PIP-II RFPI-LLRF
Interface Specification Document (ISD)

Document number: ED0016523

Document Approval

Signatures Required	Date Approved
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Approver: Elvin Harms, L2 Manager	Approver in TC
Stakeholder Reviews performed off-line using ISD Metadata sheet	Dataset in TC

Revision History

Revision	Date of Release	Description of Change
-	TBD	Initial Release. ISD released for CD-3. Update required prior to FDR with completed stakeholder review.

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1. Purpose

Interface Specification Documents (ISDs) contain the information necessary to define all of the external interfaces for the given system. Interfaces are defined globally in the PIP-II Master Interface Control Document which then reference the pertinent ISDs which contain the particular interface details. The ISD contains all the information or references to the information that is necessary to fully define and complete the given interface.

2. Scope

The RF Protection Interlocks (RFPI) system has three objectives in the PIP-II linear accelerator. The primary objective of the RFPI system is to protect the cryomodule and its RF components. The RFPI system monitors signals associated with the SSA-coupler-cavity system and inhibits the low-level RF drive under fault conditions. It provides the SSA permits. The second objective is to provide a status to the accelerator machine protection system (MPS). The third objective is to provide diagnostic information (waveforms and status bits) to the control system in real-time during operation of each SSA-Coupler-Cavity being monitored. This document describes the details of the external interfaces for the RF Protection Interlocks of the PIP-II Project.

3. Roles and Responsibilities

3.1. Author(s)

Responsible for ISD preparation, including layout, proper format, interface identification, interface verification expectations, interface traceability, and additional descriptive detail, as appropriate. The author is expected to engage subject matter experts as needed to ensure technical content is appropriately assessed and captured. The author is also expected to identify all applicable stakeholders to their noted interface(s). In some cases, the author can also have the role of the document Owner.

3.2. Owner

Primary stakeholder and responsible for identifying the goals, objectives, and roles/responsibilities pertaining to the document and for assuring activities/expectations are performed as described. This is typically the Level 3 Manager of the sub-system to which this ISD belongs. The document owner is responsible for maintaining document content, revisions, and updates. An Owner is considered a “Checker” in Teamcenter workflow release when they are not the document Author.

3.3. Reviewer

Technical Integration Office (TIO) reviewers are responsible for ensuring ISD format is consistent with project standards, the appropriate document owner/author/reviewer/approver have been identified, the appropriate review process was implemented, and the appropriate document release process is executed. The TIO reviewers are required to be aware that the ISD document exists and is maintained within the framework of the project Document Management and Control Procedure. A Reviewer is considered a “Checker” in the Teamcenter workflow release.

3.4. Approver

The L2 Manager will evaluate the basis for interface definition, ensure that interfaces are properly articulated, and ensure that they align with higher level interfaces. The L2M will ensure that CAMs, associated engineering staff, and other Systems Managers are properly engaged and notified of the document’s technical implications. Only the System Manager responsible for the work product addressed in the specification is expected to provide approval. The Approver is an “Approver” in the Teamcenter workflow release.

3.5. Stakeholder

Each ISD includes a metadata sheet which lists each ISD interface individually and assigns stakeholders to each. A stakeholder is the associated L3 or subject matter expert that the interface connects or interfaces to and as a result has a direct stake in the interface. Identified stakeholders are expected to be reviewers, ensuring accuracy and completeness, and general agreement of the interface and content applicable to them. Stakeholder reviewers ensure a record of decision is made offline for accepting, rejecting, or modifying the interfaces assigned to them within the ISD metadata sheet (included as a dataset in Teamcenter).

4. Acronyms

CM	Cryomodule
ISD	Interface Specification Document
L2M	Level 2 Manager
L3M	Level 3 Manager
PIP-II	Proton Improvement Plan II Project
RFPI	Radio Frequency Protection Interlocks
TRS	Technical Requirements Specification

5. Summary Table

The following table summarizes each interface by Master ICD ID number and provides additional verification details.

Table 5-1. Interface Summary Table

#	Master ICD ID#	Interface Name	Interface with	Internal Reference(section)	External Reference
1	1834-002	SSR CM Power Coupler Diagnostic Connections	SSR	6	ED0013970
2	1955-002	650 MHz CM Power Coupler Diagnostic Connections	LI	6	ED0013970
3	2129-001	Permit signals from CDS	CDS	6	ED0013970
4	2500-014	HPRF Provides STC 650 MHz Amp Ready Signal	HPRF	7	ED0013970
5	2500-018	HPRF Provides HWR Amp Ready Signal	HPRF	7	ED0013970
6	2500-020	HPRF Provides SSR1 Amp Ready Signal	HPRF	7	ED0013970
7	2500-025	HPRF Provides LB650 Amp Ready Signal	HPRF	7	ED0013970
8	2500-029	HPRF Provides HB650 Amp Ready Signal	HPRF	7	ED0013970
9	2500-030	Raw signals from HPRF (HWR)	HPRF	7	ED0013970
10	2500-031	Raw signals from HPRF (SSR)	HPRF	7	ED0013970
11	2500-032	Raw signals from HPRF (650 MHz)	HPRF	7	ED0013970
12	2500-039	HWR Amp Ready Signal (Buncher)	HPRF	7	ED0013970
13	2500-040	LB650 Amp Ready Signal (Buncher)	HPRF	7	ED0013970
14	2550-001	Digital Control and Analog Readbacks using PLC	MagPS	8	ED0013970
15	2551-001	Vacuum System Permit Signals	Vac	9	ED0013970
16	2552-003	Cryomodule Permit Signals (CNTRL)	Cntrl	10	ED0013970
17	2553-001	ESS Permit Signals	SS	11	ED0013970
18	2555-003	Data Logging from MPS	MPS	12	ED0013970
19	2555-004	Cryomodule Permit Signals (MPS)	MPS	12	ED0013970
20	2564-008	RFQ HPRF Raw signals to LLRF interlocks	WFE	7	ED0013970
21	2564-010	Buncher HPRF Raw signals to LLRF interlocks	WFE	7	ED0013970
22	2564-011	RFQ Vacuum System Permit Signals	WFE	7	ED0013970
23	2566-008	Raw Signals for HPRF Interlocks	BldgI	7	ED0013970
24	2566-011	Raw Signals from HPRF Sensors (HWR Couplers)	BldgI	7	ED0013970

25	2566-013	Raw Signals from HPRF (HWR Interlocks)	BldgI	7	ED0013970
26	2566-016	Raw Signals from HPRF (SSR Interlocks)	BldgI	7	ED0013970
27	2566-019	Raw Signals from HPRF (650 interlocks)	BldgI	7	ED0013970
28	2566-020	Permit Signal from Vacuum System	BldgI	9	ED0013970
29	2566-021	Connection to Control System for monitoring control	BldgI	13	ED0013970
30	2566-027	Cable Specifications	BldgI	14	ED0013970

6. Coupler Diagnostic Connections

Master ICD interface(s): 1834-002, 1955-002, 2129-001
Interface with HWR, SSR1, SSR1, 650MHz CM, CDS
Applicable TRSs: ED0013970

Power Coupler diagnostics is a critical component to the RFPI system. This category includes monitoring and ability to interlock on the following diagnostics: Field emission probe (also known as FEP or coupler e-probe), HV Coupler Bias Supply Current, HV Coupler Bias Supply Voltage, Coupler window temperatures. It will be noted here that a Coupler Vacuum permit will also be part of RFPI, however this will be captured in the Vacuum System section.

The Field Emission Probe connection will be made available at the instrumentation port with a flanged female type N connector. An RG11 cable will be terminated with a male type N connector and mate with the FEP at the instrumentation port. The other end of the cable will run to the RFPI system rack electronics.

HV Coupler Bias supply current and permit status is monitored by the RFPI system. The power supply is kept in the same rack as the RFPI. The current is read from this power supply. The coupler voltage is taken from a bias tee at the coupler. This signal goes to the RFPI's HV Divider Box which divides the voltage with a 1000:1 ratio. This divided signal is then passed to the RFPI electronics

The Coupler Window temperature is measured using platinum PT-103 RTD sensors. Due to the criticality, two sensors will be used on every coupler window.

Lastly, the RFPI system will interface with Control system for Coupler Window Cooling Airflow Permit which will use a relay contact switch P3-08TRS-1. A shielded twisted pair cable will be used to make this connection between the two systems.

7. Interface with HPRF System

Master ICD interface(s): 2500-014, 2500-018, 2500-020, 2500-025, 2500-029, 2500-030, 2500-031, 2500-032, 2500-039, 2500-040
Interface with HWR, SSR1, SSR1, 650MHz CM, CDS
Applicable TRSs: ED0013970

The RFPI interface with the amplifiers in the HPRF systems is straightforward. The HPRF amplifiers provide a status permit to the RFPI system. The RFPI sends permits to the amplifiers. In the case of the SSR and 650MHz amplifiers, the RFPI will send two permits to each amplifier: one RF permit and one DC permit. The amplifiers will have a female BNC flange connector on it so that an RG-58 will be terminated with a male BNC to connect to the amplifier.

Antennas will be place nearby the amplifiers. A 50Ω shielded cable will be used to interface with the RFPI system. The RFPI system will take the raw signal from the antenna, filter, amplify and process the signal level to check that the signal level does not exceed limits.

8. Interface with Magnet Power Supply

Master ICD interface(s): 2550-001
Interface with HWR, SSR1, SSR1, 650MHz CM, CDS
Applicable TRSs: ED0013970

Presently the RFPI will not interlock on any Magnet power supply readbacks or magnet quench. (TBD1)

9. Interface with Vacuum System

Master ICD interface(s): 2551-001
Interface with HWR, SSR1, SSR1, 650MHz CM, CDS
Applicable TRSs: ED0013970

The RFPI will interlock upon Vacuum faults. The Vacuum system will receive the raw signals from the vacuum gauge, maintain the trip limits and provide the RFPI with a permit using a relay contact switch. Specifically, the RFPI will receive one cavity/beamline vacuum permit and one coupler vacuum permit. The relay switch used will be. It will be designed to be fail-safe, where an open contact with indicate a fault. Shielded twisted pair cables are used to make this connection to the Vacuum PLC.

10. Cryomodule Permit Signal

Master ICD interface(s): 2552-003
Interface with HWR, SSR1, SSR1, 650MHz CM, CDS
Applicable TRSs: ED0013970

The RFPI will receive a permit from the Cryogenics System representing the Helium Pressure and Level of the Cryomodule. The permit from the Cryogenics system will be and open relay contact switch in presence of a fault and in a closed state when the Cryogenics system is operating nominally. The relay contact switch in the Cryogenics system will be KHAU17D11-24 (silver contact).

A shielded twisted pair cable will be used to make the connection from the Cryogenics system to the RFPI.

Antennas will be place nearby the Cryomodule. A 50Ω shielded cable will be used to interface with the RFPI system. The RFPI system will take the raw signal from the antenna, filter, amplify and process the signal level to check that the signal level does not exceed limits.

11. ESS Permit Signals

Master ICD interface(s): 2553-001
Interface with HWR, SSR1, SSR1, 650MHz CM, CDS
Applicable TRSs: ED0013970

The RFPI system will receive a permit from ESS. A relay contact switch will be used to create the permit with the specifications shown below.

Table 11-1. ESS Interface Specifications for Relay Contact Switch

Specification:	Value:
Max. switching power	30 W, 31.25 VA (resistive load)
Max. switching voltage	30 V DC
Max. switching current	1.0 Amps DC
Minimum operating power	200 mW (8mA @24Vdc)

In accordance with ADSP-10-0003 a blue jacketed 2 conductor #18 AWG cable will be used as a connection from each signal output to the RFPI system.

12. MPS

Master ICD interface(s): 2555-004
Interface with HWR, SSR1, SSR1, 650MHz CM, CDS
Applicable TRSs: ED0013970

The RFPI system will provide a permit to the MPS system. This will indicate to the MPS system that the RFPI system is interlocked on any fault that should prohibit beam. It is to be determined (TBD2) if there will be a high-speed serial link (bi-directional) or a 50Ω digital TTL to communicate the permit status.

13. Connection to Control System for Monitoring Control

Master ICD interface(s): 2566-021
Interface with HWR, SSR1, SSR1, 650MHz CM, CDS
Applicable TRSs: ED0013970

A standard control system interface will be used for operator use. Ethernet cable connection will interface with the RFPI System to standard EPICS interface designed by Controls Department.

14. Cable Specifications

Master ICD interface(s): 2566-021
Interface with HWR, SSR1, SSR1, 650MHz CM, CDS
Applicable TRSs: ED0013970

Table 14-1. Cables Specifications for Interfaces

Signal Name	Interface	Interface Cable
Field Emission Probe (FEP)	Coupler	RG-11
Coupler Bias Voltage (V)	Coupler	Belden 1325A
Coupler Bias Current (A)	Coupler	Belden 1325A
Temperature Probe RTD 1, (PT-103)	Coupler	Belden 1325A
Temperature Probe RTD 2, (PT-103)	Coupler	Belden 1325A
RF antenna(s)	Cryomodule, HPRF	LDF1-50
He Pressure & Level	Cryomodule	Belden 1325A
Coupler Window Cooling Airflow Permit	Coupler	Belden 1325A
Coupler Vacuum Permit	Vacuum System	Belden 1325A
Beam Vacuum Permit	Vacuum System	Belden 1325A

Personal Safety Permit	ESS	KSM #CT-E202F blue jacketed 2 conductor #18 AWG cable
LLRF Ready (RF level status, Ready status, quench)	LLRF	TBD3
SSA Ready	HPRF	RG-58
SSA Inh (Permit)	HPRF	RG-58
SSA DC Inh (Permit)	HPRF	RG-58
LLRF Inh (Permit)	HPRF	RG-58
MPS Inh (Permit)	HPRF	RG-58

15. TBD Milestone Completion Table

TBD #	TBD Description	TBD Milestone Completion
1	Interface with MagPS (Section 8)	LLRF FDR
2	Communication decision with MPS (Section 12)	LLRF FDR
3	LLRF Ready status cable (Table 14-1)	LLRF FDR

16. References Table

#	Reference	Document #
1	PIP-II Master Interface Control Document	ED0010433
2	LLRF Interlocks TRS	ED0013970