
Discrete output interface shall be non-voltage contact.
Contact of discrete output interface shall open when output signal is OFF.
Contact of discrete output interface shall short when output signal is ON.

Optical Transmission Input Interface

The OPRM unit shall have optical transmission input interface to generate optical serial signal.
Transmission cycle of the optical transmission input interface from LPRM unit shall be[ ][a,c] msec.
Transmission cycle of the optical transmission input interface from APRM unit shall be[ ][a,c] msec.

Optical Transmission Output Interface

The OPRM unit shall have optical transmission output interface to generate optical serial signal.
Transmission cycle of the optical transmission output interface shall be[ ][a,c] msec.

1. Input

The OPRM unit shall receive signals listed in Table 5-7-1.

Table 5-7-1 OPRM unit Input List (1/2)

Input type	From	Signal Name	Number of cables	Safety-Related (S)or Non-Safety-Related (N)
Optical Transmission	LPRM unit	-LPRM Level -LPRM Upscale Alarm -LPRM Downscale -LPRM Bypass -LPRM Minor Failure	4	S
	APRM unit	-LPRM Level -APRM Level -Simulated Thermal Power level -Core Flow Level -Z value -RC value -Core support plate differential pressure -APRM Gain -LPRM Upscale Alarm -LPRM Downscale -LPRM Bypass -LPRM Inoperative -LPRM Minor failure -APRM Inoperative -APRM minor failure -APRM Upscale Flux Trip Setpoint (only in Run) -APRM Upscale Flux Trip Setpoint (not in Run) -APRM Upscale Flux Alarm Setpoint (only in Run)	2	S

Table 5-7-1 OPRM unit Input List (2/2)

Input type	From	Signal Name	Number of cables	Safety-Related (S)or Non-Safety-Related (N)
Optical Transmission	APRM unit	-APRM Upscale Flux Alarm Setpoint (not in Run) -APRM Downscale Setpoint -Simulated Thermal Power Upscale Trip Setpoint -Core Flow Downscale Setpoint -Core Flow Rapid Coastdown bypass Setpoint -Core Flow Low-Cut Setpoint -Core Flow Upscale Alarm Setpoint -APRM Bypass -Simulated Thermal Power Upscale Trip -Reactor mode signal -Core Flow Rapid Coastdown -Core Flow Downscale -Core Flow Upscale Alarm	2	S
Discrete	Relay unit	-APRM Bypass	1	S

2. Output

The OPRM unit shall provide signals and data listed in Table 5-7-2.

Table 5-7-2 OPRM unit Output List (1/2)

Output type	To	Signal Name	Number of cables	Safety-Related (S)or Non-Safety-Related (N)
Optical Transmission	ELCS -FD (via[ ][a,c] [ ][a,c] and ANN (via O/E	-ABA Trip -GRA Trip -PBDA Trip -OPRM Trip -OPRM Inoperative -OPRM Minor Failure -Normalized Cell Value -Active OPRM Cells Downscale Setpoint -LPRM Lower-Limit Setpoint -Active LPRM Lower-Limit Setpoint -OPRM Area APRM Level Setpoint -OPRM Area Core Flow Level Setpoint -Threshold Setpoint -Minimum Threshold Setpoint -Growth Rate Factor -Maximum Amplitude Trip Setpoint (AGRD) -Time Window for Minimum Threshold -Time Window for Trip Setpoint -Growth Rate Amplitude Setpoint -Period Minimum Setpoint -Period Maximum Setpoint -Period Tolerance Setpoint -Confirmation Count Trip Setpoint -Maximum Amplitude Trip Setpoint (PBD) -OPRM Cell Bypass -OPRM Automatic Bypass -Number of Active OPRM Cells -OPRM Status of Formation of Condition (defined in OPRM Unit DDS)	1 (To[ ])[a,c] 1(To O/E converter)	S (ELCS-FD) N ([ ][a,c] and ANN)

Table 5-7-2 OPRM unit Output List (2/2)

Output type	To	Signal Name	Number of cables	Safety-Related (S)or Non-Safety-Related (N)
Optical Transmission	TDR, SOE, PC (via TDR & SOE IF)	-ABA Trip -GRA Trip -PBDA Trip -OPRM Trip -OPRM Inoperative -OPRM Minor Failure -Normalized Cell value -Active OPRM Cells Downscale Setpoint -LPRM Lower-limit Setpoint -Active LPRM Lower-limit Setpoint -OPRM Area APRM Level Setpoint -OPRM Area Core Flow Level Setpoint -Threshold Setpoint -Minimum Threshold Setpoint -Growth Rate Factor -Maximum Amplitude Trip Setpoint (AGRD) -Time Window for Minimum Threshold -Time Window for Trip Setpoint -Period Minimum Setpoint -Period Maximum Setpoint -Prtiod Tolerance Setpoint -Confirmation Count Trip Setpoint -Maximum Amplitude Trip Setpoint (PBD) -OPRM Cell Bypass -OPRM Automatic Bypass -Number of Active OPRM Cells -Number of Active LPRM channel in Cell	1 (To TDR & SOE IF)	N
Discrete	Relay Unit	-OPRM Trip -ABA Trip -GRA Trip -PBDA Trip -OPRM Inoperative -OPRM Minor Failure -OPRM Automatic Bypass	1	S

5.2.1.4. Relay Unit

Discrete Input Interface

Relay units shall have discrete input interface to receive digital signal.
Input signal of the relay unit shall be maximum voltage when it is opened in 24VDC.
Rated current of the relay unit when it is closed shall be about 37mA for each relay.

Discrete Output Interface

Relay units shall have discrete output interface to generate digital signal.
Output signal of the relay unit shall be non-voltage contact.
Maximum rating voltage of the relay unit shall be 125VAC/DC.
Maximum rating current of the relay unit shall be 3A AC/DC.

1. Input

The Relay unit shall receive signals listed in Table 5-8-1.

Table 5-8-1 Relay unit Input List

Input type	From	Signal Name	Number of cables	Safety-Related (S)or Non-Safety-Related (N)
Discrete	MCP	-Reactor mode signal	1	S
	LDP	-APRM Bypass	1	S
	NMS Panel	-APRM Inoperative Trip Bypass signal -OPRM Inoperative Trip Bypass signal	1 1	S
	APRM unit	-Reactor mode signal -APRM Bypass -APRM Upscale Flux Trip -Simulated Thermal Power Upscale Trip -APRM Inoperative -Core Flow Rapid Coastdown Trip -APRM ATWS Permissive -APRM Upscale Flux Alarm -APRM Downscale -APRM Minor failure -Core Flow Upscale Alarm -Core Flow Downscale	1	S
	OPRM unit	-OPRM Trip -ABA Trip -GRA Trip -PBDA Trip -OPRM Inoperative -OPRM Minor failure -OPRM Automatic Bypass	1	S

2. Output
The Relay unit shall provide signals listed in Table 5-8-2.

Table 5-8-2 Relay unit Output List

Output type	To	Signal Name	Number of cables	Safety-Related (S)or Non-Safety-Related (N)
Discrete	RPS	-APRM Scram -Core Flow Rapid Coastdown Division Trip -OPRM Scram	4	S
	LDP	-Bar Chart Color Change signal	1	S
	ELCS	-APRM Divisional ATWS Permissive	4	S
	[ ][a,c]	-APRM Inoperative Trip Bypass signal -OPRM Inoperative Trip Bypass signal	1 1	N
	RCIS	-APRM Rod Block	2	N
	APRM unit	-APRM Bypass -Reactor mode signal	1	S
	OPRM unit	-APRM Bypass	1	S

5.2.2. Unit Function Requirements

5.2.2.1. LPRM Unit Function

5.2.2.1.1. LPRM Unit Configuration Requirements

The LPRM unit has separate and independent circuits dedicated for 13 LPRM detectors, called LPRM channel, and performs the following signal processing for each LPRM detector signal:

1. An LPRM unit shall receive 13 LPRM detector signals.
2. The LPRM unit shall have the 13 modules to perform the LPRM detector signal processing for each LPRM detector signal input.

5.2.2.1.2. LPRM Signal Processing

1. Each LPRM channel of the LPRM unit shall accept a 0 to -3 mA current signal from each LPRM detector.
2. The measurement range shall cover from 0 to 138.9% of the LPRM Level.
3. The LPRM Level exceeding 138.9% shall be clamped.
4. The Full Scale (FS) range shall be defined as 0 to 125.0% of the LPRM Level.
5. Each LPRM channel of the LPRM unit shall convert the current signals to the voltage signals.
6. Each LPRM channel of the LPRM unit shall apply a low pass filter having the following characteristics for anti-aliasing and high frequency noise reduction to the voltage signal.
   Cutoff frequency: [ ][a,c]Hz +/-[ ][a,c]%
   Gain[ ][a,c]
7. Each LPRM channel of the LPRM unit shall multiply the voltage signal and an Ical value
8. Each LPRM channel of the LPRM unit shall convert the voltage signals to digital signals.
9. Each LPRM channel of the LPRM unit shall apply a moving average digital filter having the following characteristics to reduce the power supply noise as well as high frequency noise.
   Pass band: below[ ][a,c]Hz
   Pass band Fluctuation: +/-[ ][a,c]dB
   Stop band: [ ][a,c]Hz -[ ][a,c]% more
   Stop band Attenuation: more than[ ][a,c]dB
   more than[ ][a,c]dB for[ ][a,c]Hz
   Number of Samples for averaged group: [ ][a,c]
10. Each LPRM channel of the LPRM unit shall generate the LPRM Level, which is proportional to the neutron flux level.
11. Output cycle of the LPRM Level data of the each LPRM channel shall be designed to be [ ][a,c] +/- [ ][a,c] milliseconds
12. The LPRM unit shall generate the 13 LPRM Levels as optical transmission data.

5.2.2.1.3. LPRM High Voltage Power Supply

1. Each LPRM channel of the LPRM unit shall have high voltage power supply for an LPRM detector.
2. The high voltage power supply of the each LPRM channel shall have capabilities to supply 3mA at 100 VDC.

5.2.2.1.4. Operation Modes of LPRM Unit

A) The LPRM unit shall be designed to allow mode selection listed in Table 5-9.
B) The LPRM unit shall switch operation modes with key switches.

Table 5-9 Operation Modes of LPRM unit

Mode	Action
OP (Operation)	The LPRM unit performs normal measuring and monitoring The LPRM unit displays parameters on the front panel display
CAL (Calibration)	The LPRM unit generates the LPRM Inoperative signal. The LPRM unit allows Ical calibration The LPRM unit allows alarm test The LPRM unit displays parameters on the front panel display
BYP (Bypass)	The LPRM unit generates the LPRM Inoperative signal. The LPRM unit allows alarm test and circuit test. The LPRM Upscale Alarm and LPRM Downscale are bypassed The LPRM detector high voltage power supply is bypassed.

5.2.2.1.5. Alarm Generation

The LPRM unit generates the following Alarms:

1. LPRM Upscale Alarm

A) Each LPRM channel of the LPRM unit shall generate the LPRM Upscale Alarm if the LPRM Level becomes equal to or larger than the LPRM Upscale Alarm setpoint.
B) The LPRM unit shall generate 13 LPRM Upscale Alarms independently by optical transmission data output.
C) The LPRM unit shall generate the LPRM Upscale Alarm as the logical sum of the 13 LPRM channels by optical transmission data output.

2. LPRM Downscale

A) Each LPRM channel of the LPRM unit shall generate the LPRM Downscale if the LPRM Level becomes equal to or smaller than the LPRM Downscale setpoint
B) The LPRM unit shall generate 13 LPRM Downscale signals independently by optical transmission data output.
C) The LPRM unit shall generate the LPRM Downscale signal as the logical sum of the 13 LPRM channels by optical transmission data output.

3. LPRM Inoperative

A) The LPRM unit shall generate the LPRM Inoperative signal when the instrument anomalies or error on the processes, which may cause significant negative impact on signal processing or alarm judgment, occur.
B) The LPRM unit shall generated the LPRM Inoperative signal if any of the following conditions occur:
- Operation mode of the LPRM unit is “CAL” or “BYP”
- The self-diagnosis detects a failure
- The voltage of the LPRM High Voltage Power Supply is less than a voltage-low setpoint
- The voltage of the LPRM High Voltage Power Supply is more than a voltage-high setpoint
- Module loss of configuration

C) The LPRM unit shall generate 13 LPRM Inoperative signal independently by optical transmission data output.
D) The LPRM unit shall generate the LPRM Inoperative signal as the logical sum of the 13 LPRM channels by optical transmission data output.

4. LPRM Minor Failure

A) The LPRM unit generates the LPRM Minor Failure signal when the instrument anomalies, which may not cause significant negative impact on signal processing or alarm judgment, occurs.

B) The LPRM unit shall generate the LPRM Minor Failure signal by optical transmission data output.

5.2.2.1.6. Alarm Reset Requirements

Once the LPRM Level exceeds its setpoint, and an alarm is generated, the alarm shall not be reset until the signal return as shown in Figure 5-3.
The LPRM unit shall have hysteresis width of the alarm listed in Table 5-10.
The LPRM unit shall have alarm reset point as shown in Figure 5-3.

Table 5-10 Alarm Hysteresis Width

Condition	Trip or Alarm	Hysteresis Width
LPRM Level	LPRM Upscale Alarm	2% of full scale
	LPRM Downscale	2% of full scale

Full scale value represents the output level of 125.0% or equivalent.

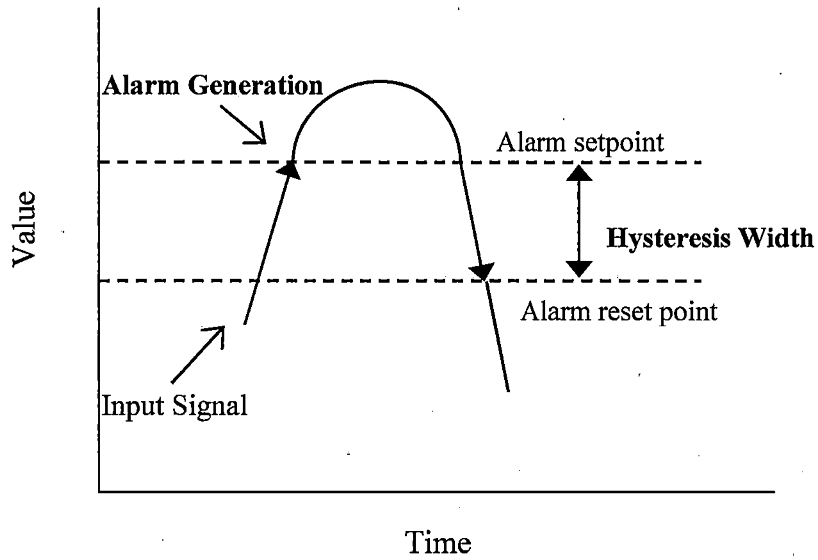


Figure 5-3 Alarm Setpoint and Hysteresis

5.2.2.1.7. LPRM Calibration Function

The LPRM unit has the LPRM gain calibration function for each LPRM signal processing. An Ical value is used for calibrating the LPRM gain. The LPRM unit provides the following two methods to calibrate the LPRM.

1. Manually Entering Ical
A) Ical Setpoint of each LPRM channel of the LPRM unit shall be capable of being changed manually.

2. GAF download function (LPRM automatic calibration function)
The LPRM unit can receive, on demand, LPRM gains (GAF: Gain Adjustment Factor) calculated in [ ][a,c] via APRM unit. Maintenance personnel can initiate a GAF download on the APRM unit front panel. This function is accomplished by the combination of the APRM function and LPRM function.

A) The LPRM unit shall calculate a new Ical calibration value for each channel LPRM calibration (Ical new) using the following equation.

$$\text{Ical new} = \text{Ical present} / \text{GAF}$$

Where,
Ical present: present Ical value (= present Ical Setpoint)
Ical new: Ical value calibrated by GAF value (= Ical calibration value)
GAF: GAF value

For example, when the present Ical value is 2400μA and GAF value is 2, the Ical calibrated value becomes 1200. Then the LPRM Level is calibrated by the Ical calibrated value as follows.

LPRM Level new = LPRM Level present / (Ical new / Ical present)

Where,
LPRM Level present: LPRM Level (=present LPRM Level)
LPRM Level new: LPRM Level calibrated by Ical value

In the above conditions, LPRM Level new becomes 80% if LPRM Level present is 40%.

5.2.2.1.8. Unit Front and Rear Panel Display

The LPRM unit panel provides the following displays.

1. The LPRM unit shall indicate items by the numerical display on the front panel listed in Table 5-11-1
   The LPRM unit shall indicate the numerical value within the range listed in Table 5-11-1

Table 5-11-1 LPRM unit Numerical Display on the front panel

Indication Item	Range
High Voltage monitoring value	0.0 to 200.0VDC
LPRM detector current value	0 to 3mA.
LPRM Level	0 to 138.9%
LPRM Upscale Setpoint	5.0 to 125.0%.
LPRM Downscale Setpoint	0.0 to 10.0%.
Ical Setpoint	60.00 to 2400μA.
Ical Calibreted Setpoint	60.00 to 2400μA.
GAF value	2.500E-2 to 4.000E+1.

2. The LPRM unit shall indicate the alarm status with LED on the front panel listed in Table 5-11-2
   The LPRM unit shall indicate the alarm status with LED on the front panel with the color listed in Table 5-11-2
   The LPRM unit shall latch the indications of trip and alarm on the front panel, and allow the operator to reset them.

Table 5-11-2 LPRM unit Alarm Display on the front panel

Indication Item	Color
LPRM Upscale Alarm	Orange
LPRM Downscale	Yellow
LPRM Inoperative	Yellow
Unit Power Supply Failure	Yellow
LPRM Minor Failure	Yellow
LPRM Status Data Reception Error	Yellow

3. The LPRM unit shall indicate the mode status with LED on the front panel listed in Table 5-11-3.
   The LPRM unit shall indicate the mode status with LED on the front panel with the color listed in Table 5-11-3.

Table 5-11-3 LPRM unit Mode Display on the front panel

Indication Item	Color
Operation Mode (OP)	Green
Bypass Mode (BYP)	Yellow
Calibration Mode (CAL)	Yellow

4. The LPRM unit shall indicate the status with LED on the front panel listed in Table 5-11-4.
   The LPRM unit shall indicate the status with LED on the front panel with the color listed in Table 5-11-4.

Table 5-11-4 LPRM unit Status Display on the front panel

Indication Status	Color
GAF download value display (glow if GAF download value is indicated)	Yellow
GAF download value reception (glow if signal reception is completed)	Green
Ical value display (glow if Ical calibration value is indicated)	Yellow

5. The LPRM unit shall indicate the unit power supply and optical data transmission status with LED on the rear panel listed in Table 5-11-5.
   The LPRM unit shall indicate the unit power supply and optical data transmission status with LED on the rear panel with the color listed in Table 5-11-5.

Table 5-11-5 LPRM unit Power Supply and Data Transmission Status Display on the rear panel

Indication Status	Color
Status of Data Transmission(Normal/Abnormal)	Green/Orange
Unit Power Supply Lamp(glow during power activation)	Green

5.2.2.1.9. Setpoint/Parameter Adjustment Function

The LPRM unit shall have setpoints and parameters listed in Table 5-12.
Each setpoint and parameter adjustment function of LPRM unit shall be designed to avoid any out-of-range setpoints of being set.

Table 5-12 LPRM unit Setpoints and Parameters

Item	Initial Setpoint	Setting Range	Setting Method
LPRM Upscale Alarm Setpoint	100%	5.0 to 125.0%	manual
LPRM Downscale Setpoint	5%	0.0 to 10.0 %	manual
Ical Setpoint	2400 μA	60 to 2400 μA	manual

5.2.2.1.10. Alarm Test Function

1. The LPRM unit shall generate the simulated-LPRM Level to check alarm generation.

5.2.2.1.11. Power Supply Fluctuation Protection Function

Power supply of the LPRM unit shall have functions to protect itself from overvoltage, over current, reverse current, and inrush current.
The LPRM unit shall satisfy normal operation even when AC input power to Power Factor Correction (PFC) fluctuates.

5.2.2.2. APRM Unit Function

5.2.2.2.1. APRM Unit Configuration Requirements

The APRM unit has APRM function and Core Flow measurement function to calculate the APRM Level and the Core

Flow Level.

1. The APRM unit shall receive 52 LPRM Levels from the four LPRM units in the same division.

5.2.2.2.2. APRM Function Signal Processing

The APRM unit performs the following signal processing to generate the APRM Level, Simulated Thermal Power Level, Simulated Thermal Power Upscale Trip Setpoint, and APRM Upscale Flux Alarm setpoint:

1. APRM Level

A) The APRM unit shall perform the signal processing to generate the APRM Level, which is proportional to the average neutron flux.

B) The APRM unit shall calculate the APRM Level using the following formula:

$$APRM\_level = \frac{\sum_i LPRM\_level_i}{LPRM\_COUNT} \times APRM\_GAIN$$

Where,

APRM_level: Average neutron flux
LPRM_level: i-LPRM Level
APRM_GAIN: APRM Gain
LPRM_COUNT: Number of Active LPRMs.

C) The Full Scale (FS) range shall be defined as 0 to 125.0% of the APRM Level.
The APRM Level is overlap with the SRNM measurement range.

D) The LPRM Levels from inoperative LPRM channels shall be capable of being excluded from the average calculation.
i.e. Only the LPRM Levels from operating LPRM channel are in the numerator, and LPRM_COUNT in the denominator is the Number of Active LPRMs.

2. Simulated Thermal Power Level

A) The APRM unit shall calculate the Simulated Thermal Power Level of the reactor core as the first order lag of the APRM Level by applying time constant using the following formula:

$$TPM\_level_{n+1} = \frac{TPM\_level_n \times 6.000 + APRM\_level \times [\quad]^{a,c}}{6.000 + [\quad]^{a,c}}$$

Where,

TPM_level: Simulated Thermal Power Level
APRM_level: Average neutron flux
6.000: Time constant
[ ]a,c Sampling period

B) The measurement range shall cover from 0 to 125.0% of the Simulated Thermal Power Level.

3. Simulated Thermal Power Upscale Trip Setpoint

A) The Simulated Thermal Power Upscale Trip Setpoint shall be biased by the core flow as shown in Figure 5-1.

B) The APRM unit shall calculate the Simulated Thermal Power Upscale Trip Setpoint as follows:

Simulated Thermal Power Upscale Setpoint (Clamp) = (Slope x Flow) + Intercept

Where,

Slope	Slope of the Power/Flow value line
Flow	Core Flow Level
Intercept	flux offset at zero flow

The each setpoint of the Slope and Intercept is set as described in Section 5.2.2.2.10.

4. APRM Upscale Flux Alarm Setpoint

A) When the Reactor mode is at "RUN," the APRM Upscale Flux Alarm setpoint shall be biased by the core flow as shown in Figure 5-1.

B) The APRM shall calculate the APRM Upscale Flux Alarm setpoint as follows:

APRM Upscale Flux Alarm setpoint (Clamp) = (Slope x Flow) + Intercept
Where,

Slope	Slope of the Power/Flow value line
Flow	Core Flow Level
Intercept	flux offset at zero flow

The each setpoint of the Slope and Intercept is set as described in Section 5.2.2.2.10.

5.2.2.2.3. Core Flow Measurement Function Signal Processing

The APRM unit performs the following signal processing to generate the Core Flow Level:

1. The APRM unit shall accept a 4 to 20 mA Core Support Plate Differential Pressure signal from the differential pressure transmitter that measures the Core Support Plate Differential Pressure.
2. The APRM unit shall convert the current signal to a digital signal.
3. The APRM unit shall calculate the Core Support Plate Differential Pressure read from the digital signal as follows:

$$CPdP = \frac{I-4}{16} \times 300$$

Where,

CPdP	Core Support Plate Differential Pressure [kPa]
I	current value

4. The APRM unit shall calculate the n-th filtered Core Support Plate Differential Pressure ay applying a first order lag filter of[ ]^{a,c} milliseconds time constant using the following formula:

$$CPdP_{filt}(n) = \frac{CPdP_{filt}(n-1) \times [\quad]^{a,c} + CPdP \times [\quad]^{a,c}}{[\quad]^{a,c} + [\quad]^{a,c}}$$

Where,

$CPdP_{filt}(n)$	n-the filtered Core Support Plate Differential Pressure [kPa]
[ ]^{a,c}	Time constant
[ ]^{a,c}	Sampling period

5. The APRM unit shall calculate the Core Flow Level as follows:

$$CPdPflow = (a + b \times \sqrt{CPdP_{filt}} + c \times CPdP_{filt}) \times (d + e \times P + f \times P^2) \times k$$

Where,

CPdpflow	Core Flow Level [%]
$CPdP_{filt}$	Core Support Plate Differential Pressure (after filter process) [kPa]
P	Simulated Thermal Power Level [%]
a-f and k	Core Flow Factors

6. The Full Scale (FS) range shall be defined as 0 to 125.0% of the Core Flow Level.
7. The Core Flow Level shall become 0 when Core Flow Level becomes equal to or smaller than the Core Flow Low-Cut Setpoint.

5.2.2.2.4. Operation Modes of APRM Unit

A) The APRM unit shall be designed to allow the mode selection listed in Table 5-13.
B) The APRM unit shall switch operation modes with key switches

Table 5-13 Operation Modes of APRM unit

Mode	Action
OP (Operation)	The APRM unit performs normal measuring and monitoring. The APRM unit displays parameters on the front panel display
STANDBY (Standby)	The APRM unit performs normal measuring and monitoring. The APRM unit generates the APRM Inoperative signal. The APRM unit displays parameters on the front panel display
CAL (Calibration)	The APRM unit generates the APRM Inoperative signal. The APRM unit allows trip testing Parameters (APRM gain value and Core Flow factors (a-f and k)) can be adjusted

5.2.2.2.5. Trip and Alarm Generation

The APRM unit monitors the APRM Level and Core Flow Level, and generates the following Trips and Alarms:

1. APRM Inoperative

A) The APRM unit shall generate the APRM Inoperative signal if the APRM unit is inoperative.

B) The APRM unit shall be inoperative if any of the following conditions occur:
- Operation mode of the APRM unit is "CAL" or "STANBY".
- Number of Active LPRMs is less than Minimum Number of Operating LPRMs
- Number of Active LPRMs on a same plate orthogonal to the core axial direction is less than Minimum Number of Operating LPRMs on same plane.
- The self-diagnosis detects a major failure.
- The trip function for Core Flow Rapid Coastdown described in Section 5.2.2.2.5-9 is inoperative.
- Module loss of configuration

C) The APRM unit shall generate the APRM Inoperative signal in negative logic by discrete output.

2. APRM Upscale Flux Trip

A) The APRM unit shall generate the APRM Upscale Flux Trip when the APRM Level becomes equal to or larger than the APRM Upscale Flux Trip setpoint (only in RUN) during Reactor mode is at "RUN."

B) The APRM unit shall generate the APRM Upscale Flux Trip when the APRM Level becomes equal to or larger than the APRM Upscale Flux Trip setpoint (not in RUN) during Reactor mode is not at "RUN."

C) The APRM unit shall generate the APRM Upscale Flux Trip (used as a reactor scram signal to RPS) in negative logic by discrete output.

3. Simulated Thermal Power Upscale Trip

A) The APRM unit shall generate the Simulated Thermal Power Upscale Trip when the Simulated Thermal Power Level becomes equal to or larger than the Simulated Thermal Power Upscale Trip Setpoint.

B) The APRM unit shall generate the Simulated Thermal Power Upscale Trip (used as a reactor scram signal to RPS) in negative logic by discrete output.

4. APRM Upscale Flux Alarm

A) The APRM unit shall generate the APRM Upscale Flux Alarm when the APRM Level becomes equal to or larger than the APRM Upscale Flux Alarm setpoint (only in RUN) when Reactor mode is at "RUN."

B) The APRM unit shall generate the APRM Upscale Flux Alarm when the APRM Level becomes equal to or larger than the APRM Upscale Flux Alarm setpoint (not in RUN) when Reactor mode is not at "RUN."

C) The APRM unit shall generate the APRM Upscale Flux Alarm (used as a rod block signal to RCIS) in negative logic by discrete output.

5. APRM Downscale

A) The APRM unit shall generate the APRM Downscale when the APRM Level becomes equal to or smaller than the APRM Downscale setpoint.

B) The APRM unit shall generate the APRM Downscale (used as a rod block signal to RCIS) in negative logic by discrete output only when Reactor mode is "RUN."

6. APRM Minor Failure
A) The APRM unit shall generate the APRM Minor Failure signal when the instrument anomalies, which may not cause significant negative impact on signal processing or alarm judgment, occurs.

7. Core Flow Upscale Alarm
A) The APRM unit shall generate the Core Flow Upscale Alarm when the Core Flow Level becomes equal to or larger than the Core Flow Upscale Alarm Setpoint.
B) The APRM unit shall generate the Core Flow Upscale Alarm (used as a rod block signal to RCIS) in negative logic by discrete output.

8. Core Flow Downscale
A) The APRM unit shall generate the Core Flow Downscale when the Core Flow Level becomes equal to or smaller than the Core Flow Downscale Setpoint.
B) The APRM unit shall generate the Core Flow Downscale (used as a rod block signal to RCIS) in negative logic by discrete output.

9. Core Flow Rapid Coastdown
A) The APRM unit shall generate the Core Flow Rapid Coastdown when Core Flow Rapid Coastdown parameter (Z value) in the following formula becomes equal to or smaller than the Core Flow Rapid Coastdown setpoint.

Z= CPdP flow (t)+A x CPdP flow(t-3))+B

Where,

Z: Core Flow Rapid Coastdown parameter
A, B: Parameter (A = -0.4, B = -11)
CPdP flow(t) : Core flow [%]at time t[s].
CPdP flow(t-3) : Core flow [%]at time(t-3) [s].

To satisfy the above algorism equivalently, the RC Value defined in the following formula is applied in the actual unit design.
The APRM unit shall generate the Core Flow Rapid Coastdown when Core Flow Level becomes equal to or smaller than RC Value in the following formula.

RC= -A x CPdPflow(t-3)-B+Z_trip
Where, RC: Core Flow Rapid Coastdown generating point
Z_trip: Core Flow Rapid Coastdown setpoint

B) The Core Flow Rapid Coastdown shall be automatically bypassed when the Simulated Thermal Power Level of the past 3 seconds is less than Core Flow Rapid Coastdown Bypass setpoint.
C) The APRM unit shall generate the Core Flow Rapid Coastdown (used as a reactor scram signal to RPS) in negative logic by discrete output.

10. APRM ATWS Permissive
A) APRM ATWS Permissive signal shall be a binary interlock signal indicating whether the APRM Level is above or below the APRM ATWS Permissive setpoint.
In the case that the APRM Level is above the APRM ATWS Permissive setpoint, the PRNM system allows the ELCS to permit ATWS protection action for ADS inhibit.
B) The APRM unit shall generate the APRM ATWS Permissive signal when the APRM Level becomes equal to or larger than the APRM ATWS Permissive setpoint.

C) The APRM unit shall generate the APRM ATWS Permissive signal in the positive logic by discrete output.

5.2.2.2.6. Trip and Alarm Reset Requirements

Once the APRM Level, Simulated Thermal Power Level, Core Flow Level, or LPRM Level exceeds its setpoint, and a trip or alarm is generated, the trip and the alarm shall not be reset until the signal return as shown in Figure 5-3.

The APRM unit shall have hysteresis width of the trip and alarm listed in Table 5-14.
The APRM unit shall have trip and alarm reset point as shown in Figure 5-3.

Table 5-14 Trip and Alarm Hysteresis Width

Condition	Trip or Alarm	Hysteresis Width
APRM Level	APRM Upscale Flux	1% of full scale
	APRM Upscale Flux Trip	1% of full scale
	APRM Downscale	1% of full scale
	APRM ATWS permissive	1% of full scale
Simulated Thermal Power Level	Simulated Thermal Power Upscale Trip	1% of full scale
Core Flow Level	Core Flow Upscale Alarm	1% of full scale
	Core Flow Rapid Coastdown	1% of full scale
	Core Flow Low-Cut	1% of full scale

Full scale value represents the output level of 125.0% or equivalent.

5.2.2.2.7. APRM Gain Calibration Function

1. APRM Gain of the APRM unit shall be capable of being changed manually.

5.2.2.2.8. GAF Download function

The APRM unit can receive, on demand, LPRM gains (GAF: Gain Adjustment Factor) calculated in [ ]a,c Maintenance personnel can initiate a GAF download on the APRM unit front panel. The APRM unit provides GAF value to LPRM units. This function is accomplished by the combination of the APRM unit function and LPRM unit function.

1. The APRM unit shall be able to request the GAF downloading to the [ ]a,c via [ ]a,c and [ ]a,c

5.2.2.2.9. Unit Front and Rear Panel Display

The APRM unit panel provides the following displays.

1. The APRM unit shall indicate items by the numerical display on the front panel listed in Table 5-15-1.
   The APRM unit shall indicate the numerical value within the range listed in Table 5-15-1.

Table 5-15-1 APRM unit Numerical Display on the front panel

Display Item	Range
Number of Operating LPRM Channel	0 to 52
APRM Level	0.0 to 125.0%
Simulated Thermal Power Level	0.0 to 125.0%
APRM Upscale Flux trip Setpoint (only inRUN)	60.0 to 125.0%
APRM Upscale Flux trip Setpoint (not in RUN)	6.0 to 20.0%
APRM Upscale Flux Alarm Setpoint(only in RUN)	47.0 to 108.0%
APRM Upscale Flux Alarm Setpoint (not in RUN)	6.0 to 20.0%
APRM Downscale Setpoint	2.0 to 20.0%
Simulated Thermal Power Upscale Trip Setpoint	60.0 to 125.0%
APRM ATWS Permissive Setpoint	0.0 to 99.9%
Minimum Number of Operating LPRM Channel Setpoint	32 to 52
APRM Upscale Flux trip Hysteresis Setpoint	1 or 2%
APRM Upscale Flux Alarm Hysteresis Setpoint	1 or 2%
APRM Downscale Hysteresis Setpoint	1 or 2%
Simulated Thermal Power Upscale trip Hysteresis Setpoint	1 or 2%
APRM ATWS Permissive Hysteresis Setpoint	1 or 2%
APRM Gain	1.000 to 3.000
Core Flow Level	0.0 to 200%
Core Support Plate Differential Pressure value	0.0 to 300 kPa
Input current value	0.0 to 32.77%
RC value	11.0 to 106.0%
Core Flow factors (a-f)	-9.9999E-9 to 9.9999E+9
Core Flow factor (k)	0.000 to 9.9999
Core Flow Upscale Alarm Setpoint	100.0 to 125.0%
Core Flow Low-Cut Setpoint	0.0 to 40.0%
Core Flow Rapid Coastdown Setpoint	0.0 to 15.0%
Core Flow Rapid Coastdown Bypass Setpoint	60.0 to 85.0%
Z value	0.0 to 189.0%
Core Flow Upscale Alarm Hysteresis Setpoint	1 or 2%
Core Flow Low-Cut Setting Hysteresis Setpoint	1 or 2%
Core Flow Rapid Coastdown Hysteresis Setpoint	1 or 2%

2. The APRM unit shall indicate the trip and alarm status with LED on the front panel listed in Table 5-15-2.
The APRM unit shall indicate the trip, alarm status with LED on the front panel with the color listed in Table 5-15-2.
The APRM unit shall latch the indications of trip and alarm on the front panel, and allow the operator to reset them. (The Core Flow Rapid Coastdown Bypass, the APRM ATWS Permissive OFF, the APRM Bypass, and Reactor Mode shall be reset automatically).

Table 5-15-2 ARPM unit Trip, Alarm, and Bypass Status Display on the front panel

Indication Item	Color
APRM Upscale Flux Trip	Red
Simulated Thermal Power Upscale Trip	Red
APRM Upscale Flux Alarm	Red
APRM Downscale	Yellow
APRM ATWS Permissive OFF (glow when APRM ATWS Permissive is OFF)	Yellow
APRM Upscale Flux Trip (RPS)	Red
Simulated Thermal Power Upscale Trip (RPS)	Red
Core Flow Upscale Alarm	Orange
Core Flow Downscale	Orange
Core Flow Rapid Coastdown	Red
Core Flow Rapid Coastdown Bypass (Light up at trip function being bypassed)	Yellow
APRM Inoperative	Red
APRM Minor Failure	Yellow
Unit Power Supply Failure	Yellow
LPRM Unit Data Transmission Error	Yellow
APRM Bypass	Yellow
Reactor Mode (RUN)	Green

3. The APRM unit shall indicate the mode status with LED on the front panel listed in Table 5-15-3.
The APRM unit shall indicate the mode status with LED on the front panel with the color listed in Table 5-15-3.

Table 5-15-3 APRM unit Mode Display on the front panel

Indication Item	Color
Operation Mode (OP)	Green
Standby Mode (STANBY)	Yellow
Calibration Mode (CAL)	Yellow

4. The APRM unit shall indicate the status with LED on the front panel listed in Table 5-15-4.
The APRM unit shall indicate the status with LED on the front panel with the color listed in Table 5-15-4.

Table 5-15-4 APRM unit Status Display on the front panel

Indication Status	Color
GAF downloading (glow during GAF download)	Green
GAF download error (glow if GAF download error occurs)	Yellow

5. The APRM unit shall indicate the unit power supply and optical data transmission status with LED on the rear panel listed in Table 5-15-5.
The APRM unit shall indicate the unit power supply and optical data transmission status with LED on the rear panel with the color listed in Table 5-15-5.

Table 5-15-5 APRM unit Power Supply and Data Transmission Status Display on the rear panel

Indication Status	Color
Status of Data Transmission(Normal/Abnormal)	Green/Orange
Unit Power Supply Lamp(glow during power activation)	Green

5.2.2.2.10. Setpoint/Parameter Adjustment Function

The APRM unit shall have setpoints and parameters listed in Table 5-16.
Each setpoint and parameter adjustment function of APRM unit shall be designed to avoid any out-of-range setpoints of being set.

Table 5-16 APRM unit Setpoints and Parameters

Item		Initial Setpoint	Setting Range	Setting Method
APRM Upscale Flux Trip Setpoint	(only in Run)	118.0%	60.0 to 125.0%	Manual
	(not in RUN)	13.0%	6.0 to 20.0%	Manual
Simulated Thermal Power Upscale Trip Setpoint	(Slope)	0.68	0.40 to 1.50	Manual
	(Intercept)	52.0%	20.0 to 125.0%	Manual
	(Clamp)	113.0%	60.0 to 125.0%	Manual
APRM Upscale Flux Alarm Setpoint	(Only in Run) (Slope)	0.68	0.40 to 1.50	Manual
	(Only in Run) (Intercept)	47.0%	20.0 to 125.0%	Manual
	(Only in Run) (Clamp)	108.0%	60.0 to 125.0%	Manual
	(not in RUN)	10.0%	2.0 to 20.0%	Manual
APRM Downscale Setpoint		5.0%	2.0 to 20.0%	Manual
Minimum Number of Operating LPRM Channel		32	32 to 52	Manual
Minmum Number of Operating LPRM Channel on a same plane		6	fixed	-
APRM ATWS Permissive Setpoint		6.0%	0.0 to 99.9%	Manual
Core Flow Low-Cut Setpoint		25.0%	0.0 to 40.0%	Manual
Core Flow Upscale Alarm Setpoint		120.0%	100.0 to 125.0%	Manual
Core Flow Rapid Coastdown Trip Setpoint		0.0%	0.0 to 15.0%	Manual
Core Flow Rapid Coastdown Trip Bypass Setpoint		75.0%	60.0 to 85.0%	Manual
Core Flow Downscale		2.0mA	fixed	-
APRM Upscale Flux trip Hysteresis Setpoint		1% of full scale	1% or 2% full scale	Manual
APRM Upscale Flux Alarm Hysteresis Setpoint		1% of full scale	1% or 2% full scale	Manual
APRM Downscale Hysteresis Setpoint		1% of full scale	1% or 2% full scale	Manual
APRM ATWS Permissive Hysteresis Setpoint		1% of full scale	1% or 2% full scale	Manual
Simulated Thermal Power Upscale Trip		1% of full scale	1% or 2% full scale	Manual
Core Flow Upscale Alarm Hysteresis Setpoint		1% of full scale	1% or 2% full scale	Manual
Core Flow Rapid Coastdown Hysteresis Setpoint		1% of full scale	1% or 2% full scale	Manual
Core Flow Low-Cut Setting Hysteresis Setpoint		1% of full scale	1% or 2% full scale	Manual
Core flow factor "a"		10.876[% (rated flow)]	-9.9999E-9 to 9.9999E+9	Manual
Core flow factor "b"		5.7616[% (rated flow) / $(kPa)^{0.5}$]	-9.9999E-9 to 9.9999E+9	Manual
Core flow factor "c"		0.1316[% (rated flow) /kPa]	-9.9999E-9 to 9.9999E+9	Manual
Core flow factor "d"		1.1875[pu]	-9.9999E-9 to 9.9999E+9	Manual
Core flow factor "e"		-2.2228×10^{-3}[$(\%)^{-1}$(Reactor power)]	-9.9999E-9 to 9.9999E+9	Manual
Core flow factor "f"		3.4778×10^{-6}[$(\%)^{-2}$(Reactor power)]	-9.9999E-9 to 9.9999E+9	Manual
Core flow factor "k"		1[pu]	-9.9999E-9 to 9.9999E+9	Manual
APRM Gain		1.000	1.000 to 3.000	Manual

5.2.2.2.11. Trip Test Function

1. The APRM unit shall generate the simulated-APRM Level signal to check trip generation.
2. The APRM unit shall generate the simulated-Simulated Thermal Power Level signal to check trip generation.
3. The APRM unit shall generate the simulated-Core Flow Level signal to check trip generation.

5.2.2.2.12. Power Supply Fluctuation Protection Function

Power supply of the APRM unit shall have functions to protect itself from overvoltage, over current, reverse current, and inrush current.
The APRM unit shall satisfy normal operation even when AC input power to PFC fluctuates.

5.2.2.3. OPRM Unit Function

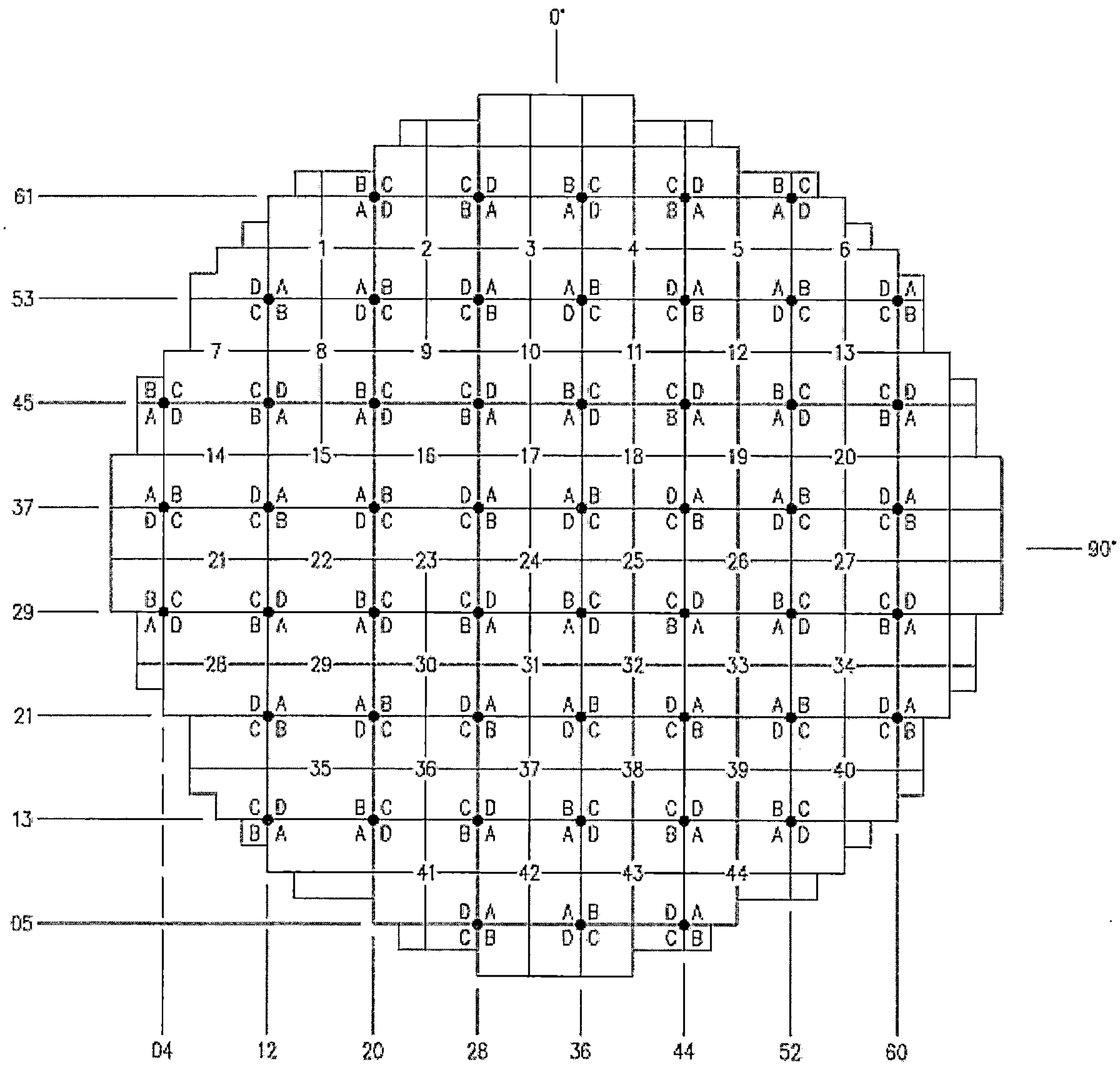
5.2.2.3.1. OPRM Unit Configuration

The OPRM unit is a functional subsystem of the APRM unit. The OPRM unit receives the same LPRM signals as that for a corresponding APRM unit. The OPRM unit determines when there is thermal hydraulic instability and provides trip functions to the RPS to suppress neutron flux oscillation prior to the violation of safety thermal limits to prevent damage to the fuel. The OPRM trip logics are performed separately from the APRM trip logics.

5.2.2.3.2. OPRM Cell Configuration

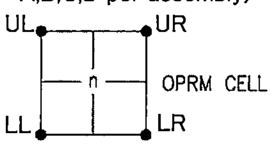
Each OPRM unit cell receives four LPRM inputs from four LPRM strings at the four corners of the 4 X 4 fuel bundle square. For locations near the periphery where one corner of the square does not include an LPRM string, the OPRM Cells use the inputs from the remaining three LPRM strings. The overall axial and radial distributions of these LPRM channels between the OPRM units are identical. Each OPRM Cell has four LPRM channel from all four different elevations in the core. The LPRM signals assigned to each cell are summed and averaged to provide a Normalized Oscillation Signal for this cell.

1. The assignment of LPRM detectors for OPRM Cell complies with Figure 5-4 and Table 5-17.



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

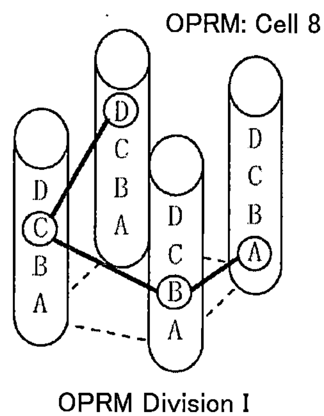


Figure 5-4 Core Map and OPRM Cell

Table 5-17 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 5-4.
**: Refer to Table 5-4.

5.2.2.3.3. OPRM Signal Processing

1. The OPRM unit generates the Normalized Oscillation Signal using LPRM Levels for each OPRM Cell.
A) The OPRM unit shall filter out the noise from the LPRM Level to generate the Filter Flux.
B) OPRM unit shall average all the active Filter Flux in the OPRM Cell to generate the Averaged Filter Flux.
C) The OPRM unit shall filter out the short period time oscillation from the Averaged Filter Flux to generate the Time Averaged Flux
D) The OPRM unit shall divide the Averaged Filter Flux by the Time Averaged Filter Flux to generate the Normalized Oscillation Signal
E) The OPRM unit shall initialize the Normalized Oscillation Signal to 1 at certain conditions that may have a negative impact on signal processing.
F) OPRM trip function shall be executed at the cycle of 50ms or less.

5.2.2.3.4. Operation Modes of OPRM Unit

1. The OPRM unit shall be designed to allow the mode selection listed in Table 5-18.
2. The OPRM unit shall switch operation modes with key switches.

Table 5-18 Operation Modes of OPRM unit

Mode	Action
OP	The OPRM unit perform normal measuring and monitoring
(Operation)	The OPRM unit displays parameters on the front panel display
STANDBY	The OPRM unit generates the OPRM Inoperative signal
(Standby)	The OPRM unit displays parameters on the front panel display
CAL	The OPRM unit generates the OPRM Inoperative signal
(Calibration)	The OPRM unit allows trip testing
	The OPRM unit allows the simulated-Filter Flux generation
	The OPRM unit allows the simulated-APRM/Core Flow Level generation
	The OPRM unit allows setpoint modification

5.2.2.3.5. Trip and Alarm Generation

1. OPRM Minor Failure
A) The OPRM unit shall generate the OPRM Minor Failure signal when the instrument anomalies, which may not cause significant negative impact on signal processing or trip judgment, occur. The OPRM indicates the instrument anomalies by self diagnosis at the following conditions.

[ ]a,c

-
-
-
-
-
-

B) The OPRM unit shall generate the OPRM Minor Failure signal in negative logic by discrete output.

2. OPRM Inoperative
A) The OPRM unit shall generate the OPRM Inoperative signal when the instrument anomalies or error on the processes, or loss of all power supply occur, which may cause significant negative impact on signal processing or trip judgment, occur. The OPRM indicates the instrument anomalies or error by self diagnosis at the following conditions.

[ ]a,c

-
-
-

- [
-] a,c

B) The OPRM unit shall generate the OPRM Inoperative signal when the "STANDBY" mode or "CAL" mode is selected.
C) The OPRM unit shall generate the OPRM Inoperative signal when the APRM unit in same division becomes inoperative.
D) The OPRM unit shall generate the OPRM Inoperative signal when the Number of Active OPRM Cell is lower than the setpoint.
E) The OPRM unit shall generate the OPRM Inoperative signal when the CELL module, AGRD module, PBD module, or DAT/ST module is disconnected.
F) The OPRM unit shall generate the OPRM Inoperative signal in negative logic by discrete output.

3. ABA Trip
A) The OPRM unit shall generate the ABA Trip when the trip condition occurs in accordance with the Amplitude Based Detection Algorithm.
B) The OPRM unit shall conduct the ABA Trip judgment for all the Normalized Oscillation Signals individually.

The Amplitude-Based Detection Algorithm is described in Section 5.2.2.3.5.1

4. GRA Trip
A) The OPRM unit shall generate the GRA Trip when the trip condition occurs in accordance with the Growth Rate Based Detection Algorithm.
B) The OPRM unit shall conduct the GRA Trip judgment for all the Normalized Oscillation Signals individually.

The Growth Rate-Based Detection Algorithm is described in Section 5.2.2.3.5.2.

5. PBDA Trip
A) The OPRM unit shall generate the PBDA Trip when trip condition occurs in accordance with the Period Based Detection Algorithm.
B) The OPRM unit shall conduct the PBDA Trip judgment for all the Normalized Oscillation Signals individually.

The Period-Based Detection Algorithm is described in Section 5.2.2.3.5.3.

6. OPRM Trip
The OPRM unit shall generate an OPRM Trip signal if any of the following conditions is satisfied:
A) The ABA Trip is detected in any of 44 OPRM Cells.
B) The GRA Trip is detected in any of 44 OPRM Cells.
C) The PBDA Trip is detected in any of 44 OPRM Cells.

The OPRM unit shall generate the OPRM Trip signal (used as a reactor scram signal to RPS) in negative logic by discrete output.

Note: The Relay unit generates an OPRM Scram signal by combining the OPRM Trip signal with the OPRM Inoperative signal with "AND" logic.(Inoperative=0, Trip=0)

The OPRM unit shall resets each trip and alarm signal generated in accordance with the process described in this section without hysteresis.

5.2.2.3.5.1 Amplitude-Based Detection Algorithm
Amplitude-Based Detection Algorithm trip judgment is conducted to each Normalized Oscillation Signal, which is generated in "OPRM Signal Processing" described in Section 5.2.2.3.3.

A) Amplitude-Based Detection Algorithm of the OPRM unit shall be designed based on the basic principle of

Amplitude-Based Detection Algorithm shown in Figure 5-5.

B) The implemented ABA logic shall avoid false peak detection, using the peak detection logic.
C) The implemented ABA logic shall avoid false minimum detection, using the minimum detection logic.
D) The implemented ABA logic shall conduct continuous trip judgment.
E) OPRM unit shall hold the ABA Trip generation for the ABA and GRA Trip Hold Time setpoint (initial value is [ ]a,c second).
F) The OPRM unit shall initialize the Amplitude-Based Detection Algorithm trip judgment at certain conditions that may cause false ABA Trip.
G) In the case of Algorithm initialization, the OPRM unit shall not generate the ABA Trip signal.

5.2.2.3.5.2 Growth Rate-Based Detection Algorithm

Growth Rate-Based Detection Algorithm trip judgment is conducted to each Normalized Oscillation Signals, which is generated in "OPRM Signal Processing" described in Section 5.2.2.3.3.

A) Growth Rate-Based Detection Algorithm of the OPRM unit shall be designed based on the basic principle of Growth Rate-Based Detection Algorithm shown in Figure5-5.
B) The implemented GRA logic shall avoid false peak detection, using the peak detection logic.
C) The implemented GRA logic shall avoid false minimum detection, using the minimum detection logic.
D) The implemented GRA logic shall conduct continuous trip judgment.
E) The OPRM unit shall hold the GRA Trip generation for the ABA and GRA Trip Hold Time setpoint (initial value is [ ]a,c second).
F) OPRM unit shall initialize Growth Rate-Based Detection Algorithm trip judgment at certain conditions that may cause false GRA Trip.

In the case of Algorithm initialization, OPRM unit shall not generate GRA Trip signal.

5.2.2.3.5.3 Period-Based Detection Algorithm

Period-Based Detection Algorithm trip judgment is conducted to each Normalized Oscillation Signal, which is generated in "OPRM Signal Processing" described in Section 5.2.2.3.3.

A) Period-Based Detection Algorithm of the OPRM unit shall be designed based on the basic principle of Period-Based Detection Algorithm shown in Figure 5-6.
B) The implemented PBDA logic shall avoid false peak detection, using the peak detection logic.
C) The implemented PBDA logic shall avoid false minimum detection, using the minimum detection logic.
D) The implemented PBDA logic shall conduct continuous trip judgment.
E) The OPRM unit shall hold the PBDA Trip generation for PBDA Trip Hold Time setpoint (initial value is 3.5 second).
F) OPRM unit shall initialize the Period-Based Detection Algorithm trip judgment at certain conditions that may cause false PBDA Trip.
G) In the case of Algorithm initialization, the OPRM unit shall not generate the PBDA Trip signal.

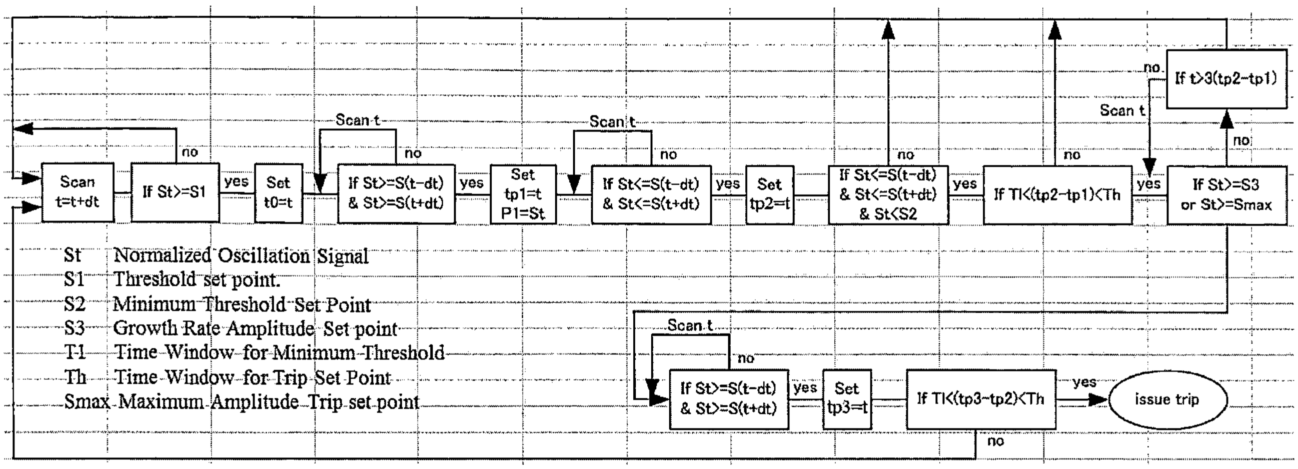


Figure 5-5 Amplitude-Based Algorithm and Growth Rate-Based Algorithm Flow Chart

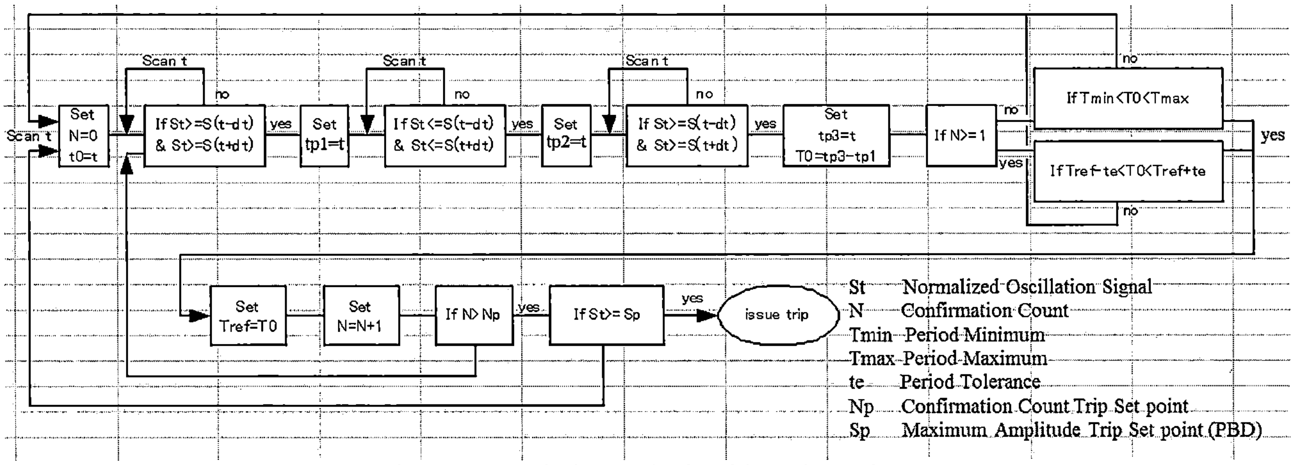


Figure 5-6 Period-Based Algorithm Flow Chart

5.2.2.3.6. OPRM Region Reset Requirements

The OPRM unit shall have hysteresis width for OPRM region judgment listed in Table 5-19.
The OPRM unit shall have OPRM region reset point.

Table 5-19 OPRM Region Hysteresis Width

Condition	Hysteresis Width	Hysteresis Width Range
OPRM Region APRM Level	1% of full scale	0 to 9% full scale
OPRM Region Core Flow value	1% of full scale	0 to 9% full scale

Note: Full scale value represents the output level of 125.0% or equivalent.

5.2.2.3.7. OPRM Bypass Function

1. LPRM Bypass Function

A) The OPRM unit shall exclude the LPRM Level less than LPRM Lower-limit Setpoint from average calculation in "OPRM Signal Processing" described in Section 5.2.2.3.3 (B).

B) The OPRM unit shall exclude the LPRM Level, which is from Inoperative LPRM detector from average calculation in "OPRM Signal Processing" described in Section 5.2.2.3.3 (B).

C) The OPRM unit shall exclude the LPRM Level with transmission error from average calculation in "OPRM Signal Processing" described in Section 5.2.2.3.3 (B).

D) The OPRM unit shall generate the simulated-Filter Flux to confirm validity of the LPRM Bypass Function.

2. OPRM Cell Bypass Function

A) The OPRM unit shall exclude the OPRM Cell from trip judgments when Number of Active LPRMs fall below the Minimum Number of Active LPRMs setpoint.

3. OPRM Unit Bypass Function (OPRM Region)

The region where the APRM Level is greater or equal to the OPRM Region APRM Level Setpoint and the Core Flow Level is less or equal OPRM Region Core Flow Level Setpoint is called OPRM Region.

A) OPRM trip function shall be automatically bypassed, if the APRM Level is less than OPRM Region APRM Level Setpoint or the Core Flow Level is greater than the OPRM Region Core Flow Level Setpoint.

B) The OPRM trip function shall become operative automatically when the APRM Level is greater or equal OPRM Region APRM Level Setpoint and the Core Flow Level is less or equal to the OPRM Region Core Flow Level Setpoint"

C) The OPRM unit shall generate the simulated APRM Level to confirm validity of the OPRM Unit Bypass Function.

D) The OPRM unit shall generate the simulated Core Flow Level to confirm validity of the OPRM Unit Bypass Function.

5.2.2.3.8. Unit Front and Rear Panel Display

The OPRM unit panel provides the following displays.

1. The OPRM unit shall indicate items by the numerical display on the front panel listed in Table 5-20-1.
   The OPRM unit shall indicate the numerical value within the range listed in Table 5-20-1.

Table 5-20-1 OPRM unit Numerical Display on the front panel

Indication Item	Range
Normalized Oscillation Level	0.000 to 9.999
APRM Level	0.0 to 125.0%
Core Flow Level	0.0 to 200.0%
Number of active OPRM cell	0 to 44
Filter Flux	0.0 to 125.0%
Calibrated APRM Level	0.0 to 125.0%
Calibrated Core Flow Level	0.0 to 200.0%
Calibrated Filter Flux	0.0 to 125.0%
Confirmation Count	0 to 127
LPRM Lower-limit Setpoint	0.0 to 99.9%
Active OPRM Cell Lower-limit Setpoint	0 to 44
OPRM Area APRM Level Setpoint	0.0 to 99.9%
OPRM Area Core Flow Level Setpoint	0.0 to 99.9%
Active LPRM Lower-limit Setpoint	1 to 3
Threshold Setpoint	1.00 to 1.99
Minimum Threshold Setpoint	0.50 to 1.99
Growth Rate Factor	1.00 to 1.99
Maximum Amplitude Trip Setpoint (ABA)	1.00 to 1.99
Growth Rate Amplitude Setpoint	1.00 to 1.99
Time Window for Minimum Threshold	0.00 to 0.99s
Time Window for Trip Setpoint	0.00 to 9.99s
ABA and GRA Trip Hold Time Setpoint	0.0 to 9.9s
Period Minimum Setpoint	0.00 to 9.99s
Period Maximum Setpoint	0.00 to 9.99s
Period Tolerance Setpoint	0.000 to 0.999
Confirmation Count Trip Setpoint	0 to 99
Maximum Amplitude Trip Setpoint (PBDA)	1.00 to 1.99
PBDA Trip Hold Time Setpoint	0.0 to 9.9s
OPRM Area APRM Level Hysteresis Setpoint	0 to 9%
OPRM Area Core Flow Level Hysteresis Setpoint	0 to 9%

2. The OPRM unit shall indicate the trip and alarm status with LED on the front panel listed in Table 5-20-2.
The OPRM unit shall indicate the trip and alarm status with LED on the front panel with the color listed in Table 5-20-2.
The OPRM unit shall latch the trip and alarm indications on the front panel, and allow an operator to reset them.

Table 5-20-2 OPRM unit Trip and Alarm Display on the front panel

Indication Item	Color
OPRM Minor Failure	Yellow
OPRM Inoperative	Yellow
OPRM Trip	Red
ABA Trip	Red
GRA Trip	Red
PBDA Trip	Red
LPRM Unit Data Transmission Failure	Yellow
APRM Unit Data Transmission Failure	Yellow
Unit Power Supply Failure	Yellow

3. The OPRM unit shall indicate the mode status with LED on the front panel listed in Table 5-20-3.
The OPRM unit shall indicate the mode status with LED on the front panel with the color listed in Table 5-20-3.

Table 5-20-3 OPRM unit Mode Display on the front panel

Indication Item	Color
Operation Mode (OP)	Green
Standby Mode (STANDBY)	Yellow
Calibration Mode (CAL)	Yellow

4. The OPRM unit shall indicate the status with LED on the front panel listed in Table 5-20-4.
The OPRM unit shall indicate the status with LED on the front panel with the color listed in Table 5-20-4.

Table 5-20-4 OPRM unit Status Display on the front panel

Indication Status	Color
OPRM Bypass	Yellow
OPRM Region	Green
LPRM Bypass	Yellow
APRM Unit Data Selection	Green

5. The OPRM unit shall indicate a status of the unit power supply and the optical data transmission with LED on the rear panel listed in Table 5-20-5.
The OPRM unit shall indicate a status of the unit power supply and the optical data transmission with LED on the rear panel with the color listed in Table 5-20-5.

Table 5-20-5 OPRM unit Power Supply and Data Transmission Display on the rear panel

Indication Status	Color
Status of Data Transmission(Normal/Abnormal)	Green/Orange
Unit Power Supply Lamp(glow during power activation)	Green

5.2.2.3.9. Setpoint/Parameter Adjustment Function

The OPRM unit shall have setpoints and parameters as listed in Table 5-21.
An adjustment function for each setpoint and parameter in the OPRM unit shall be designed to avoid any out-of-range setpoints.

Table 5-21 OPRM unit Setpoints and Parameters

Item	Initial Setpoint	Setting Range	Setting Method
LPRM Lower-limit Setpoint	5.00%	0.0 to 99.9%	Manual
Active OPRM Cell Lower-limit Setpoint	32	0 to44	Manual
OPRM Area APRM Level Setpoint	30.00%	0.0 to 99.9%	Manual
OPRM Area Core Flow Level Setpoint	60.00%	0.0 to 99.9%	Manual
Active LPRM Lower-limit Setpoint	2	1 to 3	Manual
Threshold Setpoint (S1)	1.1	1.00 to 1.99	Manual
Minimum Threshold Setpoint (S2)	0.92	0.50 to 1.99	Manual
Growth Rate Factor (DR3)	1.3	1.00 to 1.99	Manual
Maximum Amplitude Trip Setpoint (ABA) (Smax)	1.3	1.00 to 1.99	Manual
Time Window for Minimum Threshold (T1)	0.31s	0.00 to 0.99s	Manual
Time Window for Trip Setpoint (Th)	2.20s	0.00 to 9.99s	Manual
ABA and GRA Trip Hold Time Setpoint	3.5s	0.0 to 9.9s	Manual
Period Minimum Setpoint (Tmin)	1.00s	0.00 to 9.99s	Manual
Period Maximum Setpoint (Tmax)	[ ]s^{a,c}	0.00 to 9.99s	Manual
Period Tolerance Setpoint (te)	0.150s	0.000 to 0.999s	Manual
Confirmation Count Trip Setpoint (Np)	10	0 to 99	Manual
PBDA Amplitude Setpoint (Sp)	1.1	1.0 to 1.99	Manual
PBDA Trip Hold Time Setpoint	[ ]s^{a,c}	0.0 to 9.9s	Manual
OPRM Area APRM Level Hysteresis Setpoint	1% of full scale	0 to 9%	Manual
OPRM Area Core Flow Level Hysteresis Setpoint	1% of full scale	0 to 9%	Manual

5.2.2.3.10. Trip Test Function

To confirm validity of the OPRM unit trip algorithms;

1. The OPRM unit shall generate the simulated-Normalized Oscillation Signal to check trip generation.
2. The OPRM shall provide indications of the Growth Rate-Based Trip, Amplitude-Based Maximum Trip, and Period-Based Trip signals against test signals, while the OPRM unit is bypassed.

5.2.2.3.11. Power Supply Fluctuation Protection Function

Power supply of the OPRM unit shall have functions to protect itself from overvoltage, over current, reverse current, and inrush current.
The OPRM unit shall satisfy normal operation even when AC input power to PFC fluctuates.

5.2.2.4. Relay Unit Function

5.2.2.4.1. Relay Unit Function Summary

1. The Relay unit shall be designed to perform trip, alarm, permissive, or indication logic by signals from the APRM unit.
2. The Relay unit shall be designed to perform trip, alarm, permissive, or indication logic by signals from the OPRM unit.
3. The Relay unit shall bypass trip, alarm and indication signals from the APRM unit when receiving the APRM Bypass signal.
4. The Relay unit shall bypass trip, alarm and indication signals from the OPRM unit when receiving the APRM Bypass signal.

5.2.2.4.2. Relay Logic

APRM and OPRM relay logics are specified in IBD, FC51-2205-0001 (Reference 3 (6)).

5.2.2.4.2.1. APRM Relay Logic

1. APRM Scram

A) Following signals shall be combined by a single channel in "AND" logic as an APRM Trip signal.
  - Simulated Thermal Power Upscale Trip
  - APRM Upscale Flux Trip
  - APRM Inoperative

B) The APRM Trip signal in a PRNM division shall be combined with the APRM Bypass signal in "OR" logic as an APRM Scram signal.

C) The APRM Scram signal shall be generated to all the divisions in RPS for scram.

2. Core Flow Rapid Coastdown Division Trip

A) The Core Flow Rapid Coastdown in a PRNM division shall be combined with the APRM Bypass signal in "OR" logic as a Core Flow Rapid Coastdown Division Trip signal.

B) The Core Flow Rapid Coastdown Division Trip signal shall be generated to all the divisions in RPS for scram.

3. APRM Rod Block

A) Following signals shall be combined by a single channel in "AND" logic as an APRM Alarm signal.
  - APRM Downscale
  - APRM Upscale Flux Alarm
  - APRM Inoperative
  - Core Flow Downscale
  - Core Flow Upscale Alarm

B) The APRM Alarm signal shall be combined with the APRM Bypass signal in "OR" logic as an APRM Rod Block signal.

C) The APRM Rod Block signal shall be generated to all the channels in RCIS for rod block.

4. APRM Divisional ATWS Permissive

A) The APRM ATWS Permissive shall be combined with negation of the APRM Bypass in "AND" logic as an APRM Divisional ATWS Permissive signal.

B) The APRM Divisional ATWS Permissive signal shall be generated to identical division of ELCS for ADS inhibit.

5. Bar Chart Color Change Signal

A) Following signals shall be combined by a single channel in "AND" logic as a Bar Chart Color Change Signal
  - A combined signal of APRM Upscale Flux Alarm in positive logic and APRM Downscale in positive logic
  - APRM Bypass signal in negative logic

B) The Bar Chart Color Change Signal shall be generated to LDP.

5.2.2.4.2.2. OPRM Relay Logic

1. OPRM Scram

A) The OPRM Trip and OPRM Inoperative shall be combined in "AND" logic. (Inoperative=0, Trip=0)

B) A combined signal of OPRM Trip and OPRM Inoperative shall be combined with the APRM Bypass signal in "OR" logic as an OPRM Scram signal.(Bypass=1)

C) The OPRM Scram signal shall be generated to the all the divisions in RPS for Scram.

5.2.3. General Design

5.2.3.1. NMS Panel Requirements

NMS panel requirements shall have following configuration.
Number of NMS Panel: 4
NMS Panel in the Division I has four LPRM units, one APRM unit, one OPRM unit, one Relay unit and two DC power supplies for relay unit.
NMS Panel in the Division II has four LPRM units, one APRM unit, one OPRM unit, one Relay unit and two DC power supplies for relay unit.
NMS Panel in the Division III has four LPRM units, one APRM unit, one OPRM unit, one Relay unit and two DC power supplies for relay unit.
NMS Panel in the Division IV has four LPRM units, one APRM unit, one OPRM unit, one Relay unit and two DC power supplies for relay unit.

Outline dimension of NMS Panel shall be
2000mmW (78.74inch) x 2300mmH (90.55inch) x 1000mmD (39.37inch) (Handle is not included)
Weight of NMS Panel shall be 2500 kg or less

The following NMS Panel specifications shall be applied.

Material:	SS400 (Front panel thickness 4.5mm (0.17inch), Side panel thickness 4.5mm (0.17inch), Ceiling thickness 2.3mm (0.091inch))
Installation:	Installed on the channel base
Insulation Withstand Voltage:	2kVAC /1 min (between the AC power circuit and chassis)
Insulation Resistance:	2M ohm or more/500VDC (between the AC power circuit and chassis)
Door:	Double hinged doors 2 door handles Key lock is equipped.
Lifting Lug:	L-shaped and attached at 4 parts with screw on top of the NMS panel only for transportation.
Channel Base:	Welded with hexagon nuts

5.2.3.2. Unit Structure Requirements

Chassis that are used as the enclosure of the LPRM unit, the APRM unit and the OPRM unit must be suitable for mounting in a standard 19 inch rack, and must have sufficient strength to meet seismic requirements specified in Section 5.5.2.

Outline dimension of LPRM unit, APRM unit, and OPRM unit shall be
482.6mmW (19.00inch) x 177mmH (6.97inch) x440.8mmD (17.35inch) (Excluding protrusions)
Weight of LPRM unit, APRM unit, and OPRM unit shall be 20kg or less. (Including modules)

Detail specifications of LPRM unit, APRM unit, and OPRM unit are as follows:

Input Power:	220VDC, 0.65A (*1)
Insulation Withstand Voltage	2kVAC /1 min (between the control circuit and chassis)
Insulation Resistance	500M ohm or more/500VDC (between the control circuit and chassis)

Note (*1): This input power specification is input power for each unit via PFC.

5.2.3.3. Relay Unit Structure Requirements

Outline dimension of Relay unit shall be 446mmW (17.6inch) x 159mmH (6.26inch) x 300mmD (11.8inch).
Weight of Relay unit shall be 20kg or less.

Detail specifications of Relay unit are as follows:

Material: Steel (Thickness 1.6 mm (0.063 inch))
Input Power: 24VDC (Both bus A and bus B)
Insulation Withstand Voltage: 1kVAC /1 min (between the DC power supply circuit and chassis)
Insulation Resistance: 100M ohm or more/500VDC (between the DC power supply circuit and chassis)

5.2.3.4. Name Plate Requirements

Name plate requirements are as follows:
The location of the name plates for instruments, relays, and apparatus shall be placed where one can easily identify. Name plates for panels shall be placed at a height which is easily visible when standing at the side of the panel (1.5m (59inch) or less from lower limit of the panel).
The following consideration shall be given depending on whether the door is lockable or not.

1. Panel with its door unlocked
   Inner side of the door will be acceptable if the nameplate is placed at level where one can easily find.
2. Panel with its door locked
   The nameplate shall be placed on the outer surface of the panel at the level where one can easily find.

The display items of the name plate shall include manufacturer and date of the manufacture.

5.2.3.5. Service Name Plate Requirements

Service name plate requirements are as follows:
Materials of service name plates are either of the following. The nameplate and its screw for outdoor panels shall be of stainless steel to make it corrosion proof.

1. Metal
   Silver background, black character, rounded Gothic font, framed by black line
2. Acrylic resin
   Milky white, black character, rounded Gothic font

5.2.3.6. Control Switch Requirements

NMS Panel Control switch requirements are as follows:
Control switches shall be rotary type.
Movable contacts as well as fixed ones of the rotary switches shall use metals which have good conductivity.
Movable contacts as well as fixed ones of the rotary switches shall be designed to minimized arcing and abrasion. These devices, such as springs, shall be corrosion resistant.

5.2.3.7. Cables and Connectors Requirements

1. Appropriate conduits or trays shall be provided to signal cables and power cables. Signal cable shall be independent from power cable.
   Conduits or trays shall be provided to optical cables.
2. Connectors shall be designed to withstand under environmental conditions as described in Section 5.5.
3. All the power cables and signal cables shall be independent from other divisions respectively.
4. Wires shall be flame-retardant or non-flammable for the fire protection.
   The wires in PRNM system shall use following wires.
   - Non-collusive flame-retardant annealed cupper twisted wire
     Insulated part thickness: 0.8mm (0.03 inch)
     Cross sectional area: #16AWG, #14AWG, and #10AWG
   - Teflon Shielded Wire
     Cross sectional area: #22AWG

   Low power circuit (normally less than 1A) that their connectors have the limitation for the wire thickness shall use Teflon shielded wire with #22AWG of the cross sectional area.
5. External cables in the NMS panel shall be connected at terminal block below the panel.
6. Output wire of the of LPRM unit, APRM unit, and OPRM unit shall be shielded.
7. Wires used for AC power shall be yellow.

Wires used for DC power shall be blue.
3-wire Cabtyre cables shall not be used.
As for the signal common line, wires where current flow as a loop shall be blue.
Wires used for special grounding connection shall be green.

5.2.3.8. Requirements for Power Supply Lines

1. Varistors shall be inserted in the power supply lines of each LPRM unit, APRM unit, and OPRM unit to protect from surge voltage.
2. Noise filters shall be inserted in the power supply lines of each LPRM unit, APRM unit, and OPRM unit to reduce noise.

5.2.3.9. Grounding and Shielding Requirements

1. The PRNM system shall comply with the Grounding and Shielding requirements which required by Section 4.6.8 of EPRI TR-107330 (Reference 2 (19)).
2. The signal ground and the frame ground in the PRNM system shall be separated as described in Guide for Instrumentation Control Equipment Grounding in Generating Stations, IEEE Std 1050 (Reference 2 (16)).

5.2.3.10. Bus-Bar Requirements

Bus-Bar shall be copper belt with silver plating.
Thickness of the bus-bar shall be 50 mm (2.0inch) in longitudinal direction and 6 mm (0.2inch) in lateral direction.

5.2.3.11. Terminal Block Requirements

Terminal block requirements are as follows:
Terminal blocks shall be molded synthetic resin.
Terminal blocks shall be assembly type with separators between terminals.
Terminal blocks for control shall be provided with a removable transparent flame-retardant cover.
Terminal blocks for control shall have a minimum of 10% spare terminals.
Cable number and terminal number shall be marked on the terminal blocks to enable verification with external cables to be connected.

5.2.3.12. DC Power Supply Requirements

The DC power supply shall be used for Relay unit to supply +24VDC from external 120VAC.

5.2.3.13. Fuse Requirements

Fuse requirements are as follows:
Fuses shall not be used as protective device of primary circuit.
The rating of fuse for control circuit shall be as large as about 200% of maximum load current.

5.2.3.14. PFC Requirements

PFC shall be used as DC power supply for LRNM unit, APRM unit, and OPRM unit. PFC reduces noise in the AC power supply line. PFC converts AC voltage into DC voltage.

5.2.3.15. Receptacle Requirements

Receptacle requirements are as follows:
Plug receptacle (3-wire grounding type) shall be provided for all panels.
The power shall be a single phase, 120VAC derived from inboard lighting distribution power.
The power used for receptacle shall not be branched from AC control and instrumentation power supply.
Receptacle shall be displayed as "120VAC".
Electrical Requirement shall be as "1kw"

5.2.3.16. Inboard Lighting Requirements

Inboard lighting requirements are as follows:
A lamp shall be provided in every 1200 to 1500mm (47.24 to 59.06inch) over panel width.
The lamp shall be capable of being turned on from both right entry and left entry.
The power used for inboard lighting shall be derived from distributed panel for inboard lighting, not branched from AC control and instrumentation power supply.

5.2.3.17. Fire Protection Requirements

The fire retardant characteristics of the materials used in the PRNM system shall be addressed in order to minimize the probability of fire and subsequent consequences.

5.3. Software Specification

Any unused functions of the NMS equipment shall be identified, and be ensured that they have no adverse effect to the safety functions.
Section 5.1 and 5.2 include the PRNM functions that will be allocated to software as FPGA logic. The LPRM Unit Design Specification, the APRM Unit Design Specification and the OPRM Unit Design Specification provide precise functional allocation to the FPGA logic.
FPGA logic development shall be performed in accordance with NQ-2030 Procedural Standard for FPGA Products Development (Reference 3 (21)).
NICSD prepares the Software Management Plan (SMP) (Reference 3 (30)), Software Configuration Management Plan (SCMP) (Reference 3 (31)) and SQAP (Reference 3 (28)) that describes more detail FPGA logic development processes of software management, configuration management and qualification assurance.
NICSD prepares the VVP (Reference 3 (29)) that describes approach, methods, and roles of the V&V activities to be performed for the PRNM.

5.4. Design Life

The PRNM shall be able to satisfy the operation for 60 years with appropriate replacement and maintenance of PRNM equipment.
The design life of PRNM equipment are [ ]^{a,c} years based on sound engineering practices and manufacturer's recommendations using known significant aging mechanisms and reliability data.
As for the design life of parts that are less than [ ]^{a,c} years used in PRNM equipment, appropriate maintenance and replacement shall be provided in accordance with instruction manual.

5.5. Environmental Condition

This section describes environmental condition for PRNM system refers to R.G 1.209 (Reference 2 (25)).

5.5.1. Environmental Specification

The PRNM system shall perform safety-related functions in the normal, abnormal, accident, and post-accident environmental conditions.

NMS panel that includes LPRM units, APRM units, OPRM units and Relay units are installed in the MCR area where environment is mild.
The PRNM system shall satisfy the functions specified by this specification under the conditions shown in Table 5-22, which is cited from EPRI TR-107330 (Reference 2 (19)).

Main Control Room Area

Table 5-22 Normal and Abnormal 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

PRNM units shall operate on the temperature/humidity profile given in Figure 5-7.

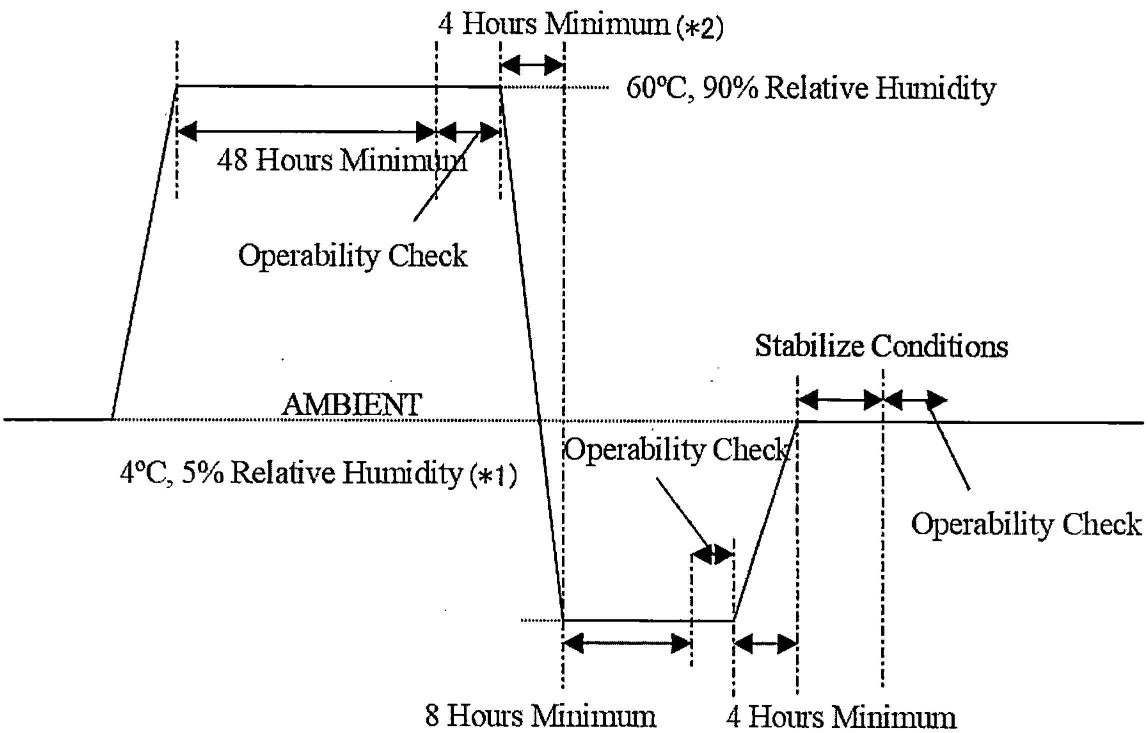


Figure 5-7 Temperature and Humidity Profile

Notes:

1. If the specified relative humidity cannot be achieved for the specified temperature, then run the test for the specified time at the lowest relative humidity that can be achieved at the specified temperature followed by running the test at the lowest temperature that the specified relative humidity can be achieved.
2. For this transition, first reduce the relative humidity, and then reduce the temperature. This is required to maintain a non-condensing atmosphere.

5.5.2. Seismic

The PRNM safety-related equipment shall be designed to operate during and after seismic events.
Each component that constitutes PRNM system shall be designed to be suitable for qualification as a Category 1 Seismic device.
Each component that constitutes PRNM system shall be designed to meet the qualification that is implemented in accordance with the requirements of IEEE Std 344 (Reference 2 (10)) and RG 1.29 (Reference 2 (22)).

The PRNM System shall meet performance requirements during and after exposure to the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE) levels (Figure 5-8).

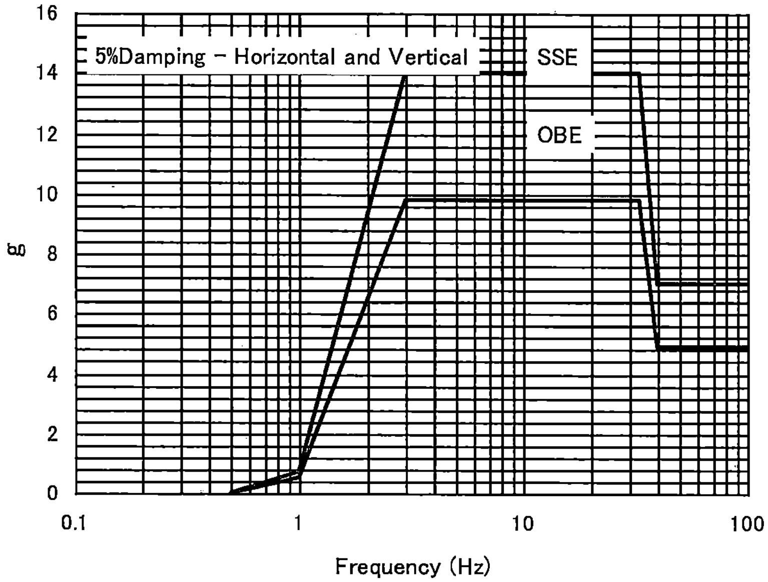


Figure 5-8 Requirement Response Spectrum

5.5.3. EMI/RFI Requirements

All safety-related systems of PRNM system shall be designed to minimize effects from and generation of Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI).
The PRNM system shall be designed to be endurable to test conditions of EMI, RFI, surge, Electrical Fast Transient / Burst (EFT/B), and Electrostatic Discharge (ESD) that conform to guidelines given in EPRI TR-107330 (Reference 2 (19)).

EMI/RFI emissions of PRNM system do not exceed the test range described in Figure 5-12 to 5-15.
As for EMI/RFI susceptibility of PRNM system, PRNM system shall not exhibit any malfunction, degradation of performance, or deviation from specified indications, beyond the tolerances indicated in the individual equipment or subsystem specification, when subjected to the either conducted or radiated electric fields as described in Figure 5-9 to 5-11 in accordance with R.G. 1.180 (Reference 2 (6)).

5.5.3.1. Low-Frequency Conducted Susceptibility Testing Power Leads (CS101)

The PRNM units shall not be susceptible to a test signal with levels as specified in Figure 5-9 that complies with R.G.-1.180 Section 4.1.1 (Reference 2 (6)). This test is performed for evaluating the conducted electromagnetic transients injected on power input leads over a frequency range from 120 Hz to 150 kHz. This test shall be performed in accordance with MIL-STD-461E CS101 (Reference 2 (23)).

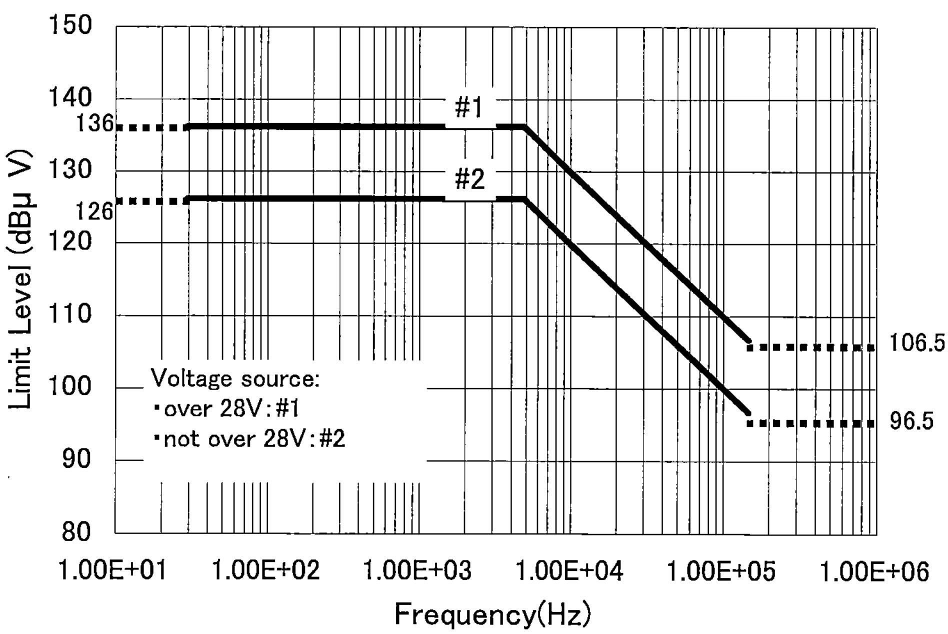


Figure 5-9 Low-Frequency Conducted Susceptibility Operating

5.5.3.2. High-Frequency Conducted Susceptibility Testing for Power Leads (CS114)

The PRNM units shall not be susceptible to a test signal with levels as specified in Figure 5-10 that complies with R.G.1.180 Section 4.1.2 (Reference 2 (6)). This test is performed for evaluating the conducted electromagnetic transients injected on power input leads over a frequency range from 10 kHz to 30 MHz. This test shall be performed in accordance with MIL-STD-461E CS114 (Reference 2 (23)).

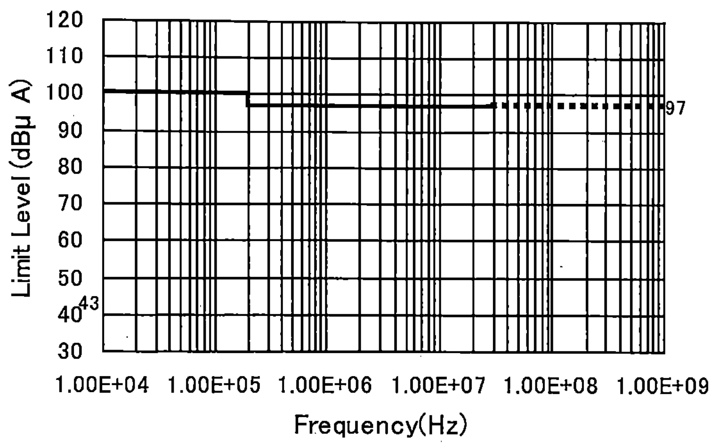


Figure 5-10 High-Frequency Conducted Susceptibility Operating Envelopes for Power Leads

5.5.3.3. High Frequency Conducted Susceptibility Testing for Signal Cable (CS114, CS115, CS116)

The PRNM units shall be designed to withstand radio frequency interference coupled onto the instrument cabling, and shall be tested by following the measurement procedure CS114, CS115 and CS116 of MIL-STD-461E (Reference 2 (23)) to meet the requirement of being subjected to a test signal levels 91dBμA (frequency range from 10 kHz to 30 MHz) (CS114), 2A (CS115) and 5A (frequency range from 10kHz to 100MHz) (CS116).

5.5.3.4. Radiated Susceptibility, Magnetic Fields (RS101)

The PRNM instruments shall not be susceptible to the electromagnetic field levels as specified in Figure 5-11 that complies with R.G.1.180 Section 4.3.1 (Reference 2 (6)). This test is performed in the frequency range of 30 Hz to 100 kHz. This test shall be performed in accordance with the MIL-STD-461E RS101 (Reference 2 (23)).

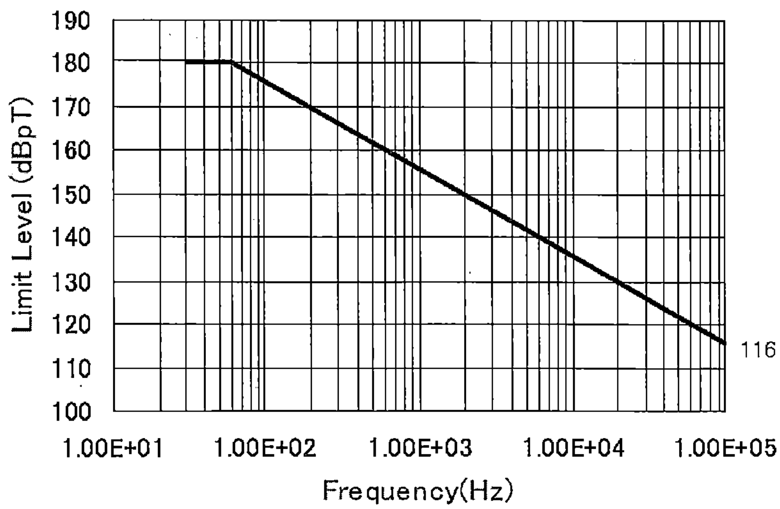


Figure 5-11 Low-Frequency Radiated Susceptibility Envelopes

5.5.3.5. Radiated Susceptibility, Electric Fields (RS103)

The PRNM instruments shall not be susceptible to the electromagnetic field strength of 10 V/m. This test shall be performed at frequency range of 30 MHz to 10 GHz. This test shall be performed in accordance with MIL-STD-461E RS103 (Reference 2 (23)).

5.5.3.6. Low-Frequency Conducted Emissions (CE101)

The low-frequency conducted emissions from the PRNM system on power leads shall be designed not to exceed the applicable Root Mean Square (RMS) values at the frequency from 60 Hz to 10 kHz shown in Figure 5-12 in accordance with R.G. 1.180 Section 3.1 (Reference 2 (6)). This test shall be performed in accordance with MIL-STD-461E CE101 (Reference 2 (23)).

Power lead of LPRM unit, APRM unit, and OPRM unit including PFC shall apply the 'AC POWER ≦ 1kVA' line, since power of LPRM unit, APRM unit, and OPRM unit including PFC is lower than 1kVA.

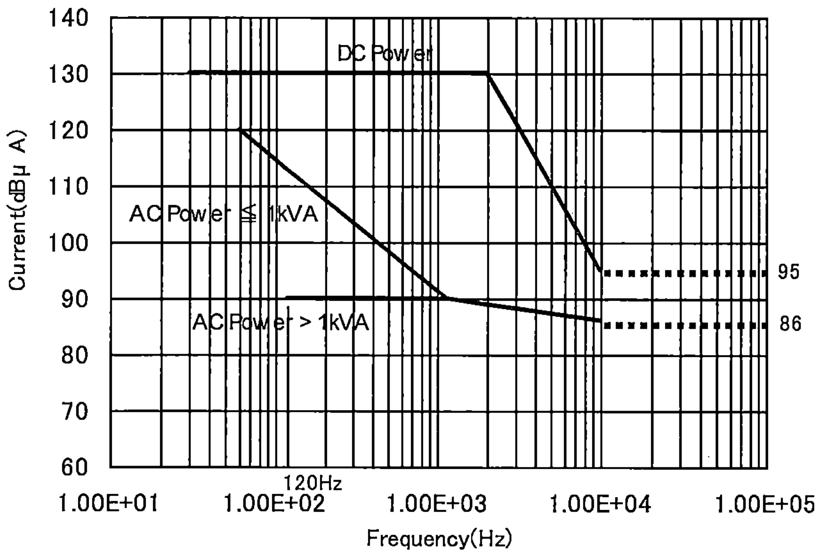


Figure 5-12 Low-Frequency Emissions Envelopes

5.5.3.7. High-Frequency Conducted Emissions (CE102)

The high-frequency conducted emissions from the PRNM system on power leads shall be designed not to exceed the applicable values at the frequency from 10 kHz to 2 MHz shown in Figure 5-13 in accordance with R.G. 1.180 Section 3.2 (Reference 2 (6)). This test shall be performed in accordance with MIL-STD-461E CE102 (Reference 2 (23)).

Power lead of LPRM unit, APRM unit, and OPRM unit including PFC shall apply the '115V' line, since input power voltage of LPRM unit, APRM unit, and OPRM unit including PFC is 120VAC.

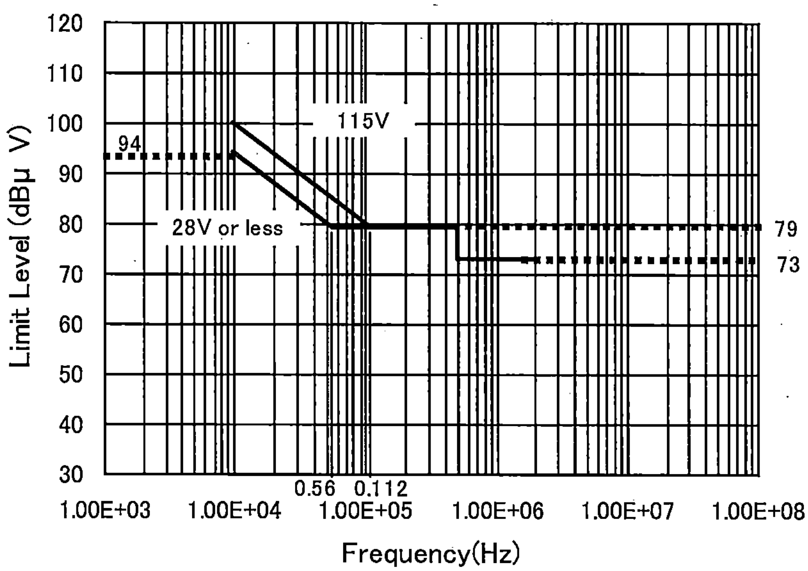


Figure 5-13 High-Frequency Conducted Emissions Envelopes

5.5.3.8. Radiated Emissions, Magnetic Field (RE101)

The radiated magnetic field emissions from the PRNM system shall be tested. Magnetic field emissions should not be radiated in excess of the levels shown in Figure 5-14 that complies with R.G.1.180 Section 3.3 (Reference 2 (6)). This test shall be performed at the frequency from 30Hz to 100kHz. This test shall be performed in accordance with MIL-STD-461E RE101 (Reference 2 (23)).

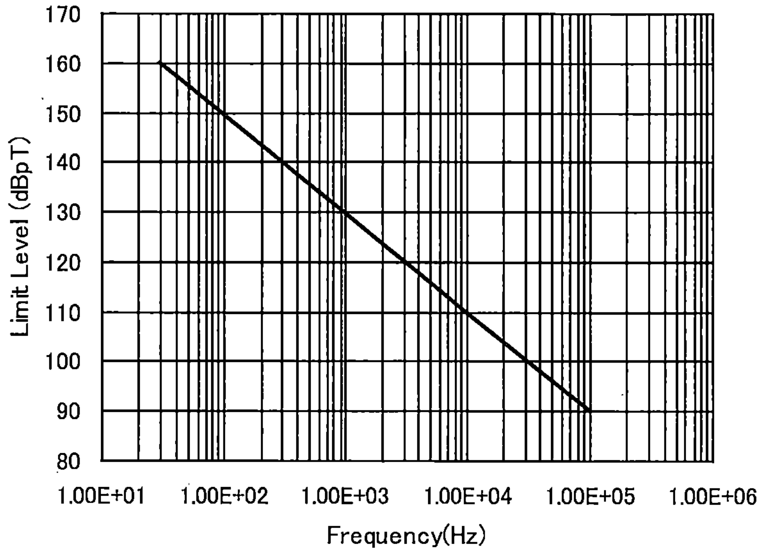


Figure 5-14 Magnetic-Field Radiated Emissions Envelope

5.5.3.9. Radiated Emissions, Electric Fields (RE102)

The radiated electric field emissions from PRNM system shall be tested. Electric field emissions should not be radiated in excess of the rms values shown in Figure 5-15 that complies with R.G.1.180 Section 3.4 (Reference 2 (6)). This test shall be performed at the frequency from 2MHz to 1GHz. This test shall be performed in accordance with MIL-STD-461E RE102 (Reference 2 (23)).

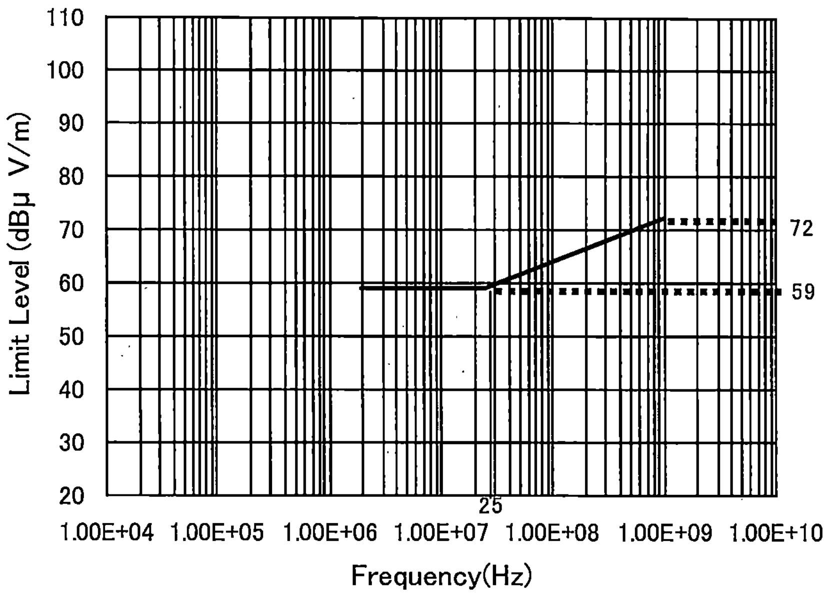


Figure 5-15 Electric-Field Radiated Emissions Envelopes

5.5.4. Surge Withstand Capability Requirements

The PRNM instruments shall be qualified to withstand surge voltages from switching and lightning effects as specified in R.G 1.180 Section 5 (Reference 2 (6)).

The withstand level shall be as follows:

A. Surge (Ring Wave)

Limits (Applied peak voltage)

- Voltage = 2 kV: for secondary or derived power distribution systems

Pulse Shape

- 100 kHz, ring wave (0.5 μs rise time, 10 μs pulse width)

Number of tests

- At least five positive and five negative at the selected points

B. Surge (Combination Wave)

Limits (Applied peak voltage)

- Voltage = ±2 kV : for secondary or derived power distribution systems

Pulse Shape

- Impulse of 1.2 μs (±30 %) rise time, 50 μs pulse width, open circuit, double exponential
- Impulse of 8 μs (±20 %) rise time, 20 μs pulse width, short circuit, double exponential

Number of tests

- At least five positive and five negative at the selected points

Surges withstand capability shall include surge applied to following points, if exist:

A. Between line and neutral for AC connections to the power supplies.
B. Between line and AC ground for AC connections to the power supplies.
C. Between neutral and AC ground for AC connections to the power supplies.

Applying the specified level of surge to the specified points does not damage any other module or device or cause disruption of the operation that could result in a loss of the safety-related function.
If there is more than one module or input that are the same type of modules or inputs, surges can be applied to only one representative module for each type.

5.5.5. EFT/B Withstand Requirements

The PRNM instruments shall be qualified to perform when they are subjected to repetitive Electrically-Fast Transient/Burst(EFT/B) as specified in R.G 1.180 Section 5 (Reference 2 (6)).

The withstand level shall be as follows:

A. EFT/B Level

Limits (Applied peak voltage)

- Voltage = ±2 kV : for secondary or derived power distribution systems (Level 3)

Pulse Shape

- Impulse of 5 ns (±30 %) rise time, 50 ns pulse width, double exponential

Repetition

- Repetition rate = 5 kHz (±2 kVp-p)
- Burst duration = 15 ms
- Burst period = 300 ms

EFT/B pulses shall be applied to following points, if exist:

A. Between line and neutral for AC connections to the power supplies.
B. Between line and AC ground for AC connections to the power supplies.
C. Between neutral and AC ground for AC connections to the power supplies.

5.5.6. ESD Withstand Requirements

The PRNM instruments shall be qualified to cope with electrostatic discharges at a severity level of 4 as specified in EPRI TR-107330 Section 4.3.8 (Reference 2 (19)).

The withstand level shall be as follows:

A. ESD Level

Pulse Wave Shape:	Specified as current output from 150pF storage capacitor through a 330 ohm discharge resistance into a specific load defined in each Referenced standard.
Pulse Rise Time:	Equal or less than 1 ns
Pulse Decay Time:	Approximately 30 ns at 50% height
Pulse Amplitude:	Specified in terms of charge voltage to simulator. For uncontrolled ambient temperature, pressure, and humidity
Air discharge:	±15kV
Contact discharge:	±8kV
Pulse repetition:	Apply minimum of ten simulations for each polarity at each test point while the digital system is operating
Relative Humidity:	Between 30%RH and 60%RH

Test Points should be selected on the basis of accessibility during operation.

Subjecting the PRM equipment to this level of ESD shall not disrupt operation or cause any damage.

5.5.7. Isolation Requirements

The PRNM system shall be protected from electric power transients and disturbances by using fuses, analog isolators, optical couplers and, fiber optic cables. The detailed isolation requirements are followings.

5.5.7.1. Electrical Isolation Specification

This section describes electrical isolation specification for PRNM system.

1. The PRNM system shall have the isolation capability of Class 1E/Non-1E that withstands at least 600VAC and 250VDC applied for 30 seconds that complies with Section 4.6.4 of EPRI TR-107330 (Reference 2 (19)).
   Applying a signal within the specified range for the time shall not disrupt the operation of any other module.
   Analog output module connected to non-class 1E equipment shall be qualified under the condition specified in Section 5.5.1.
2. The PRNM system shall have the group-to-group isolation of Digital I/O module that withstands at least 40V peak. This means that applying this level to an input shall not cause disoperation of any other channel on the module in accordance with Section 4.3.2.2 of EPRI TR-107330 (Reference 2 (19)).
3. The communication data links to be provided to systems external to the FPGA-Based system have a one-way fiber optic communication link, providing fixed data sets from each safety-related division individually to the nonsafety-related systems, providing 1E to non-1E electrical and functional isolation, and offering to possibility of data transfer from the nonsafety to the safety equipment. This design eliminates any potential for NMS data from one division being supplied to another division. The LPRM unit, APRM unit, and OPRM unit shall be isolated to non-class 1E equipment through the one way fiber optic cable.

5.5.7.2. Physical Separation Specification

This section describes physical separation specification for PRNM system.

1. Each division of the PRNM system has four LPRM units, one APRM unit, one OPRM unit
   Each division shall be independent of the other divisions in design, and isolated from the other divisions in conformance with Section 5.6 of IEEE Std. 603 (Reference 2 (14)) and IEEE Std. 384 (Reference 2 (13).

2. The cables from the detectors shall be independently led to the panel of the MCR area.
   The power leads shall be independently led to the panel of the MCR area.
   The logic circuit of each trip system shall be independently provided within the panel.
   In addition, Section 5.6 of IEEE Std. 7-4.3.2 (Reference 2 (7)) shall be applied for digital portions of the PRNM system.

3. The Relay unit uses relays. The contact points of relays are disconnected physically when not in use.

5.5.8. Power Supply

The PRNM system shall be designed to receive four divisional class 1E 120VAC vital powers and four divisional class 1E 120 VAC instrument and control powers as redundant power supplies.

The PRNM system shall operate for AC source range of 90 to 150 VAC and frequency range 57 to 63 Hz in accordance with EPRI TR-107330 Section 4.6.1 (Reference 2 (19)).

The supply modules shall operate over the temperature and humidity range given in Section 5.5.1.

Each PRNM unit has the two LVPS modules that operate in parallel. Each LVPS module has enough capacity to supply power to all modules mounted in the chassis.

During Hold up time for AC supplied power sources (40msec), digital I/Os shall not change and the change of analog I/Os shall be within 5% of full scale in accordance with EPRI TR-107330 Section 4.6.1 (Reference 2 (19)).

Failure of one of the redundant power supplies shall not cause the discrete I/O to change state for more than[ ][a,c]msec, the analog I/O signals shall not change more than 5%, and the application logic shall continue to operate.

Redundant power supply modules shall be protected so that undervoltage and overvoltage, shorts to ground, and other

faults in one power supply do not prevent operation of the alternate supply.

Electrical Requirement
NMS Panel Division I: 4140W
NMS Panel Division II: 3450W
NMS Panel Division III: 4140W
NMS Panel Division IV: 3450W

5.6. Maintenance Specification

This section describes maintenance specification for PRNM system.

1. The PRNM system shall be maintained, adjusted, tested, and calibrated during plant operation without causing a plant shutdown or scram even in their service.
   The PRNM system shall be capable of being tested for processing functions, trip functions, and calibration functions if they are in operational state.
   Furthermore, tests on electronic devices including those locally installed shall be capable of being conducted during periodic inspections.

2. For each LPRM unit, APRM unit, and OPRM unit, relay and connectors (excluding ground terminals) shall be used for external connection so that the modules and connectors can be easily disconnected.

5.7. Design Method

Design shall be performed according to the NQ-2030 Procedural Standard for FPGA Products Development (Reference 3 (21)) and NQ-2036 Procedure for Design Control (Reference 3 (22)).

5.8. Material Requirements

Material requirements for each component are described in Section 5.2.3.
If any hazardous materials are used as part of the system, then Material Data Sheets (MDSs) shall be provided for these materials.

5.9. Requirement for Third Party / Sub-Vendor Items

All items provided by sub-vendors or third parties shall be subjected to all applicable requirements and test.
The applicable technical and quality requirements for the items provided by sub-vendors or third parties shall be specified in the procurement document for each item.
The compatibility of the items with the PRNM system shall be demonstrated through the unit or system validation testing.

5.10. Redundancy

The PRNM system shall have four divisions so as to be able to tolerate a single failure.
LPRM unit, APRM unit, and OPRM unit and Relay unit shall have two power supplies in one division.

5.11. Diversity

Diversity requirements are not applicable to this project

5.12. Cyber Security

Security issues are part of the design considerations for all life cycle phases. The design process includes several aspects designed to protect proprietary information (and thus the system design), protect the computing systems inside design organizations from attack and compromise, and provide significant reductions in cyber security risks for the fielded systems.
Security issues will be assessed based on the regulatory positions in the RG 1.152 (Reference 2 (5)).

In order to avoid the configuration issues associated with software-based systems, an FPGA that provided permanent, non-volatile, unchangeable storage of the system programming should be selected.

There are documents currently being developed by engineering procurement and construction team to provide project guidance on Cyber Security which will be based on NQ-2037 (Reference 3 (23).

The following security hazards are considered during the PRNM operation:

A) Unauthorized change of logic embedded in the FPGA
B) Unauthorized change of setpoints
C) Unauthorized change of GAF in the [ ][a,c] which is relatively vulnerable to cyber attacks within the PRNM system

Against above security hazards, the following countermeasures are considered:

1. Use of NRW-FPGA prevents unauthorized change of embedded logic.

2. The Setpoints of the PRNM system cannot be changed remotely.
   Setpoints can be changed on the LPRM unit, the APRM unit and the OPRM front panel or from the rotary switches placed on the printed circuit board, but the operation is protected by a key switch.

3. The LPRM unit displays GAF download values and Ical values.
   The LPRM unit shall have a key switch to select a mode when downloading a new Ical value to prevent unauthorized GAF downloads.
   An operating procedure prescribing a method to check the GAF download values before the LPRM unit enters into a normal operation mode will prevent use of any inadequate GAF.

6. Fabrication Requirements

The PRNM equipments procured by NICSD should be fabricated in accordance with NQ-5004 (Reference 3(26)).
Power Systems Manufacturing Section (PSM) assembles or wires PRNM equipments.
PSM performs checking of mounted parts or connections of wiring.

PSM should control the manufacturing process described in NQ-5003 (Reference 3 (25)).
PSM should use the Traveler system for fabrication, which is prepared by NICSD in accordance with NQ-5001 (Reference 3 (24)).

7. Inspection and Test Requirements

1. Witness and inspection requirements based on customer / NED requirements
   Extent and frequency of monitoring and evaluating the vendor's performance is specified in the "The Common Quality Assurance Specification for NRW-FPGA-Based I&C System Qualification Project" (Reference 3 (34)).

2. FPGA Testing
   FPGA testing is performed to validate FPGA design specification.
   Scope and acceptance criteria for the FPGA testing are defined in FPGA test procedure.

3. Module Validation Testing
   Module validation testing is performed to validate module design specification.
   Scope and acceptance criteria for the module validation testing are defined in module test procedure.

4. System Validation Testing
   System validation testing including unit validation testing is performed to validate system and unit specifications prescribed in the EDS and unit detailed design specification.
   The scope and acceptance criteria for the system validation testing are defined in a software validation test plan.

5. Qualification Test
   Qualification tests are performed to demonstrate that system performs its intended safety function under the environmental, seismic and Electromagnetic Compatibility (EMC) conditions specified in Section 5.5 of EDS.
   The scope and acceptance criteria for the qualification tests are defined in the equipment qualification test plan and EMC test plan.

8. Painting and Coating Requirements

Not required.

9. Cleaning, Packaging, Shipping and Transportation Requirements

General requirements for cleaning, packaging, shipping and transportation should be met as described in AS-500A007 (Reference 3 (33)).

10. Spare and Replacement Parts

Spare and replacement parts shall be provided to avoid delay in nonscheduled repair assignments.