Neutron Monitoring System (NMS)

Applying Field Programmable Gate Array (non-CPU) Technology to a Neutron Monitoring System

Features

The Toshiba Neutron Monitoring System (NMS) is based on special Field Programmable Gate Array (FPGA) technology. An FPGA based NMS has the following design advantages:

1) **Long life**: >15 years: Longer than CPU based product
2) **High Reliability**: Less parts, lower temperature operation
3) **Less calibration**: Digital signal has lower drift

Application

Toshiba FPGA-based NMS line-up includes:

- Startup Range Neutron Monitor (SRNM)
- Power Range Monitor (PRM)
- Oscillation Power Range Monitor (OPRM)
- Traversing In-core Probe (TIP)
Neutron Monitoring System (NMS)

Applicability of Toshiba NMS
Toshiba FPGA-based NMS is applicable to conventional BWR designs.

Features & Benefits
1) FPGA-based SRNM provides the following:
   - No manual range switching
   - Improves system reliability by eliminating drive system
   - Reduces system components through simplified system structure
   - Reduces control and mechanical issues caused by mechanical components
   - No complicated detector position adjustment for adequate overlapping between Source Range Monitor (SRM) and Intermediate Range Monitor (IRM)
   - Simplified start-up operations
   - Monitoring of the neutron flux over a range of 10 decades during startup and shutdown
   - Continuous monitoring of the neutron flux from Source Range to 35% rated power

2) FPGA-based PRM applying digital filtering technique for Local Power Range Monitor (LPRM) signal processing provides the following:
   - Reduced 50/60 Hz noise caused by power supplies
   - Capable of monitoring neutron oscillations for stability monitoring
   - Plant trip response within 40 ms (from signal exceeding set point to issuing trip signal to Reactor Protection System)

3) FPGA-based PRM also utilizes improved Rod Block Monitor (RBM) to provide:
   - Complete redundancy
   - Plant RBM response within 100ms (from signal exceeding set point to issuing Rod Block signal to Reactor Manual Control System (RMCS))

4) FPGA-based OPRM signal processing provides the following:
   - Receives LPRM level from the LPRM subsystem
   - Sums and averages the LPRM signal assigned to each OPRM cell
   - Continuously monitors the OPRM cell value and detects thermal hydraulic instability by Amplitude Based detection Algorithm (ABA), Growth Rate detection Algorithm (GRA), and Period Based Detection Algorithm (PBDA)

5) FPGA-based TIP has the following features:
   - Compact drive unit allowing expanded maintenance space
   - Local control panel is separate from drive unit to improve maintenance accessibility and reduce personnel exposure
   - Keep N2 dry integrity in PCV equipment (TIP tube, Indexer, Multiway connector)
   - Inverter motor provides improved speed control and eliminates mechanical failure
   - Chain parts removed to reduce number of mechanical parts and increase reliability

Description
SRNM
The SRNM system is a Safety Related system. The SRNM system consists of the SRNM detector with drytube, pre-amplifier, and SRNM unit.

PRM
The PRM system is a Safety Related system. The PRM system consists of the LPRM detector, LPRM unit, Average Power Range Monitor (APRM) unit, and the flow unit.

TIP
The TIP system is non-Class1E system. The TIP system consists of the TIP detector, indexer, valve assembly, Lead shielded container, drive unit, local panel, drive control unit (DCU), and Flux Probe Monitor (FPM), as shown in Figure 1.

In-core Detector
Toshiba can supply SRNM detector with drytube and LPRM detector assembly.

Experience
Toshiba FPGA-based PRM, SRNM and TIP have been installed in Japanese BWR plants. Toshiba FPGA-based TIP has been installed also in European BWR plant. Regarding in-core detector, Toshiba has many years of experience of applying SRNM detector with drytube and LPRM detector assembly to Japanese BWR plants.

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