

PIP2IT SRF High Power Radio Frequency Distribution Functional Requirements Specification

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Revision History

Revision	Date of Release	Description of Change
A	5/20/2019	Initial version-Victor Grzelak

1. Purpose

The high power RF (HPRF) distribution system begins at the output flange of the high power amplifier, and ends at the input coupler to the cryomodule.

The interfaces to the HPRF distribution system are:

- HPRF amplifiers to supply power
- HPRF cryomodule to deliver power
- Low Level RF to provide reflected and forward power
- RF Protection Interlocks (RFI) to provide reflected and forward power via the LLRF
- Water utilities to cool the circulators.

2. Scope

The HPRF distribution system will consist of a transmission line between the SSA and the circulator, a high power circulator, a high power directional coupler, and a transmission line to the input coupler on the cryomodule. (This is explicitly for the HWR, SSR1 and the SSR2 test configuration)

3. Acronyms

FEM	Fermilab Engineering Manual
FESHM	Fermilab ES&H Manual
FRCM	Fermilab Radiological Control Manual
FRS	Functional Requirements Specification
HPRF	High Power Radio Frequency
L2	WBS Level 2
L3	WBS Level 3
LLRF	Low Level Radio Frequency
1mwMPS	Machine Protection System
PIP-II	Proton Improvement Plan II Project
RF	Radio Frequency
SCD	System Configuration Document
SRF	Superconducting Radio Frequency
TC	Teamcenter
WBS	Work Breakdown Structure

4. Reference

#	Reference	Document #
1	RF Power Systems EPDM	ED0002850
2	PIP-II Systems Configuration Document: Accelerator Systems WBS 121.3	ED0008104
3	Fermilab Engineering Manual (FEM)	-
4	Fermilab Environmental Safety and Health Manual (FESHM)	-
5	Fermilab Radiological Control Manual (FRCM)	-

5. Key Assumptions

These requirements for the HPRF distribution systems assume that the necessary cooling medium is provided to the circulators and that the cooling infrastructure can remove the heat generated.

6. Functional Requirements

6.1. Primary Requirements

These requirements define the primary purpose of the HPRF system within the project scope.

Requirement #	Requirement Statement
A001	The HPRF distribution deliver power with minimized attenuation or distortion over the specified bandwidth of its operation.
A002	The HPRF distribution system must provide forward and reflected power signals to the LLRF system and the RFPI.
A003	Each element in the line must capable of running a CW operation and must not damage the equipment in normal operation or the event of a rapid shutoff.
A004	The HPRF system shall transport RF power signals from the output of the power source to the cavity input coupler without RF leakage that would cause parasitic oscillations in the LLRF feedback system.
A005	The HPRF distribution system must protect the SSA from reflected power.

6.2. Personnel Safety Requirements

These requirements define system features that are necessary to protect beam enclosure and HPRF maintenance personnel.

Requirement #	Requirement Statement
B001	The HPRF system shall transport RF power signals from the output of the power source to the cavity input coupler without RF leakage over FCC maximum permissible exposure limit.

6.3. Self-Preservation Requirements

These requirements specify the necessary isolators and protection interlocks for the power amplifiers.

Requirement #	Requirement Statement
C001	The HPRF distribution system shall withstand any power wave that can be forward and reflected during operation without damage.
C002	The HPRF distribution system shall provide the RF amplifier an interlock status stating thermal conditions are satisfied, such as water flow or klixons.

6.4. Requirements

These requirements define the specifications that will ensure that the HPRF components can be successfully installed and connected between the beam line and gallery.

Requirement #	Requirement Statement
D001	Circulators in the HPRF system should be installed on aluminum and over 1 foot away from ferromagnetic materials including steel.
D002	The HPRF system distribution for each cavity shall fit inside a gallery to beam line penetration and capable of being assembled from outside the penetrations.
D003	The HPRF distribution system route shall not interfere with the route of other distribution systems nor interfere with cryomodule transport through the gallery.

7. Safety Requirements

The system shall abide by all Fermilab ES&H (FESHM) and all Fermilab Radiological Control Manual (FRCM) requirements including but not limited to: Electrical Safety
<ul style="list-style-type: none"> FESHM Chapter 9110 Electrical Utilization Equipment Safety
<ul style="list-style-type: none"> FESHM Chapter 9160 Low Voltage, High Current Power Distribution Systems
<ul style="list-style-type: none"> FESHM Chapter 9190 Grounding Requirements for Electrical Distribution and Utilization Equipment
<ul style="list-style-type: none"> FESHM Chapter 2000 Planning for Safe Operations

Any changes in the applicability or adherence to these standards and requirements require the approval and authorization of the PIP-II Technical Director or designee.

In addition, the following codes and standards in their latest edition shall be applied to the engineering, design, fabrication, assembly and tests of the given system:

NFPA 70 – National Electrical Code
IEC Standards for Electrical Components
IEEE C95.1 Standard
NRTL Standards

In cases where International Codes and Standards are used the system shall follow FESHM Chapter 2110 Ensuring Equivalent Safety Performance when Using International Codes and Standards and requires the approval and authorization of the PIP-II Technical Director or designee.

Additional Safety Requirements that are not listed in the general list above shall be included in the Requirements table in the Functional Requirements section.