PSNN-2014-1202

Safety-Related

Project Document No.	Rev.	-	2

Commercial Dedication Instruction

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Project Name	N/A (As per each Job Order)
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Product Name	DIO module
Model Number	HNS0520

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Table of Contents

1. Product Identification

a. Part Number: See following table

b. Model Number: HNS0520

c. Drawing Number: 5Q8K0017 Rev.3

d. Manufacturer's Name: TOSHIBA Corporation, Power Systems Company, Power Platform Development Department (PPDD)

Sub supplier: Toshiba Design and Manufacturing Service Corporation (TDMS)

e. Manufacturer's Model Number: See following table

f. Manufacturer's Catalog Number: N/A

g. Name plate data: N/A

h. Applicable Material/Part Specification Number: N/A

i. Identification of Parent Component: See Section 2.3

j. Software Version: N/A

k. Firmware Version: N/A

Table 1 Part Number List

Part Number: (Procurement/Purchase Specification Number./ Part Number)	Manufacturer's Model Number	Description
5Q8K0017/P001	HNS0520B00000	-

2. Product Description

2.1 Definitions

a. General Name of Product: DIO module

b. Product Name of Manufacturer: DIO module

c. Description of Terms

- AGRD module: The AGRD module mounted on OPRM unit receives neutron flux oscillation of 44 OPRM Cells from the CELL module. The AGRD module generates an Amplitude-Based Maximum Trip (ABA Trip) signal (safety function) and a Growth Rate-Based Trip (GRA Trip) signal (safety function).
- APRM: Average Power Range Monitor, a safety-related subsystem of Neutron Monitoring System (NMS).
- APRM unit: A parent component of the APRM, FLOW, GAF/ST, TRN, RCV, DIO, and LVPS modules. An APRM unit measures Core Flow Level (safety function) and APRM Level (safety function) using the LPRM Levels.
- APRM module: The APRM module mounted on APRM unit calculates APRM Level (safety function) using LPRM Levels received from the RCV module mounted in APRM unit.
- CELL module: The CELL module mounted on OPRM unit calculates neutron flux oscillation (i.e. Normalized Oscillation Signal) (safety function) using LPRM Levels received from the RCV module mounted in OPRM unit.

- DIO module: The DIO module is used to receive discrete voltage inputs from external system, and transmit discrete voltage outputs to external system. These signals are isolated by photo couplers and photo MOS relays.
- FLOW module: The FLOW module mounted on APRM unit calculates Core Flow Level (safety function) using differential pressure signal from a differential pressure transmitter and Simulated Thermal Power Level from APRM module.
- LPRM: Local Power Range Monitor, a safety-related subsystem of Neutron Monitoring System (NMS).
- LPRM unit: A parent component of the LPRM, CAL/ST, TRN, RCV, and LVPS modules.
- NMS: Neutron Monitoring System, NMS consists of three safety-related subsystems: Startup Range Neutron Monitor (SRNM), Local Power Range Monitor (LPRM), and Average Power Range Monitor (APRM) which includes Oscillation Power Range Monitor (OPRM). The LPRM, OPRM, and APRM are collectively called the Power Range Neutron Monitor (PRNM).
- OPRM: Oscillation Power Range Monitor, a safety-related subsystem of Neutron Monitoring System (NMS). OPRM is functional sub-system of APRM.
- OPRM unit: A parent component of the CELL, AGRD, PBD, DAT/ST, TRN, RCV, DIO, and LVPS modules.
- PBD module: The PBD module mounted on OPRM unit receives neutron flux oscillation of 44 OPRM Cells from the CELL module. The PBD module generates a Period-Based Trip (PBDA Trip) signal (safety function).
- PRNM: Power Range Neutron Monitor, the parent system of the LPRM unit, the APRM unit and the OPRM unit. For Advanced Boiling Water Reactor (ABWR) application, four divisions of the PRNM are installed to plant. Each of those four PRNM divisions contains four LPRM units, an APRM unit and an OPRM unit.
- RCV module: The RCV module is used to receive optical signal between units in PRNM, and also used to receive optical signal from external system.
- SRNM: Startup Range Neutron Monitor, a safety-related subsystem of Neutron Monitoring System (NMS).

d. Abbreviation

ABWR	Advanced Boiling Water Reactor
AQ	Augmented Quality
ATWS	Anticipated Transient Without Scram
CC	Critical Characteristics
CCD	Critical Characteristics for Design
CCA	Critical Characteristics for Acceptance
CDI	Commercial Dedication Instruction
CFI	Counterfeit and Fraudulent Item
CG	Commercial Grade
CMOS	Complementary Metal Oxide Semiconductor
C of C	Certificate of Conformance
DDS	Detailed Design Specification
DR	Design Review
ELCS	Engineered Safety Features Logic & Control System
EMC	Electromagnetic Compatibility
FD	Flat Display
EQ	Equipment Qualification

FMEA	Failure Mode and Effect Analysis
IV&V	Independent Verification and Validation
MDS	Module Design Specification
MOS	Metal Oxide Semiconductor
NICSD	Nuclear Instrumentation and Control Systems Department
NICS-QA	Quality Assurance Group for Nuclear Instrumentation & Control Systems
NICS-QC	Quality Control Group for Nuclear Instrumentation & Control Systems
NISD	Nuclear Instrumentation Systems Development & Designing Group
NSR	Non-Safety-Related
PPDD	Power Platform Development Department
QA	Quality Assurance
QC	Quality Control
SR	Safety-Related
TDMS	Toshiba Design and Manufacturing Service Corporation

2.2 Function of Product

A DIO module is used mounted on units that are parent components specified in Section 2.3. The DIO module has 4 discrete voltage inputs and 16 discrete voltage outputs. The DIO module receives CMOS level signals from middle plane, and sends them to external system, as non-contact output signals. The DIO module receives non-contact input signals from external system and converts them into CMOS level signals for other modules in the same unit.

2.3 Function of Parent Component

Table 2 Function of Parent Component

Part No.	Model No.	Parent Component	Function of Parent Component (Safety Function)	Functional Classification of Parent Component
P001	HNS0520	APRM unit	APRM Level, which represents an average neutron flux Simulated Thermal Power Core Flow Level APRM Upscale Flux Trip Simulated Thermal Power Upscale Trip APRM Inoperative Core Flow Rapid Coastdown APRM ATWS Permissive signals Providing the data signals, bypass state, trip state, annunciator, and operation state to the Engineered Safety Features Logic & Control System (ELCS) Flat Display (FD).	Safety Related
		OPRM unit	Neutron flux oscillation Growth Rate-Based Trip Amplitude-Based Maximum Trip Period-Based Trip OPRM Inoperative Providing the data signals, bypass state, trip state, annunciator, and operation state to the Engineered Safety Features Logic & Control System (ELCS) Flat Display (FD).	Safety Related

3. Safety Related Function

The DIO module is required to perform before, during, and after abnormal environmental conditions (seismic, environmental and Electromagnetic Compatibility (EMC) conditions). The DIO module shall perform the safety related functions described in the following table. The environmental and EMC qualification of the DIO module are not performed as a standalone item. The verification of environmental and EMC qualification will take place at a higher level as part of system equipment qualification effort (Refer to Section 6.2.1).

Table 3 Safety Related Function

Part No.	Model No.	Safety Related Function	Functional Classification
P001	HNS0520	<APRM application (ABWR Application)> One DIO module is mounted on and electrically connected to APRM unit which has safety-related functions, and insulated to external system with photo MOS relay and photo coupler. <Application 1> The DIO module receives APRM Upscale Flux Trip, APRM Upscale Flux Alarm, APRM Downscale and Simulated Thermal Power Upscale Trip signals (safety function), from APRM module, and transmits those to external system. The DIO module receives Core Flow Upscale Alarm, Core Flow Downscale and Core Flow Rapid Coastdown Trip signals (safety function), from FLOW module, and transmits those to external system. The DIO module receives APRM Inoperative signal (safety function) from Daisy-chain Connection of APRM module and FLOW module, and transmits it to external system. The DIO module receives APRM ATWS Permissive signal from APRM module, and transmits those to external system.	Safety Related (Having a safety function)
		<Application 2> The DIO module receives APRM Bypass and Reactor Mode signal from external system, and transmits those to APRM module. The DIO module receive Reactor Mode signal read back and APRM Bypass read back from APRM module, and transmit it to external system.	Safety Related (Having an effect on performance of the system safety function)
		<OPRM application (ABWR Application)> One DIO module is mounted on and electrically connected to OPRM unit which has safety-related functions, and insulated to external system with photo MOS relay and photo coupler. <Application 1> The DIO module receives OPRM Trip signal (safety function) from Daisy-chain Connection of AGRD and PBD module, and transmits it to external system. The DIO module receives ABA Trip and GRA Trip signals (safety function) from AGRD module, and transmits it to external system. The DIO module receives PBDA Trip signal (safety function) from PBD module, and transmit it to external system. The DIO module receives Trip Judgment Status (ABA) signal and Trip Judgment Status (GRA) signal from AGRD module, and transmits those to external system. The DIO module receives Trip Judgment Status (PBDA) signal from PBD module, and transmits it to external system. The DIO module receives OPRM Inoperative signal (safety function) from Daisy-chain Connection of AGRD, PBD and CELL module, and transmits it to external system. The DIO module receives OPRM Automatic Bypass signal from CELL module, and transmits it to external system.	Safety Related (Having a safety function)
		<Application 2> The DIO module receives APRM Bypass signal from external system, which is needed to bypass the OPRM unit, and transmits it to CELL module via middle plane.	Safety Related (Having an effect on performance of the system safety function)

The DIO module is required to operate during and after the defined design basis events.

■ Seismic Sensitive Part/Assembly

□ Not Seismic Sensitive

□ Application Does Not Require Seismic Adequacy

The DIO module is attached to a parent system, and the seismic integrity of the DIO module is verified by qualification testing (Refer to Section 6.2.1).

3.1 Functional Classification

The functional mode and functional classification were evaluated and identified as follows.

a. Functional Mode :	□ Active Functional Mode
	■ Passive Functional Mode
b. Functional Classification :	■ Safety-Related (SR)
	□ Non-Safety-Related (NSR)
	□ Augmented Quality (AQ)

4. Critical Characteristics for Design

Table 4-1 shows the Critical Characteristics for Design (CCD) and technical evaluations. Table 4-2 and Table 4-3 show the result of Failure Mode and Effect Analysis (FMEA). This evaluation is performed base on technical requirements for the DIO module of OPRM application and APRM application (ABWR Application).

Nuclear Instrumentation Systems Development & Designing Group (NISD) evaluated following supplier's module design:

Manufacturer's Model Number : HNS0520A10000 (Commercial use)

Module Design Specification : 5G8HA759 Rev.3 (Reference (2))

This module was developed under the ISO-9001 Quality Assurance (QA) process but not verified under the Nuclear Instrumentation and Control Systems Department (NICSD) Appendix-B QA program. For dedication of this module, NICSD requires PPDD to apply additional QA and documentation requirements specified in Purchase Specification (Reference (1)). By applying additional requirements based on the Purchase Specification (Reference (1)), manufacturer's model number is changed to the following to distinguish the commercial use and US safety-related use. NISD also evaluated following supplier's module design:

Manufacturer's Model Number : HNS0520B00000 (US safety-related use)

Module Design Specification : 5G8HC110 Rev.1 (Reference (8))

Table 4-1 CCD and Technical Evaluation

Part No.	No	CCD	Manufacturer's specification	Technical Evaluation
P001	1	Physical Characteristics -Dimension Section 6 of purchase specification*1 (30.1 W × 128.4 H × 172.4D mm) Permissible deviations for dimensions are specified in receiving inspection specification (Reference (5)). -Mass Section 6 of purchase specification*1 (200g or less)	Dimension is specified in Section 4.1.1 of MDS*2 (30.1 W × 128.4 H × 172.4D mm) Mass is specified in Section 4.1.2 of MDS*2 (200g or less)	Manufacturer's item meets the purchaser requirement. This characteristic does not directly contribute to safety function. However, this characteristic related to item compatibility, form or fit is important when considering replacement and Counterfeit and Fraudulent Items (CFI) issues. Mass is a factor which may affect seismic capability of parent component.
	2	Physical Characteristics -General configuration and shape Module configuration and shape is described in Section 6 of purchase specification*1	Module configuration is described in Section 4.1 of MDS*2	Manufacturer's item meets the purchaser requirement. This characteristic does not directly contribute to safety function. However, this characteristic related to item compatibility, form or fit is important when considering replacement and CFI issues. These characteristics contribute to Equipment Qualification (EQ) and EMC capability.
	3	Performance Characteristics -Data transmission function Sections 5.2.7-1, and -2 of Unit DDS*3 specifies data transmission functions.	Data transmission function is specified in Sections 5.1, 5.2, and 6.1 of MDS*2	Manufacturer's item meets the purchaser requirement. This characteristic contributes to safety function of parent component.
	4	Performance Characteristics -Isolation Section 5.2.7-3 of Unit DDS*3 specifies insulating function.	Isolation function is specified in Sections 5.1.1, 5.2.1, 6.1.1 and 6.1.2 of MDS*2	Manufacturer's item meets the purchaser requirement. This characteristic contributes to safety function of parent component.
	5	Performance Characteristics -Response Time (DIO module) Section 7.1 of Unit DDS*4 [ ]^{a,c} ms or less)	Delay time is specified in Section 5.2.1 of MDS*2 ([ ]^{a,c} μs or less)	Manufacturer's item meets the purchaser requirement. This characteristic contributes to safety function of parent component.

*1 Purchase Specification, 5Q8K0017 Rev.3 (Reference (1))

*2 MDS: Module Design Specification, 5G8HC110 Rev.1 (Reference (8))

*3 Unit DDS: OPRM Unit Detailed Design Specification, 5B8K0041 Rev.2 (Reference (3))

*4 Unit DDS: APRM Unit Detailed Design Specification, 9B8K0009 Rev.0 (Reference (7))

Table 4-2 Failure Mode and Effect Analysis<APRM application (ABWR Application)>

No	Function	Failure Mode	Failure Mechanism	Effect on System	Method of Detection	Effect on Plant Operation	Remarks
1	Discrete Output Function	Fail On	Circuit failure	None	This failure will be detected with a surveillance test during periodic inspection.	Loss of one division trip function	
		Fail Off	Circuit failure Cable disconnection	The DIO module sends spurious "APRM Upscale Flux Trip", "Simulated Thermal Power Upscale Trip", "APRM Inoperative", "Core Flow Rapid Coastdown", "APRM ATWS Permissive", "Reactor Mode" and/or "APRM Bypass" signals.	The display in main control room indicates 'NMS' alarm.	One division spurious trip and rod block signal The display in main control room indicates 'NMS' alarm.	
2	Discrete Input Function	Fail On	Circuit failure	The APRM module indicates a spurious "BYP" mode.	The "BYP" indicator on the APRM nodule turns on.	Loss of one division trip function	

No	Function	Failure Mode	Failure Mechanism	Effect on System	Method of Detection	Effect on Plant Operation	Remarks
		Fail Off	Circuit failure Cable disconnection	The APRM module does not receive "Reactor Mode" and/or "APRM Bypass" signals. The APRM module will detect the Reactor Mode is not at "RUN", and the APRM module will generate spurious "APRM Upscale Flux Trip" signal.	The display in main control room indicates 'NMS' alarm. The "RUN MODE" indicator on the APRM nodule turns off.	One division spurious trip signal	

Table 4-3 Failure Mode and Effect Analysis<OPRM application (ABWR Application)>

No	Function	Failure Mode	Failure Mechanism	Effect on System	Method of Detection	Effect on Plant Operation	Remarks
1	Discrete Output Function	Fail On	Circuit failure	None	This failure will be detected with a surveillance test during periodic inspection.	Loss of one division trip function	
		Fail Off	Circuit failure Cable disconnection	The DIO module sends spurious "OPRM Trip", "ABA Trip", "GRA Trip", "PBDA Trip", "OPRM Inoperative", "Trip Judgment Status (ABA, GRA, PBDA)" and/or "OPRM Minor Failure" signals.	The display in main control room indicates 'NMS' alarm.	One division spurious trip signal The display in main control room indicates 'NMS' alarm.	
2	Discrete Input Function	Fail On	Circuit failure	The CELL module indicates a spurious "BYP" mode.	The "BYP" indicator on the CELL nodule turns on.	Loss of one division trip function	
		Fail Off	Circuit failure Cable disconnection	The CELL module does not receive "APRM Bypass" signal.	This failure will be detected with a surveillance test during periodic inspection.	None	

5. Critical Characteristics for Acceptance, Verification Methods and Responsibilities

5.1 Verification of Physical and Performance Characteristics Depending on Supplier Testing

The physical characteristics and performance characteristics are able to be measured as CCAs by the supplier testing and Nuclear Instrumentation and Control Systems Department (NICSD) intends to receive Certificate of Conformance (C of C) and the supplier's test record during the receiving inspection, the following supplier's process to control CC shall be verified as CCAs, as a minimum, through Commercial Grade (CG) survey of PPDD and receiving inspection.

- Design Control (Document Control)
- Inspection and Test Control
- Measuring and Test Equipment Control

To supplement verification of the general configuration and shape, supplier's control capability regarding "Configuration Control and Traceability of Hardware" shall be verified through CG Survey of PPDD, evaluation of sub-suppliers, and receiving inspection. Refer to Table 5-1.

5.2 Verification of "Dependability" of Module

Though the DIO module has no FPGA, PPDD designs and manufactures the DIO module under the same process applied to other modules which have FPGAs. To supplement dedication process of the DIO module, NICSD verifies the "Dependability" of the DIO module. To verify the dependability of modules, the following CCAs related to supplier's control capability of CC shall be verified through CG survey of PPDD, evaluation of sub-suppliers, receiving inspection, oversight of design review meeting, review of supplier documents, and

oversight of supplier testing.

- Built-in Quality
- Configuration Control and Traceability of Hardware

Refer to Table 5-1.

Table 5-1 CCA and Verification Method

Item No	Critical Characteristics for Acceptance	Verification Method for Qualification	Responsibility	Verification Method for Production	Responsibility
1	Physical Characteristics -Dimension -Mass -General Configuration and Shape	-	-	Receiving Inspection (Receiving C of C and supplier's test record, Section 6.1.1)	NICS-QC
2	Performance Characteristics -Data Transmission Function - Isolation - Response Time	-	-	Receiving Inspection (Receiving C of C and supplier's test record, Section 6.1.1)	NICS-QC
3	Design Control (Document Control)	CG Survey of PPDD (Section 6.2.2)	NICS-QA	Receiving Inspection (Receiving C of C, Section 6.1.1)	NICS-QC
4	Inspection and Test Control	CG Survey of PPDD (Section 6.2.2)	NICS-QA	Receiving Inspection (Receiving C of C, Section 6.1.1)	NICS-QC
5	Measuring and Test Equipment Control	CG Survey of PPDD (Section 6.2.2)	NICS-QA	Receiving Inspection (Receiving C of C, Section 6.1.1)	NICS-QC
6	Build in Quality	CG Survey of PPDD (Section 6.2.2)	NICS-QA	Oversight of design review meeting (Section 6.1.2)	NICS-QC
				Review of supplier documents (Section 6.1.3)	NICSD IV&V Team
				Oversight of supplier testing (Section 6.1.4)	NICSD IV&V Team
7	Configuration Control and Traceability of Hardware	CG Survey of PPDD, Evaluation of sub-suppliers (Section 6.2.2)	NICS-QA	Receiving Inspection (Receiving C of C, Section 6.1.1)	NICS-QC

NICSD Nuclear Instrumentation and Control Systems Department
NICS-QA Quality Assurance Group for Nuclear Instrumentation & Control Systems
NICS-QC Quality Control Group for Nuclear Instrumentation & Control Systems
IV&V Independent Verification and Validation

6. Verification Instruction

6.1 Recurring Activities

6.1.1 Receiving Inspection

Receiving inspectors or QC inspectors from NICS-QC shall implement the receiving inspection in accordance with the "Receiving Inspection Procedure (Section 9-(1))" and the "Standard Receiving Inspection Specification (Section 9-(2))." The verification results are recorded in the form of "Receiving Inspection Check List/Report (Section 7-(1))."

6.1.2 Oversight of Design Review Meeting

NICSD shall perform oversight of Design Review (DR) meetings conducted by PPDD in accordance with Section 9.1.1 of the Commercial Dedication Instruction (Reference (6)).

6.1.3 Review of Supplier Documents

NICSD shall perform review of supplier documents in accordance with Section 9.1.2 of the Commercial Dedication Instruction (Reference (6)).

6.1.4 Oversight of Supplier Testing

NICSD shall perform oversight on Module Validation Testing conducted by PPDD supplier documents in accordance with Section 9.1.3 of the Commercial Dedication Instruction (Reference (6)).

6.2 Periodic Activities

6.2.1 Environmental Conditions Qualification

Equipment qualification testing and EMC qualification testing are performed in a type test using test specimen. Successful completion and continued application of qualification testing verifies that the item is capable of performing its intended safety function. Any time a design change is made to the item or item is used in another application, impact on all previous qualification programs shall be evaluated to determine if re-qualification is required.

The responsible design engineers from NISD shall identify a test report in Section 7 of this Commercial Dedication Instruction (CDI) after qualification test, which shows successful compliance with qualification test requirements. If any changes are made to a configuration as the result of qualification test, the responsible design engineers shall identify a baseline after change in the CDI. The responsible design engineers evaluates any changes to an item that are made after baseline establishment, determines the need for an additional qualification test, and documents the evaluation result in the CDI. In order to continuously purchase items with same configuration, the "Configuration Control and Traceability of Hardware" of supplier shall be verified through CG Surveys as described in Section 6.2.2.

6.2.2 Vendor Evaluation

NICSD shall perform CG Survey of PPDD and evaluation of sub-suppliers in accordance with Section 9.2 of the Commercial Dedication Instruction (Reference (6)).

7. Acceptance Documentation

(1) Receiving Inspection Check List/Report (Attachment to NQ-3024 (Reference (4))
(2) Certificate of Conformance (Attachment to Reference (1))
(3) Test record by supplier (As per supplier's form)
(4) Nuclear Instrumentation & Control Systems Department
Environmental Qualification Report for Safety-Related Oscillation Power Range Monitor (OPRM)
FC51-7513-1000 Rev.0 (5B8K0077 Rev.0)

(5) Nuclear Instrumentation & Control Systems Department
Dynamic Qualification Report for Safety-Related Oscillation Power Range Monitor (OPRM)
FC51-7513-1003 Rev.0 (5B8K0094 Rev.0)

(6) Nuclear Instrumentation & Control Systems Department
EMC Qualification Report for Safety-Related Oscillation Power Range Monitor (OPRM)
FC51-7513-1001 Rev.0 (5B8K0078 Rev.0)

8. References

(1) PURCHASE SPECIFICATON for in-house (5Q8K0017 Rev.3)
(2) DIO MODULE HNS520/HNS0520 Equipment Design Specification (5G8HA759 Rev.3)
(3) OPRM Unit Detailed Design Specification for Power Range Neutron Monitor (5B8K0041 Rev.2)
(4) Receiving Inspection Procedure, NQ-3024
(5) Standard Receiving Inspection Specification for Modules from Power Platform Development Department (5T8K0001 Rev.1)
(6) Commercial Dedication Instruction for Dedication of Modules from Commercial Supplier (Common Requirements) (9B8K0057 Rev.1)
(7) APRM Unit Detailed Design Specification for PRNM (9B8K0009 Rev.0)
(8) DIO Module HNS0520 Series Module Design Specification (5G8HC110 Rev.1)

9. Inspection and Test Procedure

(1) Receiving Inspection Procedure (Reference (4))
(2) Standard Receiving Inspection Specification (Reference (5))

10. Supplements

N/A

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