Power Systems - Integrated Machine Operations Interface Control

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National Spherical Torus eXperiment Upgrade

National Spherical Torus Experiment Upgrade

Interface Control Document

POWER SYSTEMS : INTEGRATED MACHINE OPERATIONS

NSTX-U-PWR-IMO-ICD

Revision 0
September 16, 2019

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Change Record

Revision	Date	Description of Change
0	September 16, 2019	Initial Release

References

[1] GENERAL REQUIREMENTS DOCUMENT, NSTX-U-RQMT-GRD-001-01

[2] SYSTEM REQUIREMENTS DOCUMENT, POWER SYSTEMS, NSTX-U-RQMT-SRD-006

[3] SYSTEM REQUIREMENTS DOCUMENT, RTC&P, NSTX-U-RQMT-SRD-008

[4] SYSTEM REQUIREMENTS DOCUMENT, Diagnostics, NSTX-U-RQMT-SRD-011-01.

1. Purpose

This document describes the various interfaces between the following subsystems: Power Systems and the Integrated Machine Operations. The interface locations and boundaries that connect the Power Systems to the Integrated Machine Operations are identified based on different interface types.

2. Scope

The Power Systems consists of the AC and DC power systems. The Integrated Machine Operations consists of the Machine Instrumentation and Real-Time Control and Protection Systems such as the Digital Coil Protection System and the Shorted Turn Protection System. The scope of this document addresses any defined interfaces between these identified system elements.

3. Responsibilities

The interfaces are managed between the following organizations:

- Power Systems
- Real-Time Control & Protection
- Systems Engineering and Integration

4. Interfaces

Interface requirements in the following sections are identified with a requirement number, ICD followed by a number [ICD-PWR-IMO-X] where X is a sequential count beginning with 001, PWR represents Power Systems and IMO represents Integrated Machine Operations. There is also a unique identifier for all interfaces in the format [#####-#####-X]. The identifier is a concatenation of two level 5 SBS values and the interface type. This is followed by an interface description and a list of references. References provide evidence pertaining to interfaces include but are not limited to drawings, calculations, or specifications. Reference also include a reference to a paragraph that identifies the set of interface definitions.

4.1. Interface Types

The top-level interface types are defined in Table 1. Within each heading there are sub-headings to address any special sub-elements that need consideration. For example, the Mechanical has four sub-elements that need to be addressed: Structural, Spatial, Location, and Wall/Floor Penetration. For those interface types with sub-interfaces there are corresponding sub-sections.

Table 1. Interface Types

Heading	Abbreviation	Name
4.2	Me	Mechanical
4.3	Ep	Electrical Power
4.4	Si	Signal
4.5	Di	Diagnostics
4.6	Gf	Gas/Fluid
4.7	Va	Vacuum
4.8	Sw	Software
4.9	Th	Thermal
4.10	Pe	Plasma/Eddy/ Halo Current

Table 2 provides the N2 Diagram identifying all the interfaces for NSTX-U while Table 3 provides the specific details of the interface.

Table 2. N2 Diagram Interface types

Plasma Facing Components	Me,Th, Pe		Me,Th, Va,Pe						Me	Me	Me, Pe		Me			
	In-Vessel Structures	Me,Di, Pe			Th			Me,Th, Pe	Me		Me, Pe			Di		
		Vacuum Vessel Structure			Me,Va	Me, Va	Me	Me, Th, Pe	Me	Me,Va	Me,Di, Va		Si	Di,Si		
		Va	Centerstack Structures			Va, Th	Me, Gf	Me	Me					Di		
		Me	Me, Th, Ep	Magnets				Me			Di		Si	Di	Me	
Si		Me, Va			Heating Systems		Gf	Th		Me		Si	Si	Si	Si	
					Si, Va, Me, Sw, Gf	Vacuum Pumping System		Si	Si	Gf, Si	Si		Si,Va	Si	Si	
				Gf,Si			Coolant System	Gf				Gf,Sw	Si, Sw	Si		
	Th, Gf	Ep,Di, Th, Va	Ep, Gf, Th, Pe		Si		Si	Bakeout System						Me	Si, Me	
			Gf,Va			Gf,Si			Gas Delivery System	Me	Va		Si,Sw		Me	
		Gf				Si,Gf,Va			Gf	Wall Conditioning System			Si,Sw		Si	
		Me,Va	Me,Va	Me	Me	Gf,Si	Gf			Va, Ep	Diagnostics		Si,Sw	Si	Si, Me	Si
				Ep	Ep	Ep	Ep	Ep	Ep	Ep	Ep	Power Systems	Ep,Si	Ep, Si	Me, Ep, Si, Di, Gf	Ep
					Si					Me, Si	Si		Centralized Instrumentation and Control	Si, Me		
												Si	Si,Sw	Integrated Machine Operations		
								Ep							Operations & Safety Systems	
Me		Me	Me	Me	Me	Me		Me	Me	Me	Me	Me	Me	Me	Me, Ep	D-Site Locations (Test Cell

Table 3. Callout

Power Systems	Si, Ep
	Integrated Machine Operations

The remainder of this document addresses each of the interfaces. Note the template includes a paragraph heading for each interface and a table for each interface type. In the event there is no interface, the table will remain blank with a blank row.

The following paragraphs in Section 4 address each of the interfaces, and Section 5 addresses any off-project interfaces. Off-project interfaces are those external interfaces that interact with the NSTX-U system.

4.2. Mechanical Interfaces

This paragraph addresses any type of mechanical interfaces that include a structural, spatial, location dependent interfaces or areas where penetrations into a wall or floor are required. These are identified independently as interface parameters will likely be different.

4.2.1. Structural Interfaces

This identifies any interfaces between system elements that require a structural interface. This could be based on various forces placed on the system and by the system.

Identifier	Interface	References
N/A		

4.2.2. Spatial Interface

This identifies any interfaces between the system elements pertaining to spatial restrictions or constraints.

Identifier	Interface	References
N/A		

4.2.3. Location Interfaces

This identifies any interfaces between the system elements that have any particular dependencies on element location or location constraints.

Identifier	Interface	References
N/A		

4.2.4. Wall/Floor Penetration Interfaces

This identifies any interfaces between the system elements any penetrations or modifications to the wall or floor of the D-Site building.

Identifier	Interface	References
N/A		

4.3. Electrical Power Interfaces

This identifies any interfaces between the system elements requiring AC, DC, rectification or power conditioning.

Identifier	Interface	References
1.5.1.2-1.7.3.4.1-P	Power for the Fiber Optic Strain, Temp., Disp. Meas. instrumentation	See Paragraph 4.3.1, Drawing DC1921, AE1117, ALP331
1.5.1.2-1.7.3.4.3-P	Power for the Passive Plate and Vessel Accelerometers instrumentation	See Paragraph 4.3.2, ALP331
1.5.1.2-1.7.3.4.4-P	Power for vessel voltage monitors	See Paragraph 4.3.3, Drawing 4F1579
1.5.1.2-1.7.3.6.1-P	Power for the FPDP data stream at various locations	See Paragraph 4.3.4, Drawings, ALP273, ALP331, ALP400, ALP402, ALP471
1.5.1.2-1.7.3.6.7-P	Power for the DCPS real time computer	See Paragraph 4.3.5, Drawing ALP401
1.5.1.2-1.7.3.6.4-P	Power for the DCPS autotesters	See Paragraph 4.3.6, Drawing ALP401

1.5.1.2-1.7.3.6.5-P	Power for the DCPS hardware	See Paragraph 4.3.7, Drawing ALP401
1.5.1.2-1.7.3.6.8-P	Power for the Ip Calculator	See Paragraph 4.3.8, Drawing ALP400
1.5.1.2-1.7.3.6.9-P	Power for shorted turn protection system	See Paragraph 4.3.9
1.5.1.2-1.7.3.5.1-P	Power for PDP Timer	See Paragraph 4.3.10
1.5.1.2-1.7.3.4.1-P	Power for the TF Twist instrumentation	See Paragraph 4.3.11, Drawing ALP331
1.5.1.2 - 1.7.3.4.5	Power to the TF Twist Laser Instrumentation.	See Paragraph 4.3.12

Interface Notes:

- Interface is currently defined in the available documentation and at a future point will be verified by on-site walkthrough.

4.3.1. Power - Fiber Optic Strain, Temp., Disp. Meas. instrumentation

Interface Notes:

- The equipment for the FIber Bragg sensors has not yet undergone an FDR. The Drawing AE-1117 should be updated with equipment prior to that review.

ICD-PWR-IMO-001: The FISO strain gauges for the Umbrella lid are located in CWD Drawing DC1921 that shows the termination in rack CTC-EE-493.

ICD-PWR-IMO-002: The voltage is 120 VAC and the current of 15A as well as 240 VAC and a current of 30A and is interfaced using wire connections as well as a NEMA L6-50 connector to CTC-EE-493 as shown in 4BA137.

ICD-PWR-IMO-003: The Fiber-Bragg Strain Gauges terminate in the DARM rack CDAR-EE-724 LP-331 CKTs 18 & 20 provide the power. Drawing AE-1117 provides a the component locations within the rack.

ICD-PWR-IMO-004: The voltage is 120 VAC and the current of 20A as shown in ALP331.R023.

4.3.2. Power – Passive Plate Instrumentation

ICD-PWR-IMO-005: Passive Plate accelerometers terminate in the DARM rack CDAR-EE-724 LP-331 CKTs 18 & 20 provide the power. Drawing AE-1117 provides a rack locations.

ICD-PWR-IMO-006: The voltage is 120 VAC and the current of 20A as shown in ALP331.R023.

4.3.3. Power – Vessel Voltage Monitors

Interface Notes:

- There are currently no reviews conducted that will address this capability. This will occur at a subsequent review

ICD-PWR-IMO-007: The vessel monitors are included as part of the vessel grounding system. Vessel Voltage Monitors are shown in the red ellipse in Figure 1. Note Figure states that drawing 4D1005 Sheet 1579 is voided and has been replaced with Sheet 544; however, Sheet 544 has not been posted.

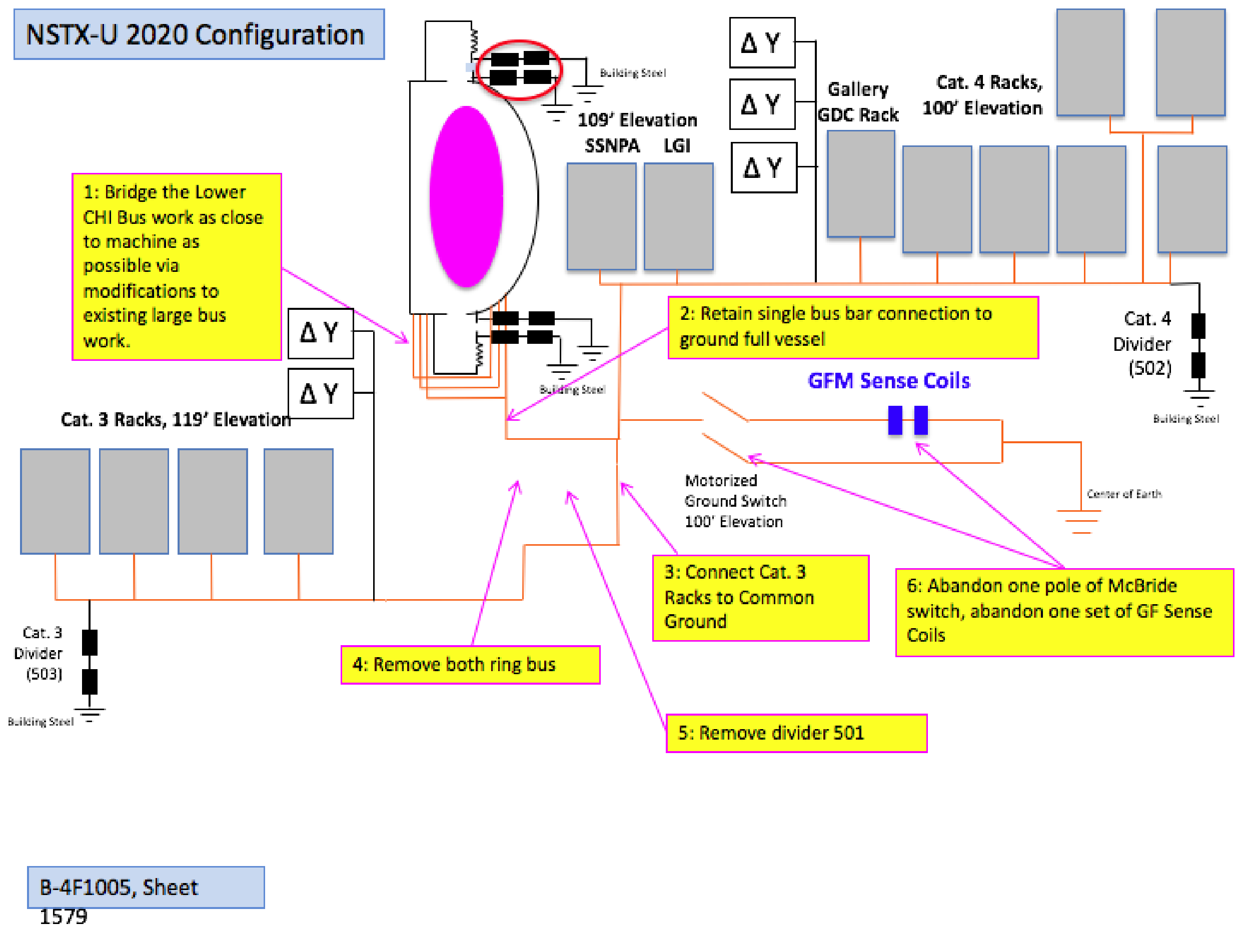

Figure 1. Recommendation for Grounding Vessel

4.3.4. Power – FPDP Data Stream

ICD-PWR-IMO-008: FPDP power is located in multiple locations as identified below. Figure 2 shows a representation of Rack CCC-EE-209 in the junction area. Power is provided via a power strip that is labeled with both the Panel LP and CKT

- DARM Rack: CDAR-EE-709 LP-331 CKT 5
- Test Cell Racks: CTC-EE-432 LP-273 CKT 21, CTC-EE-433 LP473 CKT 3
- Caged Area (by North Door): CTC-EE-445 LP-471 CKT-7
- NB area: CNBS-EE-380 - LP-402 CKT 16
- Junction Area: CCC-EE-209 LP-400 CKT 27

ICD-PWR-IMO-09: The voltages (120VAC) and currents for each circuit are.

- DARM Rack: CDAR-EE-709- 15A
- Test Cell Racks: CTC-EE-432 -20A, CTC-EE-433- 20A, CTC-EE-445 - 30A
- NB area: CNBS-EE-380 - (Rack 11 Strip) 20A

- Junction Area: CCC-EE-209 -15A

Figure 2. Rack CTC-EE-209

4.3.5. Power – DCPS Real-Time Computer

ICD-PWR-IMO-010: DCPS Real-Time Computer RT-1 is in the Junction Area Rack CCC-EE-205 as shown in Figure 3 LP 401 CKTs 31 &32. Note that the other FPDP computers are stored in the FCC Rack S-20 and is connected to UPS power in Rack S-28 LP-131

ICD-PWR-IMO-011: The voltage is 120 VAC and provide 20a to CKT 31 and 15A to CKT 32.

Figure 3: DCPS Rack 205

4.3.6. Power – DCPS Auto Tester

ICD-PWR-IMO-012: DCPS Autotester is in the Junction Area Rack CCC-EE-205 as shown in Figure 2 LP 205 CKTs 31 &32.
ICD-PWR-IMO-013: The voltage is 120 VAC and provide 20a to CKT 31 and 15A to CKT 32.

4.3.7. Power – DCPS Hardware

ICD-PWR-IMO-014: DCPS Hardware is in the Junction Area Rack CCC-EE-205 as shown in Figure 2 LP 205 CKTs 31 &32.
ICD-PWR-IMO-015: The voltage is 120 VAC and provide 20a to CKT 31 and 15A to CKT 32.

4.3.8. Power – I_P Calculator

ICD-PWR-IMO-016: I_P Calculator Power is routed from data room power to a power strip inside CCC-EE-208 LP-400 CKT 26 as shown in Figure 4.

ICD-PWR-IMO-017: The voltage is 120 VAC and 15A.

Figure 4. IP Calculator Housed Inside CCC-EE-208

4.3.9. Power – Shorted Turn Protection System

Interface Notes:

- Since the system is still in the design stage, there were no labels nor drawings that were readily available to connect identify the Panel (LP) and CKT providing power rack.

- Other components will likely also be added based on including the shorted turn for capturing Firing data as input to the data stream.

ICD-PWR-IMO-018: The location of the power connection for the Shorted Turn Protection Systems will most likely use an existing AV cabinet that is located in the junction area.

4.3.10. Power – PDP Timer

Interface Notes:

- There were no labels nor drawings that were readily available to identify the Panel (LP) and Circuit (CKT) providing power to the PDP timer cabinet.

ICD-PWR-IMO-019: PDP System Power is routed to B4F35 as shown in Figure 5. In the Cabinet there are several DC power supplies that provide power to the PDP timer components. Drawing 4F1005 SH. 749 provides the HIS interfaces the also provides power to the PDP timers. Power is provided from LP-426, CKT-25

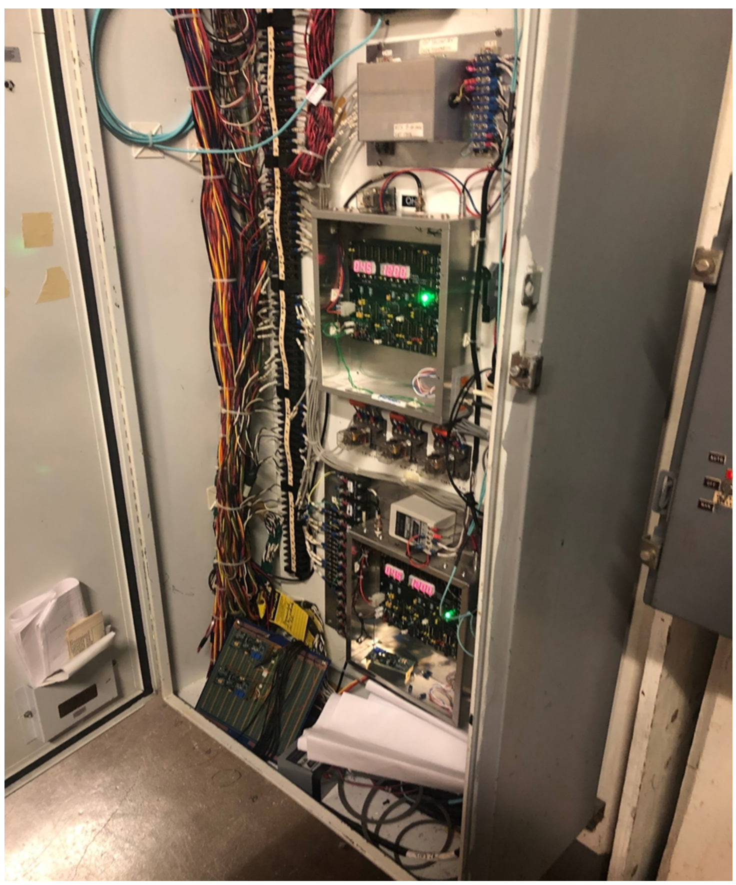

Figure 5. PDP Timers Inside B4F35

ICD-PWR-IMO-020: The voltage is 120 VAC and 20 A During a walkdown there are DC power supplies covering the power to reach the timers using wire connections.

4.3.11. Power – TF Twist Gauges

ICD-PWR-IMO-021: The Fiber-Bragg Strain Gauges terminate in the DARM rack CDAR-EE-724 LP-331 CKTs 18 & 20 provide the power. Drawing AE-1117 provides the component locations within the rack.

ICD-PWR-IMO-022: The voltage is 120 VAC and the current of 20A as shown in ALP331.R023.

4.3.12. Power – TF Twist Laser

Interface Notes:

- The review has not yet been completed as such the LP & CKT has not been solidified however a spare outlet for both the Laser and Camera near the installation will be used

ICD-PWR-IMO-023: TF Twist laser will be connected to near the Test Cell wall and data will be collected using a camera.

ICD-PWR-IMO-024: The voltage is 120 VAC and the current is TBD, more than likely 15A.

4.4. Signal Interfaces

This identifies any interfaces between the system elements and signals that are used to either send or receive control information or data. It explicitly includes the type of physical interface such as Ethernet or Fiber Optic or any specific protocols.

Identifier	Interface	References
1.5.2.1-1.7.3.6.1-Si	Reference firing angles are provided to the TF rectifiers from the Realtime Data Stream	See Paragraph 4.4.1,
1.5.2.2-1.7.3.6.1-Si	Reference firing angles are provided to the OH rectifiers from the Realtime Data Stream	See Paragraph 4.4.2,
1.5.2.3-1.7.3.6.1-Si	Reference firing angles are provided to the PF rectifiers from the Realtime Data Stream	See Paragraph 4.4.3,

1.5.3.2-1.7.3.6.5-Si	The signal from the OH current transducers in FCPC are provided DCPS hardware, which subsequently directs them to the Halmar signal conditioners	See Paragraph 4.4.4, AE4005
1.5.3.3-1.7.3.6.5-Si	The signal from the PF current transducers in FCPC are provided DCPS hardware, which subsequently directs them to the Halmar signal conditioners	See Paragraph 4.4.5, AE4005
1.5.2.4.2-1.7.3.6.1-Si	Reference currents, in the form of an analog voltage, are provided by the Realtime Data Stream	See Paragraph 4.4.6
1.5.4.1-1.7.3.6.5-Si	Output: Level-1 Fault Indication	See Paragraph 4.4.7
1.5.4.3-1.7.3.6.5-Si	HSCs are used in an integral fashion with the DCPS hardware system. HSC inputs are routed through the hardware system. HSC outputs are routed to the FPDP link and DCPS through the hardware system	See Paragraph 4.4.8, Drawing AE4005
1.5.3-1.7.3.6.9-Si	Coil Voltages	See Paragraph 4.4.9
1.5.4.1-1.7.3.6.9-Si	FCPC level-1 faults shall be declared by the system	See Paragraph 4.4.10
1.5.4.3-1.7.3.6.8-Si	Data from HSCs is input to the Ip Calculator, and some data from the Ip calculator is distributed via the HSCs	See Paragraph 4.4.11, Drawing AE4005
1.5.4.1-1.7.3.5.1-Si	PDP sends permissive signals for OH, PF and TF	See Paragraph 4.4.12
1.5.4.1-1.7.3.5.1-Si	PDP sends status signals to the HCS	See Paragraph 4.4.13
1.5.2.4.1-1.7.3.6.1-Si	Reference firing angles are provided to the OH and PF rectifiers from the Realtime Data Stream	See Paragraph 4.4.14

4.4.1. TF Firing Generator Computer - TF Firing Generator Data

ICD-PWR-IMO-025: The transmitter provides firing angle data from the FCC via the Junction area. The receiver resides with the Firing Generator computer. Figure 6 shows the Firing Generator (with receiver inside) for two rectifiers (left and right) within the red ellipse.

Figure 6. Notional Rectifier with Firing Angle Receiver and Computer

4.4.2. OH Firing Generator Computer - TF Firing Generator Data

ICD-PWR-IMO-026: The transmitter provides firing angle data from the Junction area. The receiver resides with the Firing Generator computer, Figure 6 shows the Firing Generator Receiver (upper) and Firing Generator Computer (lower) within the red ellipse.

4.4.3. PF Coil Firing Generator Computer - PF Coil Firing Generator Data

ICD-PWR-IMO-027: The transmitter provides firing angle data from the Junction area. The receiver resides with the Firing Generator computer, Figure 6 shows the Firing Generator Receiver (upper) and Firing Generator Computer (lower) within the red ellipse.

4.4.4. OH - Halmar Signal Conditioners (HSC)

Interface Notes:

- The drawing also includes connections for TF signals as well.

ICD-PWR-IMO-027: The signals for the transducers are routed from between Racks CCC-EE-205 and two CCC-EE-209 as shown in the CWD drawing AE4005 Sheet 2

4.4.5. PF - HSC

ICD-PWR-IMO-029: Halmar signals are wired from the measuring head in ETF-BR3-XT1-I to the Halmar Signal Conditioner found in CCC-EE-209 as shown in drawing 4F1005.

ICD-PWR-IMO-030: The signal is connected using 3 wire connections as shown in drawing 4F1005

4.4.6. Analog Signal Real Time Data Stream Currents

ICD-PWR-IMO-031: The Signals are transplanted in the Junction areas rack CCC-EE-209. The analog incoming connectors are shown in Figure 7.

Figure 7. CCC-EE-209

4.4.7. Fault Signals

ICD-PWR-IMO-032: The Fault indicators are shown in rack CCC-EE-205 as shown in the center of Figure 2.

4.4.8. DCPS To HCS Interface

ICD-PWR-IMO-033: The signals for the transducers are routed from between Racks CCC-EE-205 and two CCC-EE-209 as shown in the CWD drawing AE4005 Sheet 2

4.4.9. Shorted Turn

ICD-PWR-IMO-034: Coil voltages are measured in the SDS cabinets whereby the voltages are calculated using voltage sensors to compare + and - voltages to ground. The analog values are sent to the Shorted Turn Protection rack CCC-EE-214 in the Junction Area, where the signals are added to the FPDP data stream, to be sent to the control and protection computers in the FCC.

4.4.10. FCPC Fault System

ICD-PWR-IMO-035: The Fault indicators are shown in rack CCC-EE-205 as shown in the center of Figure 2.

4.4.11. HCS To IP Calculator

ICD-PWR-IMO-036: The signal conditioners are routed from CCC-EE-209 to CCC-EE-205 as shown in drawing AE4005 SH. 002

ICD-PWR-IMO-037: The signals are interfaced using 2 pair shielded twisted copper wire as shown in drawing AE4005 SH. 002

4.4.12. PDP Permissive Signals

ICD-PWR-IMO-038: THe PDP permissives are sent via fiber from cabinet B4F35 to the FOPP located in cabinet B4F37.

4.4.13. PDP - HCS

ICD-PWR-IMO-039: The components that form the interface are cabinet B4F37.

4.4.14. OH - Firing Angles

Interface Notes:

- See Paragraph 4.4.2 & 4.4.3

ICD-PWR-IMO-040: The transmitter provides firing angle data from the Junction area. The receiver resides with the Firing Generator computer, Figure 6 shows the Firing Generator Receiver (upper) and Firing Generator Computer (lower) within the red ellipse.

4.4.15. OH - Firing Angles

Interface Notes:

- See Paragraph 4.4.2 & 4.4.3

ICD-PWR-IMO-041: The transmitter provides firing angle data from the Junction area. The receiver resides with the Firing Generator computer, Figure 6 shows the Firing Generator Receiver (upper) and Firing Generator Computer (lower) within the red ellipse.

4.5. Diagnostic Interfaces

This identifies any interfaces between the system elements with any instrumentation or diagnostic equipment to collect performance data.

Identifier	Interface	References
N/A		

4.6. Gas/Fluid Interfaces

This paragraph has two different types of interfaces: Gas and Fluid.

4.6.1. Gas Interfaces

This identifies any interfaces between the system elements that use any type of gas (e.g., He).

Identifier	Interface	References

N/A		

4.6.2. Fluid Interfaces

This identifies any interfaces between the system elements that use any type of fluid (e.g., ionized water).

Identifier	Interface	References
N/A		

4.7. Vacuum Interfaces

This identifies any interfaces between the system elements that pertain to the Vacuum.

Identifier	Interface	References
N/A		

4.8. Software Interfaces

This identifies any interfaces between the system elements that use software that may exchange interfaces with other software components. This includes application programming interfaces (APIs) or any other exchange of information between different software applications.

Identifier	Interface	References
N/A		

4.9. Thermal Interfaces

This identifies any interfaces between the system elements that pertain to Thermal characteristics.

Identifier	Interface	References
N/A		

4.10. Plasma Interfaces

This paragraph has two different types of interfaces: Plasma and Eddy/Halo Current.

4.10.1. Plasma Interfaces

This identifies any interfaces between the system elements with the Plasma.

Identifier	Interface	References
N/A		

4.10.2. Eddy/Halo Current Interfaces

This identifies any interfaces between the system elements with the Eddy/Halo Currents.

Identifier	Interface	References
N/A		

5. Off-Project Interfaces

The off-project interfaces are components that are not specifically part of the NSTX-U system. They may include external systems and interfaces where the program has little control on the part of the interface. They are provided for completeness.

There are no external interfaces.