Antenna Electronics
DC Power Supply Requirements Specification

020.30.50.00.00-0001-REQ

Status: **RELEASED**

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Change Record

Version	Date	Author	Affected Section(s)	Reason
A	2018-10-24	P. Lopez	All	Initial Draft.
A.01	2021-05-27	P. Lopez	All	Updated for CoDR design.
A.02	2021-08-05	P. Lopez	All	Removal of KPP #3 (4.5V to 5V) and other minor changes.
A.03	2021-08-18	P. Lopez	All	Update for RIDs.
B	2021-10-19	A. Lear	All	Prepared PDF for signatures and release.

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1 Introduction

1.1 Purpose

This document presents the complete set of Level 2 subsystem requirements that guide the design and development of the DC Power Supply subsystem. Requirements described in this document are derived from applicable ngVLA System Requirements and System-Level Specification documents as listed in the Applicable Documents table. The engineering process and requirements hierarchy that govern this specification are defined in [AD01] and [AD02] respectively.

The content of these requirements is at the subsystem level, conforming to the system architecture [AD06], but aims to be implementation agnostic within the subsystem boundaries. Some assumptions about the subsystem may be given, but only to the degree necessary to unambiguously define the subsystem requirements.

1.2 Scope

The scope of this document is the specification of the DC Power Supply Subsystem, configuration item number 020.30.50, of the ngVLA system. This includes:

- Assumptions on which the requirements are based.
- Definition of environmental conditions to be used in the definition of requirements.
- A complete set of requirements for the subsystem needed for the development, operation and maintenance of the subsystem, including interface requirements that are derived from the applicable list of ICDs.
- Numbering of all requirement and establishment of traceability to higher level requirements.
- Verification requirements and their traceability to the subsystem main requirements.
- Identification of Key Performance Parameters (KPPs) at the subsystem level.

The Level 2 Subsystem Requirements, along with detailed explanatory notes, are found in Section 7. The notes contain elaborations regarding the meaning, intent, and scope of the requirements. These notes form an important part of the definition of the requirement. In many cases, the notes contain an analysis of how the numeric values of requirements were derived to ensure correct interpretation of the requirements and to resolve ambiguity.

2 Related Documents and Drawings

2.1 Applicable Documents

The following documents apply to this Requirements Specification to the extent specified. In the event of a conflict between the documents referenced herein and the content of this Requirements Specification, the content of the highest-level specification (in the requirements flow-down) shall be considered the superseding requirement for design elaboration and verification.

Ref. No.	Document Title	Rev./Doc. No.
AD01	Systems Engineering Management Plan	020.10.00.00.00-0001-PLA
AD02	Requirements Management Plan	020.10.15.00.00-0001-PLA
AD03	System Requirements	020.10.15.10.00-0003-REQ
AD04	System Environmental Specifications	020.10.15.10.00-0001-SPE
AD05	System EMI/RFI Requirements	020.10.15.10.00-0002-REQ
AD06	System-Level Architecture Model	020.10.20.00.00-0002-DWG
AD07	Safety Specification	020.80.00.00.00-0001-REQ
AD08	Security Management Plan and Requirements	020.80.00.00.00-0003-REQ
AD09	System Electronics Specification	020.10.15.10.00-0008-REQ
AD10	System Technical Budgets	020.10.25.00.00-0002-DSN
AD11	Product Breakdown Structure	020.10.20.00.00-0004-DSN
AD12	Safety: Risk Analysis Procedures	020.80.00.00.00-0002-PRO

2.1.1 Traceability Key

Traceability Acronym	Applicable Document Number
EMC	AD05
ENV	AD04
ETR	AD09
SAF	AD07
SYS	AD03

2.2 Applicable ICDs

The following ICDs define the external boundary of this subsystem and are applicable to its specification:

Ref. No.	Document Title	Rev./Doc. No.
AD20	Antenna Electronics to DC Power Supply Interface Control Document	020.10.40.05.00-0006-ICD
AD21	Antenna to Antenna Electronics Interface Control Document	020.10.40.05.00-0011-ICD
AD22	DC Power Supply System to Monitor and Control Interface Control Document	020.10.40.05.00-0054-ICD
AD23	Bins and Modules to Antenna Electronics Interface Control Document	020.10.40.05.00-0040-ICD

2.3 Reference Documents

The following documents are referenced within this text or provide supporting context:

Ref. No.	Document Title	Rev./Doc. No.
RD01	Antenna Electronic Front End Enclosure Block Diagram	020.30.00.00.00-0002-BLK
RD02	Antenna Electronics Pedestal Enclosure Block Diagram	020.30.00.00.00-0003-BLK
RD03	Antenna Time & Frequency Reference Requirements	020.35.20.00.00-0001-REQ
RD04	Digital Back End Requirements	020.30.25.00.00-0001-REQ
RD05	Front End Requirements	020.30.05.00.00-0003-REQ
RD06	Integrated Down Converter Requirements	020.30.15.00.00-0003-REQ
RD07	Monitor and Control Requirements	020.30.45.00.00-0002-REQ
RD08	Water Vapor Radiometer Requirements	020.45.00.00.00-0001-REQ
RD09	Cryogenics System Requirements	020.30.10.00.00-0001-REQ

3 Overview of DC Power Supply System

3.1 DC Power Supply Boundary, Context, and External Interfaces

The DC Power Supply system (specifically –48V Power Plant) receives 208V 3 phase AC and converts it to –48V DC. Lithium batteries will be used as a backup source for the –48V in the event the AC is lost. The Power Plant will act as a battery charger when AC is available. The –48V Power Plant and batteries will be located in the pedestal area of each antenna. The –48V is then fed into multiple power supply modules that convert the –48V to 5 or 6 lower voltage outputs depending on the module. Each power supply module has monitor and control (M&C) and temperature sensors in them so they can be shut down for over current or over temperature. The –48V Power Plant will also be used to supply –48V to the equipment shown below. The interfaces between the Power Plant and these modules will be detailed in the Antenna Electronics to DC Power Supply Interface Control Document (ICD) [AD20].

Equipment Interacting with –48V Power Plant	Configuration Item Number
Antenna Fire Alarm	020.25
Digital Back End (DBE) and Data Transmission System (DTS)	020.30.25.00.00
Ethernet Switch	020.30.45.50.00
Water Vapor Radiometer (WVR)	020.45.40.00.00

The Pedestal Power Supply module receives –48V and converts it to five voltage outputs for the electronics equipment located inside the Pedestal room. The Pedestal Power Supply module will supply DC voltage outputs to the equipment shown below. The interfaces between the Pedestal Power Supply and the electronics in the Pedestal Room will be detailed in the Antenna Electronics to DC Power Supply Interface Control Document (ICD) [AD20]. To cut down on size and weight across the antenna, the Pedestal Power Supply Module and M&C Module will be combined into 1 housing.

Equipment Interacting with Pedestal Power Supply Module	Configuration Item Number
LO Reference Receiver Generator and Distribution	020.35.00.00.00
Monitor and Control (M&C)	020.30.45.40.00

The Auxiliary Power Supply module receives –48V and converts it to five voltage outputs for the electronics equipment located inside the Auxiliary Enclosure. The Auxiliary Power Supply module will supply DC voltage outputs to the equipment shown below. The interfaces between the Auxiliary Power Supply and the electronics in the Auxiliary Enclosure will be detailed in the Antenna Electronics to DC Power Supply Interface Control Document (ICD) [AD20]. To cut down on size and weight across the antenna, the Auxiliary Power Supply Module and M&C Module will be combined into 1 housing.

Equipment Interacting with Auxiliary Power Supply Module	Configuration Item Number
VFD Control M&C module	020.30.45.20.00

The Front End (FE) Power Supply module receives –48V and converts it to six voltage outputs for the electronics equipment located inside the FE Enclosure. The FE Power Supply module has the extra sixth output voltage for FE receiver noise diode requirement. The FE Power Supply module will supply DC voltage outputs to the equipment shown below. The interfaces between the FE Power Supply and the electronics in the FE Enclosure will be detailed in the Antenna Electronics to DC Power Supply Interface Control Document (ICD) [AD20]. To cut down on size and weight across the antenna, the FE Power Supply Module and M&C Module will be combined into 1 housing.

Equipment Interacting with Front End Power Supply Module	Configuration Item Number
Front End (FE)	020.30.05.00.00
Integrated Downconverter/Digitizers (IRD)	020.30.15.00.00
LO Reference Clock Generator and Distributor	020.35.00.00.00
Monitor and Control (M&C)	020.30.45.10.00

The Cryo Power Supply module receives –48V and converts it to five voltage outputs for the electronics equipment located inside the CRYO/EEC platform. The Cryo Power Supply module will supply DC voltage outputs to the equipment shown below. The interfaces between the Cryo Power Supply and the electronics in the CRYO/EEC platform will be detailed in the Antenna Electronics to DC Power Supply Interface Control Document (ICD) [AD20]. To cut down on size and weight across the antenna, the Cryo Power Supply Module and M&C Module will be combined into 1 housing.

Equipment Interacting with Cryo Power Supply Module	Configuration Item Number
Cryogenics M&C module	020.30.45.30.00

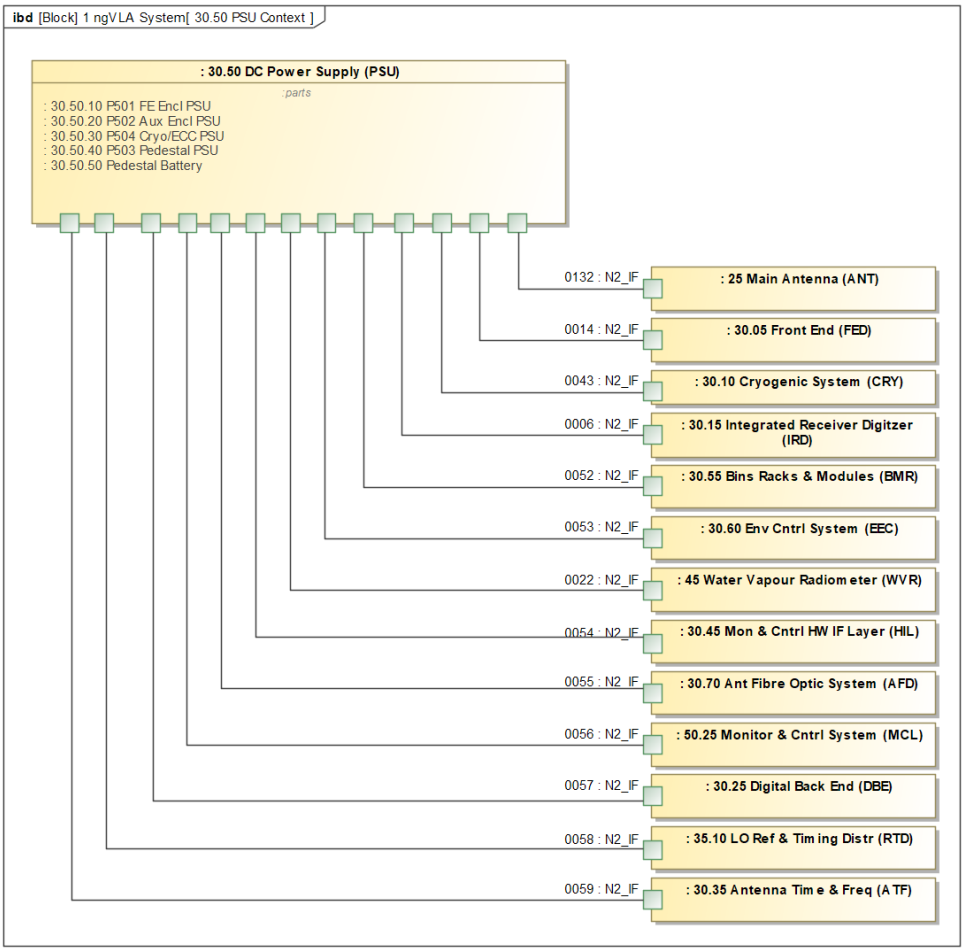

Figure 1: PSU context diagram.

3.2 DC Power Supply Product Breakdown

Below is the planed DC Power Supply Product Tree Break down.

- 020.30.50.00.00: DC Power Supply System General
- 020.30.50.01.00: FE Enclosure Power Supply Unit
- 020.30.50.02.00: Auxiliary Enclosure Power Supply Unit
- 020.30.50.03.00: CRYO/EEC Platform Power Supply Unit
- 020.30.50.04.00: Pedestal Room Power Supply Unit
- 020.30.50.05.00: Pedestal Battery

3.2.1 –48V Power Plant System

This subsystem consists of an AC to –48V DC Power Plant, configuration item number 020.30.50.05.01, and Lithium Batteries, configuration item number 020.30.50.05.02. Cabling to and from the –48V Power Plant System will be covered in the 020.30.50.05.00 product breakdown structure.

3.2.2 DC Power Supply Units

The DC Power Supply Units (PSU) or Modules convert –48V DC to the required DC voltages needed for the electronics located in an enclosure or platform. There will be DC Power Supply modules located in the Pedestal Room, Auxiliary enclosure, FE enclosure, and CRYO/EEC platform.

Each DC Power Supply Module consist of a Module Interface Board (MIB) for M&C purposes, configuration item number 020.30.50.0X.01, a Digital board that converts analog signals to digital signals needed for M&C purposes or could be used to carry out commands from the MIB, configuration item number 020.30.50.0X.02, and a Mother board that contains the regulators that converts –48V to the appropriate voltages for the other electronic LRUs, configuration item number 020.30.50.0X.03. "X" will depend on the enclosure or platform location. The Pedestal Power Supply Module, and Front End Power Supply Module will require a distribution board, configuration item number 020.30.50.0X.04. Cabling from each DC Power Supply module will be covered in the respective product breakdown structure.

3.3 DC Power Supply Functional Overview

Below is a basic block diagram of the DC Power Supply system. The diagram shows the input and output voltages for each power supply module.

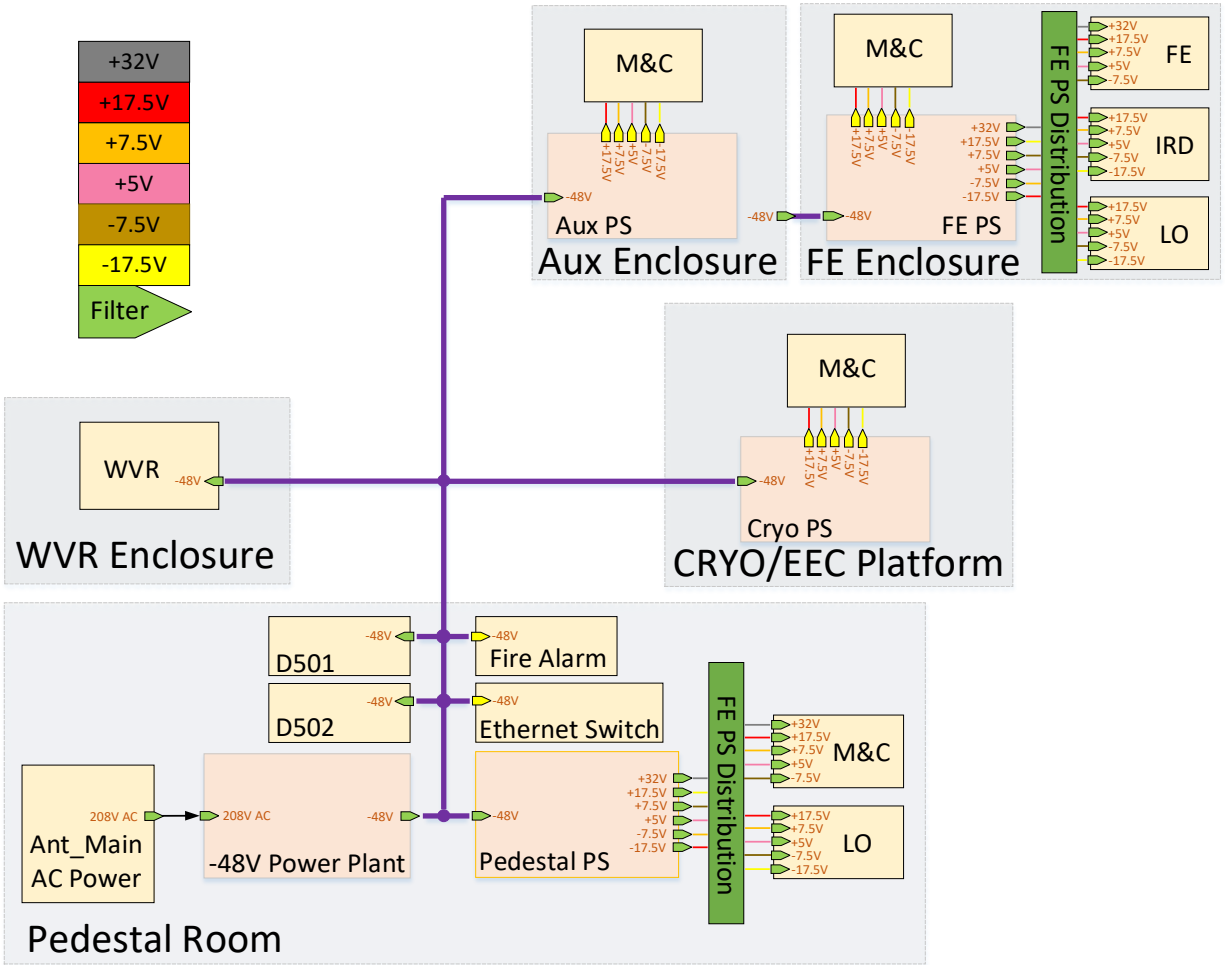

Figure 2: Block Diagram of DC Power Supply.

3.4 Design Driving Requirements

The following table provides a summary of the major design-driving requirements for the DC Power Supply. Should there be a conflict between the requirements listed here and the descriptions in Section 7, the latter shall take precedence.

Parameter	Req. #	Value & design driver	Traceability
AC to DC Conversion	PSU0001	DC Power Supply system Input AC voltage shall be converted to –48V DC via Power Plant subsystem.	ETR0819, ETR0821
DC Power Supply Module Input Voltage	PSU0002	Each DC Power Supply module shall require –48V DC input.	ETR0821
LRU Power Input	PSU0003	DC Power Supply system output power to all LRUs shall be considered raw power. Internal regulation and filtering are required.	ETR0803
RFI Emission Threshold	PSU0004	The DC Power Supply system RFI suppression will eliminate certain supply architectures.	SYS2104, SYS2106, ETR0601
Number of Batteries needed	PSU0005	The time needed to safely place the antenna electronics into a safe standby mode will determine the number of backup batteries needed for the DC Power Supply system.	ETR0810

4 Requirements Management

4.1 Requirements Definitions

Consistent with the Requirements Management Plan [AD02], the following definitions of requirement "levels" are used in the ngVLA program. The requirements in this document are at the L2 subsystem level.

Requirement Level	Definition
L0	User requirements expressed in terms applicable to their needs or use cases (Science Requirements or Stakeholder Requirements)
L1	Requirements of the System, expressed in technical functional or performance terms (System Level Requirements)
L2	Requirements that define a specification for an element of the system, presuming a system architecture (Subsystem Requirements)

4.2 Requirements Flow Down

Figure 3 shows the relationships between the Subsystem (L2) requirements and the System (L1) requirements from which they are derived.

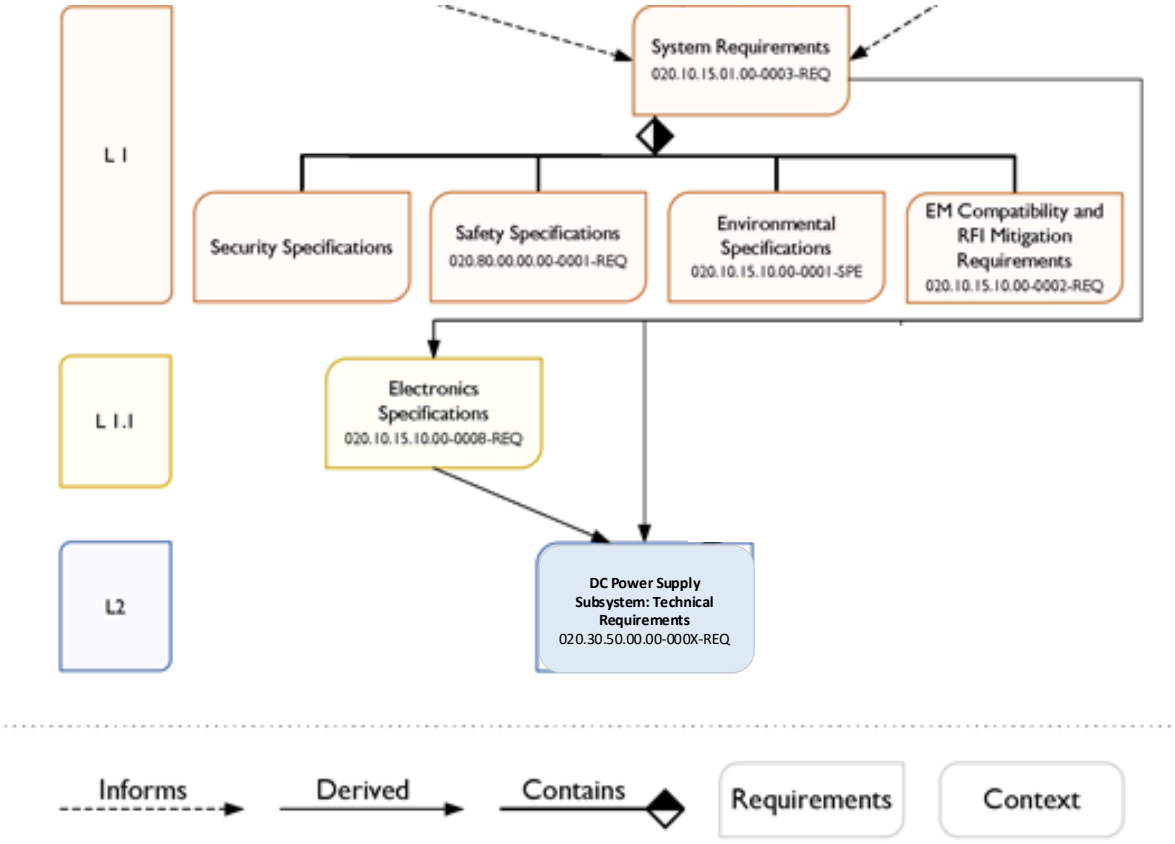

Figure 3: Requirements flow-down to the DC Power Supply Subsystem Requirements.

Individual subsystem specifications (Level 2) flow from the Level 1 requirements, and may not always be directly attributable to a single system requirement. Completeness of the Level 2 requirements is assessed at the requirements review of each subsystem.

While this is a top-down design process, the process is still iterative rather than a "waterfall" or linear process. The feasibility and cost of requirements implementation lead to trade-offs that feedback to higher-level requirements. The end goal is to build the most generally capable system that will support the Key Science Goals within the programmatic constraints of cost and schedule. Maintaining enumerated traceability between system requirements and subsystem requirements ensures that this trade-off process can be managed in a controlled way.

4.3 Verb Convention

This document uses "shall" to denote a requirement. The verbs "should" and "must" denote desired but not strictly required parameters. "Will" denotes a future happening. Desired but not required features are noted as "desirable" or "goals."

5 Assumptions

The following assumptions are made in the definition of the DC Power Supply system requirements:

- Hardware requirements assume that all system parts that would normally be in place during observations are working within their respective specifications (e.g., HVAC, RTP system) unless explicitly stated otherwise.
- Most COTS –48V DC Power Plant Units our size do not come in 480V inputs. If one is found the options would be limited to that one unit. To have more COTS options, ability to change the size of antenna 208V transformer will be assumed.
- Pedestal Power Supply module requirements assume the Fire Alarm will be powered by –48V @ ~2A.
- Pedestal Power Supply module requirements assume the Ethernet switch will be powered by –48V @ ~2A.
- FE Power Supply module requirements assume all LO reference modules needed for each IRD module will be located in the FE Enclosure.
- All Power Supply Modules assume all LOIF modules will be powered by +17.5V @ ~2.5A, +7.5V @ ~1A, +5V @ ~2A, -7.5V @ ~250mA, and -17.5V @ ~250mA.

6 Environmental Conditions

Based on historical weather data of the VLA site and other public weather databases, the following definitions of environmental conditions are adopted. The power supplies shall conform to these requirements.

6.1 General Operating Conditions

The general environment operating conditions must be met during all other possible operating conditions.

Parameter	Req. #	Value	Traceability
Altitude Range	PSU0011	DC Power Supply system shall work from sea level to 2500 meters.	ENV0351, ETR0903
Thermal Protection	PSU0012	The DC Power Supply LRUs shall be thermally protected.	SYS2700, SAF0100, SAF0770, ETR0807
Thermal Protection Monitoring	PSU0013	The DC Power Supply LRUs shall be able to monitor the state of thermal protection features. An exception is if the thermal protection activated disables the LRUs M&C interface. In this situation the LRU ceases to communicate and should be presumed as bad by the responding technician (i.e. they take a spare with them and swap the LRU after evaluating M&C connections).	SYS2700, SYS2701, ETR0808

Parameter	Req. #	Value	Traceability
Thermal Analysis	PSU0014	The designer of the DC Power Supply system shall analyze their designs and take steps to optimize thermal performance with a focus on proper cooling, thermal stability and the elimination of hot spots. They shall publish these results in a memo and be prepared to discuss their analysis and the techniques used to address the results in the design reviews for their equipment and subsystems.	SYS2801, SYS2700, SAF0100, SAF0770, ETR0816
Lightning Protection, Electronics Systems	PSU0015	The DC Power Supply systems shall be protected against Lightning Electromagnetic Impulse (LEMP) in accordance with IEC 62305-4.	ENV0512, ETR0825, ETR1205
Equipment Protection Against Dust	PSU0016	The DC Power Supply system shall be protected against windblown dust, ashes, and grit	ENV0541
Rodent Protection	PSU0017	The DC Power Supply system wiring and cables installed in areas vulnerable to rodents shall utilize armoring or a rodent deterrent insulation. Alternatively, the cables can be enclosed to prevent vulnerability.	SYS2700, SAF0080, SAF0120, SAF0140, ENV0551, ETR1127
Vibration	PSU0018	The DC Power Supply system shall be designed to withstand persistent vibrations with a power spectral density defined in Figure 4. The system shall also be tested to this specification along all three axes as defined in the MIL-STD-810H Method 514.8 Procedure 1 for General Vibration for a period of 60 min.	ENV0531, SAF0810

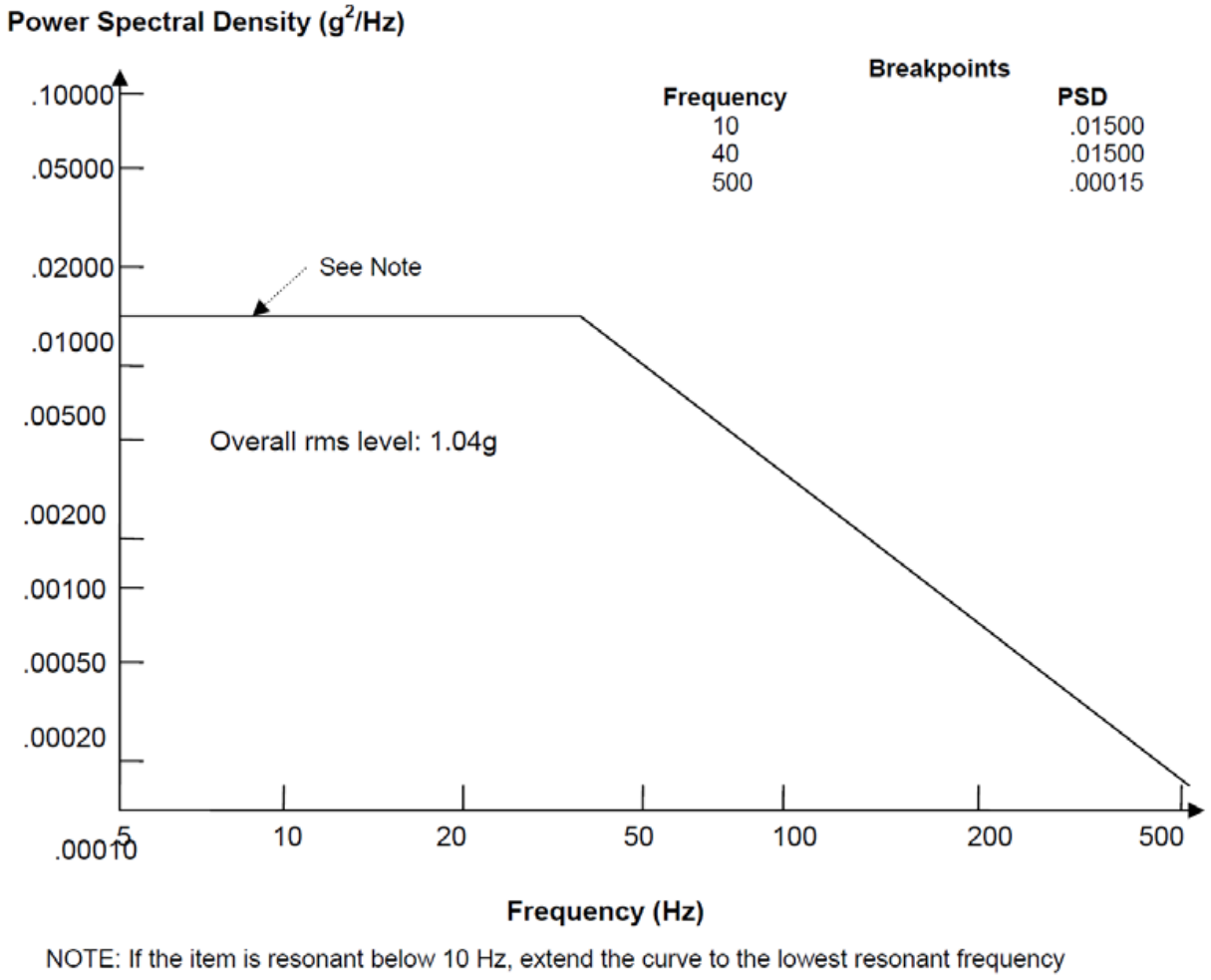

Figure 4: Power spectral density of design spectra for vibration mitigation.

6.2 Normal Operation Temperature Conditions

When the environment meets the constraints of the normal operating conditions, system performance requirements are relaxed but are still expected to provide adequate performance. Below lists the normal operating temperature of the DC Power Supply system and not the outside environment conditions.

Parameter	Req. #	Value	Traceability
Power Supply System Temperature (Except Batteries)	PSU0021	DC Power Supply system, except the batteries, shall operate normally at –20 C ≤ T ≤ 40 C.	ENV0323, SAF0100, ETR0903
Power Supply Battery Ambient Temperature	PSU0022	DC Power Supply system batteries shall operate normally at 0 C < T ≤ 40 C.	ENV0323, SAF0100, ETR0903

6.3 Standby Temperature Conditions

After the limits to the operating conditions are exceeded, the antennas will be placed in the "stow-survival" position for equipment safety and the system placed in a standby state. While in standby, the

system shall remain capable of resuming operation within five minutes of conditions returning to within the Limits of the Operating Conditions. Should the environment then reach the Normal Operating Conditions, the system shall perform to the performance specifications associated with that environment. Subsystems may automatically shut down, or have temporarily degraded performance, once the environment exceeds the constraints of the Standby Conditions. Below lists the Standby operating temperature of the DC Power Supply system and not the outside environment conditions.

Parameter	Req. #	Value	Traceability
Power Supply System Temperature (Except Batteries)	PSU0031	DC Power Supply system, except the batteries, shall operate in standby at –25 C ≤ T ≤ 45 C.	ENV0362, SAF0100, ETR0903
Power Supply Battery Ambient Temperature	PSU0032	DC Power Supply system batteries shall operate in standby at 0 C < T ≤ 45 C.	ENV0362, SAF0100, ETR0903

6.4 Survival Temperature Conditions

The survival conditions describe the environment that the antenna and all outside structures should be able to withstand without damage when placed in its least-vulnerable state. Below lists the Survival operating temperature of the DC Power Supply system and not the outside environment conditions.

Parameter	Req. #	Value	Traceability
Power Supply System Temperature (Except Batteries)	PSU0041	DC Power Supply system, except the batteries, shall survive at –30 C ≤ T ≤ 50 C.	ENV0342, SAF0100, ETR0903
Power Supply Battery Ambient Temperature	PSU0042	DC Power Supply system batteries shall survive at 0 C < T ≤ 50 C.	ENV0342, SAF0100, ETR0903

6.5 Storage and Transportation Conditions

Parameter	Req. #	Value	Traceability
Power Supply System Storage Temperature Requirements (Except Batteries)	PSU0051	DC Power Supply system, except the batteries, shall be stored at 0°C to 30°C.	SYS3912, ENV0372, SAF0100, SAF0240, ETR0903
Battery Storage Requirements	PSU0052	DC Power Supply system batteries shall be stored at 10°C to 25°C.	SYS3912, ENV0372, SAF0100, SAF0240, ETR0903
Storage Humidity	PSU0053	The DC Power Supply system shall survive storage at relative humidity in the range 10% ≤ RH ≤ 90%	SYS3912, SAF0240, ENV0373, ETR0903

Parameter	Req. #	Value	Traceability
ESD Packaging and Storage	PSU0054	The DC Power Supply system shall be packaged, shipped, and stored in ESD protective packaging and/or equipped with shorting plugs and conductive caps on all external connections. These items shall only be sealed and opened at ESD safe workstations.	SYS3904, SYS3912, SAF0240, ETR0503, ETR0903
Transportation Temperature	PSU0055	DC Power Supply system shall be transported at –30 C ≤ T ≤ 60 C.	ENV0382, SAF0100, ETR0903
Design for Transportation	PSU0056	All DC Power Supply system assemblies shall be designed to survive shipping and transportation. No fragile or insecure assemblies or wiring.	SAF0240, SAF0250, SAF0260, SAF0470, ETR1179, ETR0903
Mechanical Shock	PSU0057	The DC Power Supply system packaged for transportation shall survive mechanical shock levels from handling as defined in the MIL-STD-810H Method 516.8 Logistic Transit Drop Test, modified to use the drop heights specified in Table 1.	ENV0582, ETR0903

Mass of Package	Height of Drop	Number of Drops
0 kg to 25 kg	75 cm	Drop on each face and corner. Total of 26 drops.
25 kg to 50 kg	75 cm	Drop on each corner. Total of 8 drops.
50 kg to 100 kg	35 cm	Drop on each bottom edge and bottom face. Total of 5 drops.
>100 kg	25 cm	Drop on each bottom edge and bottom face. Total of 5 drops

Table 1: Modified drop heights for logistic transit drop test.

7 DC Power Supply Requirements

7.1 Functional and Performance Requirements

This section describes the functional and performance requirements for each sub-system of the Power Supply System.

7.1.1 –48V Power Plant System

The Power Plant requirements are shown in the table below.

Parameter	Req. #	Value	Traceability
AC Voltages Available	PSU0101	The –48V Power Plant shall utilize 480V/277V or 208V/120V 60 Hz AC Power.	ERT0819, Local Interface Requirement
AC Input Voltage Tolerance	PSU0102	The –48V Power Plant system shall tolerate AC voltage variations of +/– 10%	ETR0820, Local Interface Requirement
Battery Use	PSU0103	The Batteries shall not be used in the ngVLA system except in the case of the antenna DC Power Supply system.	ETR0817

7.1.2 DC Power Supply Modules

The DC Power Supply module requirements are shown in the table below.

Parameter	Req. #	Value	Traceability
–48 VDC Tolerance	PSU0121	All devices on the –48 VDC system shall tolerate voltages from –42.0 VDC to –60.0 VDC.	ETR0822, Local Interface Requirement
DC Output Tolerance	PSU0122	All DC Power Supply modules shall have an output tolerate +/– 10% of the rated voltages unless specifically stated otherwise.	ETR0823, Local Interface Requirement

7.2 Interface Requirements

In this section, requirements are derived from the applicable ICDs as listed in Section 2.2. As stated in the SEMP [AD01], ICDs define the interface, but do not contain any requirements. All interface requirements that drive the design and verification of the subsystem shall be listed in this section.

7.2.1 –48V Power Plant System Interface Requirements

The Power Plant System receives 208V 3 phase AC and converts it to –48V DC. Lithium batteries will be used as a backup source for the –48V in the event the AC is lost. The Power Plant will act as a battery charger when AC is available. The Power Plant and batteries will be located in the pedestal area of each antenna. The –48V is then fed into multiple power supply modules that convert the –48V to five or six voltage outputs depending on the module location. The Power Plant is also used to power the Fire Alarm, Ethernet switch, Digital Back End (DBE) and Data Transmission System (DTS). The interfaces between the Power Plant and these modules will be detailed in the Antenna Electronics to DC Power Supply Interface Control Document (ICD) [AD20].

Parameter	Req. #	Value	Traceability
AC to Power Plant	PSU0201	The –48V Power Plant input shall require 208V 3 Phase AC @ ~36A.	[AD20], ETR0819, Local Interface requirement
Power Plant to Batteries	PSU0202	The –48V Power Plant shall include an Upper Voltage fail-safe limit of 53.5 VDC or lower and a fail-safe low voltage limit or Low Voltage Disconnect of 41.9VDC or higher to prevent over discharge.	[AD20], [AD22]
Power Plant to Pedestal Power Supply Module	PSU0203	The –48V Power Plant shall deliver –48 VDC @ ~12A to the Pedestal Power Supply Module, which shall tolerate voltages from –42.0 VDC to –60.0 VDC.	[AD20], ETR0821, ETR0822
Power Plant to Auxiliary Power Supply Module	PSU0204	The –48V Power Plant shall deliver –48 VDC @ ~3A to the Auxiliary Power Supply Module, which shall tolerate voltages from –42.0 VDC to –60.0 VDC.	[AD20], ETR0821, ETR0822
Power Plant to Front End Power Supply Module	PSU0205	The –48V Power Plant shall deliver –48 VDC @ ~61A to the Front End Power Supply Module, which shall tolerate voltages from –42.0 VDC to –60.0 VDC.	[AD20], ETR0821, ETR0822
Power Plant to CRYO/EEC Power Supply Module	PSU0206	The –48V Power Plant shall deliver –48 VDC @ ~3A to the CRYO/EEC Power Supply Module, which shall tolerate voltages from –42.0 VDC to –60.0 VDC.	[AD20], ETR0821, ETR0822
Power Plant to Water Vapor Radiometer System	PSU0207	The –48V Power Plant shall deliver –48 VDC @ ~11A to the Water Vapor System, which shall tolerate voltages from –42.0 VDC to –60.0 VDC.	[AD20], ETR0821, ETR0822
Power Plant to Digital BE & Data Transmission System	PSU0208	The –48V Power Plant shall deliver –48 VDC @ ~10A to the Digital BE & Data Transmission System, which shall tolerate voltages from –42.0 VDC to –60.0 VDC.	[AD20], ETR0821, ETR0822
Power Plant to Fire Alarm	PSU0209	The –48V Power Plant shall deliver –48 VDC @ ~2A to the Fire Alarm, which shall tolerate voltages from –42.0 VDC to –60.0 VDC.	[AD20], ETR0821, ETR0822
Power Plant to Ethernet Switch	PSU0210	The –48V Power Plant shall deliver –48 VDC @ ~2A to the Ethernet Switch, which shall tolerate voltages from –42.0 VDC to –60.0 VDC.	[AD20], ETR0821, ETR0822

7.2.2 Pedestal Power Supply Module Interface Requirements

The Pedestal Power Supply module is used to power the Monitor and Control (M&C) and LO Reference Receiver Generator and Distribution module. This power supply module will be located inside the Pedestal room. The interfaces between the Pedestal Power Supply and the electronics in the Pedestal Room will be detailed in the Antenna Electronics to DC Power Supply Interface Control Document (ICD) [AD20].

Parameter	Req. #	Value	Traceability
Pedestal Power Supply Module to M&C Modules	PSU0221	The –48V Pedestal Power Supply Module shall supply M&C Modules with +17.5V @ ~1A, +7.5V @ ~1A, +5V @ ~2A and -17.5V @ ~1A.	[AD20], ETR0821, ETR0823
Pedestal Power Supply Module to Lo Reference Receiver Generator and Distribution Module	PSU0222	The –48V Pedestal Power Supply Module shall supply the LO Reference Receiver Generator and Distributor module with +17.5V @ ~2.5A, +7.5V @ ~1.5A, +5V @ ~2A, -7.5V @ ~250 mA, and -17.5V @ ~250 mA.	[AD20], ETR0821, ETR0823

7.2.3 Auxiliary Power Supply Module Interface Requirements

The Auxiliary Power Supply module is used to power the VFD Control M&C module. This power supply module will be located inside the Auxiliary Enclosure. The interfaces between the Auxiliary Power Supply and the VFD Control M&C module will be detailed in the Antenna Electronics to DC Power Supply Interface Control Document (ICD) [AD20].

Parameter	Req. #	Value	Traceability
Auxiliary Power Supply Module to VFD M&C Modules	PSU0231	The Auxiliary Power Supply Module shall supply the VFD M&C Module with +17.5V @ ~1A, +7.5V @ ~1A, +5V @ 2A, and -17.5V @ ~1A.	[AD20], ETR0821, ETR0823

7.2.4 Front End Power Supply Module Interface Requirements

The Front End (FE) Power Supply module is used to power sixteen Integrated Downconverter/Digitizers (IRD) for Bands 1–6, the LO Reference Sample Clock Generator and LO A-O Generator modules, M&C module, the FE, Low Noise Amplifier (LNA) noise diodes, and bias voltages for Bands 1–6. This module will be located inside the Front-End Enclosure. The interfaces between the FE Power Supply and the electronics in the FE enclosure will be detailed in the Antenna Electronics to DC Power Supply Interface Control Document (ICD) [AD20].

Parameter	Req. #	Value	Traceability
Front End Power Supply Module to Front End	PSU0241	The FE Power Supply Module shall supply the FE Module with +32V @ ~500 mA, +17.5V @ ~6A, +5V @ ~500 mA, and –7.5V @ ~500 mA.	[AD20], ETR0821, ETR0823

Parameter	Req. #	Value	Traceability
Front End Power Supply Module to Integrated Downconvert /Digitizer	PSU0242	The FE Power Supply Module shall supply the IRD Modules with +17.5V @ ~10 mA, +7.5V @ ~1A, +5V @ ~1A, -7.5V @ ~100 mA, and –17.5V @ ~10 mA.	[AD20], ETR0821, ETR0823
Front End Power Supply Module to LO Clock Receiver and LO Reference Sample Clock Generator	PSU0243	The FE Power Supply Module shall supply the LO Clock Modules with +17.5V @ ~2.5A, +7.5V @ ~1.5A, +5V @ ~2A, -7.5V @ ~250 mA, and -17.5V @ ~250 mA.	[AD20], ETR0821, ETR0823
Front End Power Supply Module to M&C Module	PSU0244	The FE Power Supply Module shall supply M&C Modules with +17.5V @ ~1A, +7.5V @ ~1A, +5V @ ~2A, and –17.5V @ ~1A.	[AD20], ETR0821, ETR0823

7.2.5 CRYO/EEC Power Supply Module Interface Requirements

The CRYO/EEC Power Supply module is used to power the M&C module that monitors the Helium Pressure Regulator Electronics and the Helium Compressor VFD. This Power Supply will be located inside the CRYO/EEC Enclosure. The interfaces between the CRYO/EEC Power Supply and the M&C module will be detailed in the Antenna Electronics to DC Power Supply Interface Control Document (ICD) [AD20].

Parameter	Req. #	Value	Traceability
Cryo Power Supply Module to M&C Module	PSU0251	The Cryo Power Supply Module shall supply M&C Module with +17.5V @ ~1A, +7.5V @ ~1A, +5V @ ~2A, and -17.5V @ ~1A.	[AD20], ETR0821, ETR0823

7.3 Monitor and Control Requirements

The expectation with self-monitoring is that the monitor & control system expose lower level sensors to the monitor and control system when queried. The cadence of access is flexible, and is not expected at high rates (typical access might be on second to minute scales). Any high-cadence monitoring should generally be internal to the DC Power Supply System control system with a summary output on the interface. Other features of the M&C interface are to be specified in the DC Power Supply System to Monitor and Control Interface Control Document [AD22].

Parameter	Req. #	Value	Traceability
Watchdogs	PSU0301	All complex DC Power Supply system programmable devices shall utilize watchdog timers and power supervisors to detect lockups and attempt self-recovery.	ETR0908

Parameter	Req. #	Value	Traceability
M&C Commanded Reset	PSU0302	All DC Power Supply system LRUs and complex programmable devices shall be provided with a physical reset line connected to a local M&C device to allow remote reset commands to be sent. This could be implemented as a ganged reset to all devices in an LRU or as individual lines to each device (or group of devices) as determined by the designer.	ETR0909, ETR0912
M&C for DC Power Supply System	PSU0303	The DC Power Supply system shall provide on-board monitoring and diagnostics to determine the health and status of the unit.	SYS3101, SYS3235, SYS3236, ETR0808, ETR0810, ETR0910, ETR0911
Overcurrent Protection Device Monitoring	PSU0304	The DC Power Supply M&C system shall be able to monitor the state of overcurrent protection devices in an LRU. An exception is if the circuit protection device activated disables the LRUs M&C interface. In this situation, the LRU ceases to communicate and should be presumed as bad by the responding technician (i.e. they take a spare with them and swap the LRU after evaluating M&C connections).	SYS2700, SYS2701, ETR0805, ETR0806
On-Site Reset/Start-Up Sequence	PSU0305	The DC Power Supply system shall be able to be started up and shut down locally at the antenna site with no intervention from operations, even in the event of no M&C and/or audio communications between the antenna and array operations.	SYS2700, SYS2309, SAF1230 ETR0809
DC Power Supply System Alerts	PSU0306	When the DC Power Supply system is out of specification, it shall generate a prioritized alert for processing by the operator and maintenance scheduler.	SYS2307, SYS3102,
Subsystem Automation	PSU0307	The DC Power Supply system shall perform system configuration and monitoring functions without the need for human intervention.	SYS3114
Fast Read-Out Modes	PSU0308	Fast-read out modes shall be available for remote engineering diagnostics of the DC Power Supply system.	SYS3105
Self-Diagnostic Function	PSU0309	The DC Power Supply system shall incorporate self-diagnosis functions to identify faults based on recorded monitor data.	SYS2405, ETR0910, ETR0911
Engineering Console	PSU0310	The DC Power Supply System shall include an engineering console for each LRU to communicate system status and assist in real-time diagnosis.	SYS2407

Parameter	Req. #	Value	Traceability
Monitor Data Stream	PSU0311	The DC Power Supply System shall stream monitor data at variable rates (0.1 sec to 10 min) for automated use by predictive maintenance programs and for direct inspection by engineers and technicians.	SYS2408
Remote Identification	PSU0312	Any DC Power Supply system device with any connectivity to the M&C system shall identify itself when polled via the M&C network. Minimum information to be reported includes 1. Module/Model Number 2. Serial Number 3. CID Number which leads to all documentation 4. Hardware Revision Level 5. Software Revision Levels (if applicable) 6. Firmware Revision Levels (if applicable) 7. UID and IUID from Physical tracking tag or device	SYS2406, SYS3600, SYS3602, SYS3603, ETR0403
Power Outage Behavior	PSU0313	All DC Power Supply system electronics shall enact a sequential managed shutdown procedure in response to power outages, placing the system in a safe standby state in order to avoid damage to hardware and minimize recovery time. This low power safe mode may be commanded via the local M&C system or, in the event of lost communications, enacted automatically within the LRU based on the combination of no commands received and monitored local conditions such as temperature or supply voltage.	SYS2700, SYS2309, SYS2601, SYS2602, SYS2701, ETR0810, ETR0811
Automated Recovery Sequence	PSU0314	All DC Power Supply electronics shall enact procedures to autonomously recover from a power outage in a state suitable for normal operations, or at least to a safe state.	SYS2700, SYS2701, ENV0366, ETR0811

7.4 Printed Circuit Board Requirements

Parameter	Req. #	Value	Traceability
Printed Circuit Board IPC Standard Compliance	PSU0401	The DC Power Supply PCBs shall be designed and manufactured to meet IPC Standard IPC-A-600K: Acceptability of Printed Circuits boards.	ETR0701
Printed Circuit Board RoHS Compliance	PSU0402	The DC Power Supply PCBs shall be designed and manufactures to meet RoHS 2 and 3 standards as described in EU Directive 2011/65/EU (8 June 2011) and EU Directive 2015/863 (31 March 2015).	SYS2803, ETR0712

Parameter	Req. #	Value	Traceability
Rigid Printed Circuit Board Material	PSU0403	Rigid DC Power Supply PCBs shall be manufactured from materials specified in and meeting IPC Specification IPC-4101E. The default material is an FR-4 type material defined by NEMA LI 1-1998.	ETR0702
Flexible Printed Circuit Board Material	PSU0404	Flexible DC Power Supply PCBs shall be manufactured from materials specified in and meeting IPC Specification IPC-4202.	ETR0703
Printed Circuit Board Plating/ Surface Finish Material	PSU0405	Rigid DC Power Supply PCBs shall utilize an Electroless Nickel/Immersion Gold (ENIG) surface finish specified in and meeting IPC Specification IPC-4552. Specialized high-performance designs which require specific or advanced plating materials are exempt from this requirement.	ETR0704
Printed Circuit Board Solder Mask Material	PSU0406	Rigid DC Power Supply PCBs shall utilize solder mask specified in and meeting IPC Specification IPC-SM-840E "Qualification and Performance Specification of Permanent Solder Mask".	ETR0705
Printed Circuit Board Solder Mask Color	PSU0407	Rigid DC Power Supply production PCBs using a solder mask shall utilize a solder mask color in the following sequence: Version/Rev: Solder Mask Color A: Green B: Blue C: Red D: Orange E: White F: Black For PCBs beyond F, the sequence repeats.	ETR0707
Printed Circuit Board Marking Material	PSU0408	Rigid DC Power Supply PCBs shall utilize legend and marking inks specified in and meeting IPC Specification IPC-4781 "Qualification and Performance Specification of Permanent, Semi-Permanent and Temporary Legend and/or Marking Inks". PCBs too small or dense to permit inclusion of useful or readable markings, or where inks may interfere with RF properties of the board, are exempt.	ETR0706
Printed Circuit Board Fiducials & Alignment Markings	PSU0409	The DC Power Supply PCBs shall include fiducials and other alignment markings necessary for machine installation of alignment critical components such as Ball Grid Array (BGA) packages.	ETR0716
PCB Identification Markings	PSU0410	The DC Power Supply PCBs shall be marked with the PCB name/function, CID number (to find all associated documents for the board), the revision level and the date the design or revision was completed. Additional information useful to the designer, assembler, or service technician is allowed and encouraged.	SYS3600, ETR0708

Parameter	Req. #	Value	Traceability
PCB Logos	PSU0411	All DC Power Supply PCBs shall include the NRAO logo that is approved at the time the PCB is designed. PCB designers are also permitted to include additional logo(s) identifying the project and/or their organization, however, at least one dimension must be the same size or smaller than the NRAO logo.	ETR0713
Overcurrent Protection	PSU0412	The DC Power Supply system shall implement overcurrent protection on LRUs.	SYS2700, SAF0150, ETR0805, ETR0806
PCB Optimum High-Frequency Performance and Low Emission	PSU0413	The DC Power Supply PCB designer shall analyze their designs and take steps to optimize PCB performance and minimize RF emission. They shall be prepared to discuss their analysis and the techniques used to address the results in the design reviews for their PCBs and subsystems. PCBs designed to operate in the central shielded chambers are exempt from this requirement but the analysis is still recommended.	EMC0310, EMC0322, ETR0714
PCB Power Supply Test Points	PSU0414	The DC Power Supply PCBs shall include labeled and accessible Test Points to be used during development, maintenance and upgrades to verify and/or adjust on-board produced supply voltages.	ETR0709
PCB FPGA Test Points and/or Indicators	PSU0415	The DC Power Supply PCBs utilizing FPGAs shall incorporate test points and/or LED indicators connected to spare pins of the FPGA. These are needed, during development, maintenance and upgrades to verify and debug operation of FPGA firmware.	ETR0710
PCB Critical Signal Test Points	PSU0416	Signals on the DC Power Supply PCBs critical for verifying proper operation of the board or calibrating the board shall be made available on labeled test points.	ETR0711
Color of LEDs Indicating Presence of Power	PSU0417	All DC Power Supply LEDs indicating the presence of power supply voltages shall be Blue. Blue LEDs shall not be used for other purposes unless part of a multicolor RGB or RGBW type LED used to display many colors. When seen by operators or maintenance personnel, BLUE should immediately be only interpretable as "power is applied to this hardware."	SYS2700, SAF0990, ETR1149
Color of LEDs Indicating Fault, Warning or Abnormal Operation	PSU0418	All DC Power Supply LEDs indicating Faults, Warnings, or Abnormal Operation shall be Red. Red LEDs shall not be used for other purposes unless part of a multicolor RGB or RGBW type LED used to display many colors. When seen by operators or maintenance personnel, RED should immediately be interpretable only as "something is not right with this equipment."	SYS2700, SAF0990, ETR1150

Parameter	Req. #	Value	Traceability
LED Brightness	PSU0419	DC Power Supply LEDs shall be operated at the minimum current required to perform their function and shall not be set at a brightness level that causes safety concerns or discomfort to individuals.	SYS2700, SAF0190, SAF0230, ETR1153
Solder Profiles for BGA Packages	PSU0420	For the DC Power Supply PCBs containing BGA or similar packages, sufficient spare PCBs and components shall be procured to be used for building soldering profiles for both assembly and long-term maintenance use.	SYS2801, SYS2805, ETR0715
PCB Design for Automated Assembly & Test	PSU0421	The DC Power Supply PCBs shall be designed with the features needed to support mass production.	ETR0717
PCB Layouts	PSU0422	Layouts of DC Power Supply system electronic circuits and printed circuit boards shall also be provided in electronically readable form. The ngVLA preferred formats are Altium Designer files for electronic circuit diagrams and printed circuit board layouts.	SYS6001, SYS605
Component Sources	PSU0423	DC Power Supply system components shall be sourced from reputable, proven manufacturers, vendors, and/or distributors as determined in the purchase requisition process. The US Government GSA Federal Acquisition Regulations (FAR) in effect at the time of purchase shall be followed where applicable.	SYS2801, SYS2805, ETR0901
Standard Component Libraries	PSU0424	Managed libraries shall be kept of commonly used DC Power Supply electronic components and hardware.	SYS2805, ETR0902
Component Environmental Specifications	PSU0425	DC Power Supply electronic and mechanical components used in the ngVLA system shall always be used in accordance with their specified environmental specifications (storage/operation temperature, humidity, altitude derating, corrosion resistance, etc.)	SYS2801, ENV0332, ENV0333, ENV0582, ENV0571, ENV0521, ENV0531, ENV0342, ETR0903
Soldering and Electrical Connections	PSU0426	All DC Power Supply electronic connections shall follow Class 2 of the IPC J-STD-001G Requirements for Soldered Electrical and Electronic Assemblies. This standard describes the materials, processes and acceptability criteria for producing electronic assemblies. Class 3 may be utilized at the discretion of the Responsible Engineer.	SYS2801, SAF0490, SAF0770, SAF0780, ETR1301

Parameter	Req. #	Value	Traceability
Local Firmware	PSU0427	All DC Power Supply system programmable devices shall have a local copy of the firmware at the antenna site. Firmware for basic functional and diagnostic purposes but that may be configured remotely for normal operation satisfies this requirement.	SYS2601, ETR0906

7.5 RFI and Emissions Requirements

7.5.1 Radio Frequency Interference Radiated Emissions Limits

Parameter	Req. #	Value	Traceability
EMC/RFI Mitigation in Designs	PSU0501	DC Power Supply system's RFI/EMC Requirements shall be in compliance with and tested per the ngVLA System Electromagnetic Compatibility and Radio Frequency Interference Mitigation Requirements	SYS2104, SYS2106, EMC0310, EMC0321, EMC0322, EMC0323, EMC0326, EMC0327, ETR0601
Spurious Signal Level	PSU0502	The DC Power Supply system's spurious signals generated by the system shall not exceed the equivalent isotropic radiated power limits in Table 2 and Table 3 at a distance of 10 m from the nearest receiving element.	SYS2104, EMC0310
Emission Verification Frequencies	PSU0503	The DC Power Supply system's spurious signal emission levels shall be verified by test over a minimum range of 1 GHz up to 12 GHz. Demonstration of EMC above 12 GHz is not required since mitigation at 12 GHz and below is expected to provide a strong indication of performance at higher frequencies. An exception is made for devices that may produce fundamental and harmonic frequencies of LO signals, which shall be tested up to 50 GHz.	SYS2104, EMC0311
Low Frequency Emission	PSU0504	The DC Power Supply system's spurious signal emission levels shall be quantified by test over an extended frequency range of 5 MHz to 1 GHz. While there is no emission threshold within this range, this information shall be collected to inform future system expansion.	SYS2104, EMC0312

ν_G (GHz)	1	3	6	10	30	45	90
$\Delta\nu$ (Hz)	333	1000	2000	3333	10000	15000	30000
F_H (dB(W/m²)/$\Delta\nu$)	−190	−176	−167	−161	−145	−139	−128
S_H (dB(W/m²/Hz))	−215	−206	−200	−196	−185	−181	−173
$EIRP_H$ ((dBm @ 10m)/$\Delta\nu$)	−129	−115	−106	−100	−84	−78	−67
PSD_H ((dBm @ 10m)/Hz)	−154	−145	−139	−135	−124	−120	−112

Table 2: Spectral Line Limits. Allowable radiated power for electronic components, at a distance of 10 from the receiving elements, at 100 m/s spectral resolution.

ν_G (GHz)	1	3	6	10	30	45	90
$\Delta\nu$ (MHz)	1	3	6	10	30	45	90
F_H (dB(W/m²)/$\Delta\nu$)	−172	−159	−149	−143	−128	−122	−111
S_H (dB(W/m²/Hz))	−232	−223	−217	−213	−203	−198	−190
$EIRP_H$ ((dBm @ 10m)/$\Delta\nu$)	−111	−98	−89	−82	−67	−61	−50
PSD_H ((dBm @ 10m)/Hz)	−171	−162	−156	−152	−142	−137	−129

Table 3: Continuum Limits. Allowable radiated power for electronic components, at a distance of 10m from the receiving elements, at 0.1% spectral resolution.

7.5.2 Electromagnetic Emissions Design Requirements

Parameter	Req. #	Value	Traceability
Amplifiers & Oscillators	PSU0521	All amplifiers and oscillators used in the DC Power Supply system shall be mounted in shielded enclosures that will provide effective shielding of radio frequency energy.	SYS2104, EMC0322
Silicone Controlled Rectifiers	PSU0522	The DC Power Supply system silicon-controlled rectifier switching devices shall not be used unless phase controlled and zero current crossing switching techniques are used.	SYS2104, EMC0323
Gaseous Discharge Devices	PSU0523	No gaseous discharge devices shall be employed in DC Power Supply system active circuits, except as noise sources for test and calibration. Use of such devices for lightning and ESD protection is permitted.	SYS2104, EMC0324
Static Discharge Mitigation	PSU0524	Means shall be employed to reduce DC Power Supply static electricity and the consequent radio frequency noise generated in any rotating machinery.	SYS2104, EMC0325

Parameter	Req. #	Value	Traceability
Display Shielding	PSU0525	All displays (LCD, plasma, LED, CRT) used in the DC Power Supply system shall have fully enclosed RFI shields, including an RFI shield in front of the display. This requirement may be waived if the screen is powered off during typical operation and is used for maintenance purposes only. It must be possible to monitor and turn off such emitting devices remotely (via the M&C System).	SYS2104, EMC0326
Digital Equipment Shielding	PSU0526	All digital equipment used in the DC Power Supply system, whether a simple logic circuit, embedded CPU, or rack mounted PC shall be shielded and have its AC or DC power line and communication line(s) filtered at the chassis.	SYS2104, EMC0327

7.6 Immunity Requirements

7.6.1 Performance Criteria

Performance Standard	Description
A	Normal performance within specifications.
B	Temporary loss of function, or degradation of performance, which ceases after the disturbance ceases. The equipment recovers to normal performance, without Operator intervention.
C	Temporary loss of function, or degradation of performance, the correction of which requires Operator or software supervisory system intervention.
D	Loss of function, or degradation of performance, which is not recoverable. Examples include damaged hardware or loss of firmware or software images.

7.6.2 Commercial Off-the-Shelf Equipment

Parameter	Req. #	Value	Traceability
COTS Immunity Standards	PSU0601	Commercial off-the-shelf (COTS) equipment used in the DC Power Supply system shall conform to IEC product family standards for immunity standards, or to the generic standard IEC 61000 – Part 6: Generic Standards if no product family standard is given.	SYS2107, EMC0401
COTS Certification	PSU0602	All commercial equipment used in the DC Power Supply system shall have a CE mark or FCC compliance identification.	SYS2107, EMC0402, SAF0060

7.6.3 Conducted Immunity

Parameter	Req. #	Value	Traceability
AC Input Voltage Fluctuation	PSU0611	The DC Power Supply system shall have an immunity limit for rectangular (step) voltage changes on the AC supply lines be a ±12% change in supply voltage, for a duration of up to 3 sec.	SYS2107, EMC0411
AC Supply Short Voltage Dip	PSU0612	The DC Power Supply system shall have an immunity limit for voltage dips on the AC supply lines be –30% change in supply for a period of 10 msec.	SYS2107, EMC0421
AC Supply Long Voltage Dip	PSU0613	The DC Power Supply system shall have an immunity limit for voltage dips on the AC supply lines be –50% change in supply for a period of 100 msec.	SYS2107, EMC0422
AC Supply Voltage Interruptions	PSU0614	The DC Power Supply system shall have an immunity limit for voltage interruptions on the AC supply lines be a voltage drop of 95% or more for a period of 5 seconds.	SYS2107, EMC0431
AC Supply Burst Immunity	PSU0615	The DC Power Supply system shall conform to MIL-STD-461G CS117 for transients and burst immunity for AC powered systems.	SYS2107, EMC0451
AC Supply Conducted Noise Immunity	PSU0616	The DC Power Supply system shall conform to MIL-STD-461G CS101 conducted susceptibility for all AC powered systems.	SYS2107, EMC0461
DC Input Voltage Fluctuation	PSU0617	The DC Power Supply system shall have an immunity limit for rectangular (step) voltage changes on the DC supply lines be a ±12% change in supply voltage, for a duration of up to 3 sec.	SYS2107, EMC0412
DC Supply Short Voltage Dip	PSU0618	The DC Power Supply system shall have an immunity limit for voltage dips on the DC supply lines be –30% change in supply for a period of 10 msec.	SYS2107, EMC0423
DC Supply Long Voltage Dip	PSU0619	The DC Power Supply system shall have an immunity limit for voltage dips on the DC supply lines be –50% change in supply for a period of 100 msec.	SYS2107, EMC0424
DC Supply Voltage Interruptions	PSU0620	The DC Power Supply system shall have an immunity limit for voltage interruptions on the DC supply lines be a voltage drop of 95% or more for a period of 5 seconds.	SYS2107, EMC0432
DC Supply Burst Immunity	PSU0621	The DC Power Supply system shall conform to MIL-STD-461G CS117 for transients and burst immunity.	SYS2107, EMC0452

Parameter	Req. #	Value	Traceability
DC Supply Conducted Noise Immunity	PSU0622	The DC Power Supply system shall conform to MIL-STD-461G CS101 conducted susceptibility.	SYS2107, EMC0462
Transient Protection of LRU I/O & Power Connections	PSU0623	Transient Voltage Suppression devices shall be used on DC Power Supply system sensitive analog and digital I/O signals and power supplies entering or exiting an LRU.	SYS2403, ETR0818
Surge Protection at Equipment I/O Entry Points	PSU0624	DC Power Supply system's power and signal lines exposed to large potential gradients shall be protected by silicon avalanche diodes at I/O entry points to circuit boards and electronics.	ENV0512, SAF0140, ETR1203

7.6.4 Eletrostatic Discharge (ESD) Requirements

Parameter	Req. #	Value	Traceability
ESD Low Air Discharge	PSU0631	The DC Power Supply system shall conform to MIL-STD-461G CS118 with an air discharge level up to 8kV while meeting performance criteria A. Testing to this discharge level at ESD Compliance Level 4 per IEC 61000-4-2 will also be accepted. Specific exceptions will be considered where components or sub-assemblies are present that are very high value or are known to be vulnerable. In these cases, evaluation will be through analysis of the design and a "best attempt" should be made in design to protect these vulnerable components in the LRUs.	SYS2107, SAF0710, EMC0471, ETR0501
ESD High Air Discharge	PSU0632	The DC Power Supply system shall conform to MIL-STD-461G CS118 with an air discharge level up to 15kV while meeting performance criteria B. Testing to this discharge level at ESD Compliance Level 4 per IEC 61000-4-2 will also be accepted. Specific exceptions will be considered where components or sub-assemblies are present that are very high value or are known to be vulnerable. In these cases, evaluation will be through analysis of the design and a "best attempt" should be made in design to protect these vulnerable components in the LRUs.	SYS2107, SAF0710, EMC0472, ETR0505

Parameter	Req. #	Value	Traceability
ESD Direct Contact Discharge	PSU0633	The DC Power Supply system shall conform to MIL-STD-461G CS118 with a direct contact discharge level up to 8kV while meeting performance criteria A. Testing to this discharge level at ESD Compliance Level 4 per IEC 61000-4-2 will also be accepted. Specific exceptions will be considered where components or sub-assemblies are present that are very high value or are known to be vulnerable. In these cases, evaluation will be through analysis of the design and a "best attempt" should be made in design to protect these vulnerable components in the LRUs.	SYS2107, SAF0710, EMC0473, ETR0506
ESD Protection	PSU0634	ESD protection of DC Power Supply system equipment and workspaces shall be based on USDOD MIL-STD-1686C (RD08) and MIL-HDBK-263B or ANSI/ESD S20.20-2014	SYS3904, ETR0502
Prevention and Discharge of Electrostatic Charge Build-Up	PSU0635	The DC Power Supply system equipment and assemblies made using dielectric materials or coated with nonconductive coatings shall be designed to prevent build up or to dissipate excessive electrostatic charge.	SYS2700, SAF0710, ETR0504

7.7 Bins and Module Requirements

To cut down on weight across the antenna, the M&C Modules and the DC Power Supply Modules will be combined into one housing. The dimensions below are for the DC Power Supply system only.

DC Power Supply System	Equipment Location	Estimated Size	Estimated Weight	Estimated Heat Dissipation	Cooling Method
–48V Power Plant	Electronics Rack in Pedestal Room	2U or 3U (depending on final overall power requirements) 48,26 cm (19") rack mount	20 kg (45 lbs)	250 Watts	Air Cooled
Battery	Backup Battery Enclosure in Pedestal Room	56.4 cm (22.2") x 17.2 cm (6.8") x 56.4 cm (22.2")	72.6 kg (160 lbs)	TBD	Air Cooled
Pedestal Power Supply Module	Electronics Rack in Pedestal Room	ARCS 2U module	6.8 kg (15 lbs)	120 Watts	Liquid Cooled
Auxiliary Power Supply Module	Auxiliary Enclosure	ARCS 2U module	6.8 kg (15 lbs)	100 Watts	Liquid Cooled
Front End Power Supply	Front End Enclosure	ARCS 2U module	8.2 kg (18 lbs)	820 Watts	Liquid Cooled
CRYO/EEC Power Supply	CRYO/EEC Enclosure	ARCS 2U module	6.8 kg (15 lbs)	100 Watts	Liquid Cooled

7.7.1 Wire, Connectors, and Other Hardware Requirements

Parameter	Req. #	Value	Traceability
AC Wiring Colors	PSU0701	All DC Power Supply system AC wiring colors shall conform to US NEC requirements.	SYS2700, SAF1000 SAF1170, ETR1124
Power Plant –48V to –54 VDC Wire Color	PSU0702	–48 to –54 VDC Wiring used in the –48V Power Plant shall be Solid Purple or Violet in color.	ETR1116
DC Power & Signal Return Wire Color	PSU0703	All return wiring for the –48V Power Plant signals shall be Solid Black in color.	SYS2700, ETR1117
+3.3 VDC Wire Color	PSU0704	DC Power Supply system +3.3 VDC wiring shall be Solid Pink in color.	ETR1103
+5.0 VDC Wire Color	PSU0705	DC Power Supply system +5.0 VDC (+4.7 to +5.3 VDC) wiring shall be Orange in color.	ETR1104
+7.5 VDC Wire Color	PSU0706	DC Power Supply system +7.5 VDC (>+5.3 to <+10.0 VDC) wiring shall be White w/Orange stripe.	ETR1105
–5.0 VDC Wire Color	PSU0707	DC Power Supply system –5.0 VDC (–4.7 to –5.3 VDC) wiring shall be Solid Brown in Color.	ETR1106
–7.5 VDC Wire Color	PSU0708	DC Power Supply system –7.5 VDC (>–5.3 to <–10.0 VDC) wiring shall be White w/Brown stripe.	ETR1107
+12 VDC Wire Color	PSU0709	DC Power Supply system +12 VDC (+10.0 to +12.5 VDC) wiring shall be Solid Blue in color.	ETR1108
+15 VDC Wire Color	PSU0710	DC Power Supply system +15 VDC (+14.7 to <+15.5 VDC) wiring shall be Solid Red in color.	ETR1110
+17.5 VDC Wire Color	PSU0711	DC Power Supply system +17.5 VDC (>+15.5 to <+20.0 VDC) wiring shall be White w/Red stripe.	ETR1111
–15 VDC Wire Color	PSU0712	DC Power Supply system –15 VDC (–14.7 to <–15.5 VDC) wiring shall be Solid Yellow in color.	ETR1112
–17.5 VDC Wire Color	PSU0713	DC Power Supply system –17.5 VDC (>–15.5 to <–20.0 VDC) wiring shall be White w/Yellow stripe.	ETR1113
+30> VDC Wire Color	PSU0714	DC Power Supply system >+30 VDC wiring shall be White w/ Grey or Slate.	ETR1115
–48 to –54 VDC Wire Color	PSU0715	DC Power Supply system –48 to –54 VDC wiring shall be Solid Purple or Violet in color.	ETR1116

Parameter	Req. #	Value	Traceability
Earth, Chassis, Safety Ground Wire Color	PSU0716	All Earth, Chassis (structure), and Safety Grounds shall be Solid Green or Green w/a Yellow Stripe in the DC Power Supply system.	SYS2700, SAF0070, ETR1118
TTL Digital Signal (+5V based) Wire Color	PSU0717	Standard TTL level Digital Signal wiring shall be Solid White w/Black and Orange Stripes in the DC Power Supply system.	ETR1119
LVTTL Digital Signal (+3.3V) Wire Color	PSU0718	Standard LVTTL level Digital Signal wiring shall be Solid White w/Black and Violet stripes in the DC Power Supply system.	ETR1120
LVDS Digital Signal Wire Color	PSU0719	Standard LVDS digital signal wiring pairs will be Yellow w/a Blue stripe (+ signal) and Blue w/a Yellow stripe (– signal) in the DC Power Supply system.	ETR1121
Low Voltage Analog Signal Wire Color	PSU0720	Low Voltage Analog Signal Wiring shall be Solid White in color in the DC Power Supply system.	ETR1123
AC Power and Grounding Design	PSU0721	The –48V Power Plant design and installation of all AC Power and Grounding wiring shall conform to US National Electrical Code NFPA 70.	SYS2700, SAF1170, ETR0801
DC Power & Grounding Design	PSU0722	Design and installation of all DC Power Supply system distribution and grounding wiring shall conform to ngVLA System and RFI/EMC requirements.	SYS2700, SYS2106, SAF0070, SAF0080, SAF1170, ETR0802
Wiring Insulation Type	PSU0723	DC Power Supply system low-voltage DC and signal wiring shall utilize Irradiated PVC type insulation certified to meet the UL 1430 specification. This shall be rated at 300 VDC minimum over a temperature range of –55° C to +105° C.	SYS2700, SAF0120, SAF0480, SAF0490, ETR1157
Moisture Protection of Wire & Cables	PSU0724	DC Power Supply system wiring and cables exposed to moisture shall be either UL rated "Wet" or enclosed to prevent exposure.	SYS2700, ENV0591, SAF0080, SAF0120, SAF0140, ETR1126
Riser Grade Cables	PSU0725	DC Power Supply system wiring and cables installed in significant vertical runs shall utilize riser grade cables designed for this application.	SYS2700, SAF0120, SAF0080, ETR1129
Flexible Cables	PSU0726	DC Power Supply system wiring and cables installed in applications where repeated bending and/or small bend radii shall utilize materials specifically designed for this purpose.	SYS2700, SAF0080, SAF0120, SAF0480, SAF0490, ETR1130

Parameter	Req. #	Value	Traceability
Bend Radius	PSU0727	The DC Power Supply system minimum bend radius of all cables shall be limited by the factory specifications for the cable.	SYS2700, SAF0080, SAF0480, SAF0490, ETR1131
Bend Radius Control of Moving Cables	PSU0728	DC Power Supply system cables that move or flex, the minimum bend radius shall be maintained by mechanical means.	SYS2700, SAF0080 SAF0480, SAF0490, ETR1189
Strain Relief and Retention of Wiring & Cables	PSU0729	All DC Power Supply system wiring and cables shall be installed with ample cable retention and strain relief. Unless specifically needed to move, no cables shall be allowed to flex, dangle or present a tripping or entanglement hazard.	SYS2700SAF0480, SAF0490, ETR1132
Connector Current Ratings	PSU0730	All DC Power Supply system connector pin current limits shall be followed. Use of multiple pins to gain an increased current rating shall not be permitted. Where the use of multiple pins is required for signal performance, each pin shall be rated to handle the total current load.	SYS2700, SAF0070, SAF0080, SAF0100, SAF0150, ETR1135
Hot Swapping	PSU0731	All DC Power Supply system connectors utilized in hot swap or live disconnect application shall have pins designed for this application and not allow exposure of dangerous voltages or currents to personnel.	SYS2700, SYS3111, SAF0070, SAF0080, SAF0100, ETR1138
Hot Swap/Live Connection Pin Length	PSU0732	DC Power Supply system connectors used in hot swap or live disconnect applications shall be designed to avoid contact arcing, abnormal current flow and sequencing issues.	SYS2700, SYS3111, SAF0070, SAF0080, SAF0100, ETR1139
Hot Connect & Disconnect Warning Labels	PSU0733	In situations where disconnecting cables or pulling of equipment with power on can cause damage, clearly visible labels shall be applied to warn on this condition in the DC Power Supply system.	SYS2700, ETR0410
Connections in Hot Swap Configuration	PSU0734	DC Power Supply system hardware designed to be hot swapped (i.e. installed or removed with power applied) interconnect shall be designed such that safety grounds, structural grounds, and power returns are connected first on installation and disconnected last on removal.	SYS2700, SAF0070, SAF0080, ETR0815
Connector Environmental Ratings	PSU0735	All DC Power Supply system connectors shall be utilized in accordance with their designed environment.	SYS2700, ENV0591, SAF0080, SAF0140, SAF0480, SAF0490, ETR1136
Connector Mating Cycles	PSU0736	The specified data sheet rating for mating cycles allowed for a connector type shall be followed in the DC Power Supply system	SYS2700, SAF0080, SAF0480, ETR1137

Parameter	Req. #	Value	Traceability
No Exposed Live Terminals	PSU0737	Live signal or power pins in connectors shall not be exposed while connectors are unmated in the DC Power Supply system	SYS2700, SAF0070, SAF0090, ETR1140
Non-RF Connector Uniqueness & Keying	PSU0738	DC Power Supply system non-RF Connectors that are similar or closely located shall be sufficiently unique or keyed to prevent incorrect connectors from being mated.	SYS2700, SAF0070, SAF0730, ETR1141
Common Connectors	PSU0739	DC Power Supply system connectors used repeatedly across multiple devices shall have critical signal pinouts standardized.	SYS2700, SAF0070, SAF0730, ETR1142
Connector Alignment Guides	PSU0740	DC Power Supply system connectors used in blind mate or back plane applications shall utilize some mechanism to ensure alignment of the connector during installation to avoid damage to the connector.	SYS2700, SAF0070, ETR1158
High Insertion Force Connector & Device Support	PSU0741	DC Power Supply system connectors & devices requiring high insertion force shall be adequately supported to prevent damage to the device, connector, cable, chassis or PCB during insertion and removal.	SYS2700, SAF0070, SAF0190, ETR1159
High Insertion Force Connector & Device Ejectors and Tooling	PSU0742	DC Power Supply system assemblies, cables, devices, and PCBs utilizing high insertion force components or connectors shall be equipped with ejectors or other tooling to aid in installation and removal. The design shall not depend on tools such as screwdrivers, pry bars, and hammers for assembly and disassembly.	SYS2700, SAF0070, SAF0190, ETR1160
Crimped Connectors	PSU0743	The DC Power Supply system designer shall use crimped connectors in wiring terminations wherever possible. It is understood that this is not possible for some connector configurations and applications.	ETR1186
Crimped Connector Installation Standard	PSU0744	When using crimped connectors, wire/cable preparation and connector crimping in the DC Power Supply system shall be in accordance with the procedures defined in IPC/WHMA-A-620. "IPC Requirements and Acceptance for Cable and Wire Harness Assemblies"	ETR1187
Cable and Connector Labeling	PSU0745	DC Power Supply system wiring, cables, harnesses, connector shall be labeled in accordance with ANSI Standard TIA-606-C.	SYS2700, ETR1102, ETR1134

Parameter	Req. #	Value	Traceability
Cable and Connector Documentation	PSU0746	All DC Power Supply system wiring, cables, harnesses, and connectors installed in the ngVLA system shall be documented in accordance to ngVLA Drafting and Documentation Standards.	SYS2700, ETR1101, ETR1133
Power On Indicators	PSU0747	The DC Power Supply system LRUs shall contain externally visible LED power indicators indicating "nominal operation" and indicating "power is on but not meeting nominal conditions."	SYS2700, ETR0812
Chromate Converted Surfaces	PSU0748	DC Power Supply system aluminum surfaces where electrical conduction is required (RFI/EMI or safety grounding) shall be treated using a Chromate Conversion process as outlined in MIL-DTL-5541E. Either Class 1A or Class 3 can be used based on requirements determined by the designer.	SYS2106, SYS2700, ENV0591, SAF0080, SAF0140, SAF0490, ETR1143
Anodized Surfaces	PSU0749	DC Power Supply system aluminum Surfaces where no electrical conductivity is required can be anodized. Anodizing shall be of a color not mistakable for chromate (i.e. clear, yellow, brown, or gold). Anodizing shall not be used on surfaces requiring electrical conductivity for RFI/EMI shielding or good safety ground conduction and shall never be scraped or sanded off to achieve this.	SYS2106, SYS2700, ENV0591, SAF0080, SAF0140, SAF0490, ETR1145
Metric Hardware	PSU0750	All of the DC Power Supply system will be assembled utilizing "M" Series metric screws, nuts, and other hardware as defined in ISO 68.1:1998 General Purpose Screw Threads – Basic Profile – Part 1: Metric Screw Threads. It is understood that this will not always be possible. Exemptions will be considered on a case by case basis. Requests for exemptions must be submitted by the Responsible Engineer with justifications to the ngVLA ECCB. Standard RF waveguide flange screws are a known exception and should be considered automatically exempted.	ETR1161
Hardware Labeling	PSU0751	All DC Power Supply system LRUs and assemblies shall contain at least one clearly visible label identifying the type of hardware used within the assembly. Labels will indicate whether "Metric," Imperial," or "Mixed" hardware is used.	ETR1162

Parameter	Req. #	Value	Traceability
Assembly Hardware: Galvanic/ Corrosion Properties	PSU0752	All DC Power Supply system assembly hardware shall be of a material, plating, and/or coating appropriate for its location based on galvanic corrosion properties.	SYS2700, SYS2801, ENV0591, SAF0140, SAF0490, ETR1163
Assembly Hardware: Electrical Properties	PSU0753	All DC Power Supply system hardware shall be of a material, plating, and/or coating appropriate for its location based on electrical conductivity.	SYS2700, SYS2801, SAF0140, SAF0490, ETR1164
Assembly Hardware: Strength Properties	PSU0754	All DC Power Supply system hardware shall be of an appropriate grade and material for its location based on strength.	SYS2700, SYS2801, SAF0140, SAF0490, ETR1165
Heads and Drivers for Pan Head Screws	PSU0755	All DC Power Supply system pan head screws within an LRU shall be of a consistent type drive and utilize a consistent type of maintenance tools.	ETR1166
Heads and Drivers for Flat Head Screws	PSU0756	All DC Power Supply system flat head screws within an LRU shall be of a consistent type drive and utilize a consistent type of maintenance tools.	ETR1167
Heads and Drivers for Cap Head Screws	PSU0757	All DC Power Supply system cap head screws within an LRU shall be of a consistent type drive and utilize a consistent type of maintenance tools.	ETR1168
Hardware Retention	PSU0758	All DC Power Supply system nut and bolt type hardware interfaces shall utilize retention techniques to prevent loosening. Examples include lock washers, adhesives, cotter pins, and safety wiring.	SYS2700, SYS2801, SAF0480, SAF0530, ETR1169
Fastener Torque Specifications	PSU0759	Torques for all fasteners shall be specified on assembly drawings of the DC Power Supply system.	SYS2700, SYS2801, SAF0530, ETR1171
Torque Tooling Calibration	PSU0760	DC Power Supply system tools utilized for setting hardware torques shall be shall calibrated to a traceable external source every 5000 uses or 12 months.	ETR1190
LRU Installation Force	PSU0761	DC Power Supply system LRU level assemblies shall fit together without applying excessive force.	SYS2700, SYS2801, SAF0190, SAF0260, SAF0730, ETR1176
LRU Ease of Replacement	PSU0762	DC Power Supply system LRUs shall be designed with ease of handling and installation/removal in mind. This includes use of handles, eye hooks, etc. These shall be installed to assure proper balance and safe handling of the LRU.	SYS2700, SAF0070, SAF0190, SAF0240, SAF0260, SAF0490, SAF0730, ETR1170, ETR1178

Parameter	Req. #	Value	Traceability
Accessibility for Adjustments & Measurements	PSU0763	Adequate clearances and access shall be provided for adjustments and measurements needed during normal operation and routine maintenance in the DC Power Supply system.	SAF0190, SAF0920, ETR1180
Assembly Cleaning	PSU0764	All DC Power Supply system assemblies shall be fully cleaned after fabrication or repair.	SYS2700, SYS2801, SAF0490, SAF0770, SAF0780, ETR1181
Assembly Inspection	PSU0765	All DC Power Supply system assemblies shall be fully inspected and tested after fabrication or repair.	SYS2700, SYS2801, SAF0490, SAF0770, SAF0780, ETR1182
LRU Orientation	PSU0766	DC Power Supply system LRUs shall be marked or keyed to prevent assembly or installation in an incorrect orientation.	SYS2700, SAF0730, ETR1183
Fasteners in Electrically Conductive Applications	PSU0767	DC Power Supply system anodized and black oxide fasteners shall not be used at mechanical interfaces requiring electrical conductivity to maintain electrical grounds or RFI/EMC integrity.	SYS2700, EMC0310, ETR1184

7.8 Safety and Security Requirements

This section defines all design requirements necessary to support the Level-1 Safety, Security and Cybersecurity requirements derived from [AD03], [AD07] and [AD08].

Parameter	Req. #	Value	Traceability
Safe under hazardous conditions	PSU0801	The DC Power Supply system shall be designed to be used and operable under expected conditions as identified in the hazard analysis. Refer to [AD12] for the procedure.	SYS2700, SAF0080, [AD12]
Identify residual risks	PSU0802	The DC Power Supply system equipment that imposes a residual risk to operators and maintainers shall be labelled to indicate such risks using standard pictograms.	SYS2700, SAF1010
US National Electric Code Compliance	PSU0803	All DC Power Supply system wiring operating at or above 50 Volts DC or 50 Volts RMS AC and all safety grounding shall follow the US NEC.	SYS2700, SAF1170, ETR1001
LRU Physical Ground	PSU0804	DC Power Supply system LRU chassis or housing shall be electrically connected to the antenna structure using a proper grounding wire. This wire can be a separate ground connection or included in the connectorized harness carrying power to the device.	SYS2700, SYS2104, SYS2106, SAF0070, SAF0080, ETR0804

Parameter	Req. #	Value	Traceability
Grounding Conflict Resolution	PSU0805	DC Power Supply system conflicts between safety grounding being compliant with the NEC and grounding designed for low noise shall be documented and brought to the attention of the Project Engineer and ECCB for analysis and resolution.	SYS2700, SYS2104, SYS2106, EMC0310, ETR1002
Power Supply Dedicated Returns	PSU0806	All DC Power Supply system shall have dedicated current return paths.	SYS2700, SYS2104, SYS2106, EMC0310, SAF0070, SAF0080, ETR0813
Power Supply Returns Separate from Ground	PSU0807	DC Power Supply system Structural/Chassis components and signal grounds shall never be used as a power supply return path.	SYS2700, SYS2104, SYS2106, EMC0310, SAF0070, ETR0814
Safe Electrical Connections	PSU0808	The DC Power Supply system equipment, together with its component parts, shall be safe to disconnect, disassemble, assemble and connect.	SAF0070
Electrical contact protection	PSU0809	The DC Power Supply system equipment shall provide adequate protection to prevent injury from direct or indirect electrical contact during operation, inspection, and routine maintenance.	SYS2700, SAF0070, SAF0090, ETR1003, ETR1006
Electrical Contact during Diagnosis & Repair	PSU0810	In situations where exposure to terminals or high voltages (i.e. at or above 50 Volts DC or 50 Volts RMS AC) must be possible during in-depth diagnosis and repair, DC Power Supply system procedures for minimizing risk of contact shall be provided in a maintenance manual for the subsystem or equipment under repair.	SYS2700, SAF0070, SAF0090, ETR1004, ETR1007
Discharge of Capacitors Operating at High Voltages	PSU0811	Any DC Power Supply system capacitor operating at 50 VDC or above shall be provided with a resistive path to discharge the capacitor to safe levels within 60 seconds of the circuit being de-energized. This discharge circuitry shall operate regardless of the condition of downstream electronics.	SYS2700, SAF0940, ETR1005
Safety Interlocks	PSU0812	DC Power Supply system shall use safety interlocks in situations where high voltages (i.e. >= 50 Volts) could be exposed.	SYS2700, SAF0070, SAF0090, SAF0930, ETR1017

Parameter	Req. #	Value	Traceability
Electrical equipment safe use labelling	PSU0813	The DC Power Supply system equipment shall be marked to indicate the conditions of its safe application/use. Where such marking on product is not practical, the marking shall refer to applicable user documentation.	SAF0065
High Voltage Labels	PSU0814	Any DC Power Supply system equipment or assembly containing voltages above 50 Volts DC or 50 Volts RMS AC shall contain at least one clearly visible "High Voltage" label.	SYS2700, ETR1008
Battery Labels	PSU0815	The Power Plant system shall contain at least one clearly visible label indicating the presence of the battery and contain space allowing for permanent marking of the battery install date.	SYS2700, ETR1009
Power Switch Labels	PSU0816	Any DC Power Supply system equipment containing a power switch shall contain at least one clearly visible label indicating the existence and location of that switch.	SYS2700, ETR1010
Safety Ground Labels	PSU0817	Any DC Power Supply system equipment containing a critical safety ground connection shall contain at least one clearly visible label indicating the existence and location of that connection.	SYS2700, ETR1012
LRU Weight Labels	PSU0818	The DC Power Supply system shall include at least one clearly visible label indicating the weight of the LRU in pounds. The label shall be compliant with applicable standards at the time of installation.	SYS2700, SAF0261, ETR0406
LRU Multiple Person Lift Labels	PSU0819	If any LRU in the DC Power Supply system weighs in excess of 50 lbs (22.68 Kg), a clearly visible label indicating "Multiple Person Lift Required" along with the number of persons required shall be included and its weight. The label shall be compliant with applicable standards at the time of installation.	SYS2700, SAF0261, ETR0407
LRU Physical Marking Label Contents	PSU0820	Each DC Power Supply system LRU shall be marked with the model number/name, serial number and hardware revision level as defined in MIL-STD-13231 and the unique part number	SYS2406, SYS3900, SYS3600, ETR0401
LRU Physical Marking Label Ruggedness	PSU0821	The attached DC Power Supply system LRU Physical Marking Label shall comply with MIL-DTL-15024 ensure durability and longevity of the label.	SYS2700, SYS2801, ENV0341, ENV0342, ENV0343, ENV0344, ENV0562, ENV0591, ETR0409

Parameter	Req. #	Value	Traceability
Safety Instruction Labels	PSU0822	Any critical instructions in the DC Power Supply system that required to safely remove, install or interact with a piece of equipment shall be affixed to the device on at least one clearly visible label.	SYS2700, SAF1010, ETR1014
Arc Flash Hazard Warning Labels	PSU0823	In any situation in the DC Power Supply system where there exists the possibility of generating an arc-flash, clearly visible label(s) shall be affixed stating this hazard. This can include, but is not limited to: connection or disconnection of cables & connectors, installing or removing hot pluggable equipment, or actuating switches & circuit breakers.	SYS2700, SAF0200, SAF1010, ETR1015
Electrical and Optical Label Safety Standards	PSU0824	All DC Power Supply system electrical and optical safety labels shall be compliant with applicable standards at the time of installation.	SYS2700, ETR1016
Dangerous temperatures prohibited	PSU0825	The DC Power Supply system equipment shall provide adequate protection to prevent injury from high/low temperature, arcs and radiation.	SYS2700, SAF0100
Electrical equipment: environmental	PSU0826	The DC Power Supply system equipment shall be safe for use in all operational environmental conditions, for the expected life of the product (e.g. UV radiation).	SYS2700, SAF0080, SAF0120, SAF0140, ETR1125
Use of PPE	PSU0827	The DC Power Supply system equipment that requires the use of Personal Protective Equipment (PPE) to operate or maintain, shall be labelled with the PPE requirements.	SYS2700, SAF0200
Hand movable equipment	PSU0828	The DC Power Supply system equipment to be moved by hand shall be fitted with means to make the machinery easily movable or equipped for picking up (e.g., hand grips) and ease of handling.	SYS2700, SAF0260
Design for stability	PSU0829	The DC Power Supply system equipment shall be stable under all operating conditions without risk of overturning, falling or unexpected movement.	SYS2700, SAF0470
Design for operation stresses	PSU0830	The DC Power Supply system equipment shall withstand all stresses imposed on it during operational conditions.	SYS2700, SAF0480
Identify inspection requirements	PSU0831	The DC Power Supply system equipment shall be delivered with instructions specifying the frequency of inspection and maintenance required for safety reasons.	SYS2700, SAF0500

Parameter	Req. #	Value	Traceability
Limit sharp edges	PSU0832	The DC Power Supply system equipment shall not have sharp edges, sharp angles, or rough surfaces likely to cause injury.	SYS2700, SAF0540, ETR1172
Energy source safety	PSU0833	The DC Power Supply system equipment design shall avoid hazards associated with all energy sources.	SYS2700, SAF0720
Energy source isolation	PSU0834	The DC Power Supply system equipment shall be fitted with means to isolate it from all energy sources. Such isolators shall be clearly identified. Isolators shall be lockable in cases where isolation is provided for extended maintenance areas.	SYS2700, SAF0930
Color code safety identifiers	PSU0835	DC Power Supply system safety signs and labelling shall be colored according to standard safety coloring standards on the DC Power Supply system.	SYS2700, SAF1000
OSHA standards	PSU0836	The DC Power Supply system equipment shall be complaint with applicable regulations from OSHA.	SYS2700, SAF1150

All of the equipment downstream from the DC Power Supply system will be capable of hot swapping. Part or all of the DC Power Supply system will need to be powered down before any maintenance or LRU replacement can be done on the system, except for the rectifiers in the –48V Power Plant. Replacement of the rectifiers in the –48V Power Plant can be hot swapped.

7.9 Reliability, Availability, and Maintainability Requirements

This section defines all RAM requirements and Logistic Support requirements derived from [AD03].

Parameter	Req. #	Value	Traceability
Mean Time Between Maintenance (MTBM)	PSU0901	DC Power Supply system electronics shall have MTBM of 21,000 hours or better.	[AD10]
Equipment Shielding	PSU0902	The DC Power Supply system shall be shielded and have AC power line and communication lines filtered at the chassis.	SYS2104, EMC0327
Modularization	PSU0903	The DC Power Supply system shall have Line Replaceable Units (LRU) to facilitate site maintenance.	SYS2403
Preventive Maintenance Schedules	PSU0904	The DC Power Supply system shall be designed with preventive maintenance (PM) interval no shorter than 1 year.	SYS3201
Use of Failure Analysis in Spares Planning	PSU0905	The DC Power Supply system failure analysis shall be used in the planning of spares inventory.	SYS3204

Parameter	Req. #	Value	Traceability
Electronic Test and Measurement Equipment – Maintenance & Calibration	PSU0906	All DC Power Supply system electronic test equipment used in the development and maintenance of ngVLA electronics shall be maintained and calibrated to traceable external standards on an annual basis or as recommended by the equipment manufacturer (whichever is shorter)	ETR0913
Operations and Maintenance: Transfer of Deliverables	PSU0907	The DC Power Supply system procedures, test equipment, and test software shall be delivered to the Operations and Maintenance staff prior to full operations.	SYS3211
Remote Updates	PSU0908	The DC Power Supply system shall permit the update of individual LRU firmware and software to be performed remotely via a network connection.	SYS3223, ETR0907
Periodic Self-Tests	PSU0909	Any of the DC Power Supply system LRUs with internal M&C capability or connected to an external M&C module shall perform self-tests at power on and on a periodic basis. Selection of the appropriate time the period is left to the designer. Results shall be reported back to the M&C system.	SYS2801, SYS3205, ETR0910
Local Control	PSU0910	The DC Power Supply systems shall not depend on the availability of remotely accessed networked systems.	SYS3224
Antenna Maintenance Personnel	PSU0911	Regular DC Power Supply system maintenance shall be achievable by two technicians with standardized maintenance vehicle.	SYS3230
Field Maintenance LRU	PSU0912	The DC Power Supply system field maintenance shall be achieved through replacement of LRUs as far as possible and should require minimum labor and equipment.	SYS3231
LRU Interchangeability	PSU0913	The DC Power Supply system LRUs should be interchangeable with no on-site calibration, tuning or alignment.	SYS3232
Reliability Analysis	PSU0914	A Reliability, Availability, Maintainability analysis shall be performed by the DC Power Supply designer at the LRU level to locate weak design points and determine whether the design meets the Maintenance and Reliability requirements. ngVLA suggests to apply the Parts Count Method for predicting the reliability of the system as described in the MIL-HDBK-217F, but the designer may propose to use other methods. For non-electronic parts, the values of NPRD-95 or data from manufacturers or other databases may be used. They shall publish these results in a memo and be prepared to discuss their analysis and the techniques used to address the results in the design reviews for their equipment and subsystems.	SYS2801, SYS2802, SYS2805, ETR0904

Parameter	Req. #	Value	Traceability
Robustness Analysis	PSU0915	DC Power Supply system designs shall be subject to a robustness analysis. Results of this analysis are a required part of the design review process.	SYS2601, SYS2602, SYS2801, SYS2802, SYS2805, ETR0905
Report Failure Information	PSU0916	DC Power Supply system maintenance significant items shall report failures and failure isolation information and configuration information, via the M&C system.	SYS3235
Report Predicted Failures	PSU0917	DC Power Supply system maintenance significant items, where possible, shall report fault prediction sensor data via the M&C system.	SYS3236

7.10 Configuration and Document Management Requirements

This section defines Configuration Management requirements and Documentation requirements, derived from [AD03]. Any deviation shall be agreed to by ngVLA.

Parameter	Req. #	Value	Traceability
Identification by Serial Numbers	PSU1001	All DC Power Supply system configuration items shall be uniquely identifiable to facilitate status and location tracking across the Observatory. Identification for LRUs shall be both visible and electronic.	SYS2406, SYS3600, SYS3603, ETR0403
LRU Physical Tracking Device	PSU1002	Each DC Power Supply system LRU shall be equipped with a standardized physical tracking label or device, e.g., bar code or RFID tags, which provides for quick and unique identification via a UID and IUID as described in US DoD Standard MIL-P-19834. UID and IUID data used in the ngVLA project will be generated by NRAO.	SYS2406, SYS3233, SYS3600, SYS3900, SYS3902, ETR0402, ETR0405,
LRU Tracking Label & Tag Specifications	PSU1003	The DC Power Supply system physical tracking label and/or device attached to each LRU shall conform to the specifications outlined in US DoD Standards MIL-DTL-15024 and MIL-P-19834.	SYS2801, SYS3600, SYS3900, ETR0405
Language	PSU1004	The language used for DC Power Supply system written documentation shall be English.	SYS6004
Engineering Dimensions	PSU1005	All DC Power Supply system engineering dimensions shall be specified on reviewed design documentation.	ETR1173
Engineering Dimension Units	PSU1006	On reviewed DC Power Supply system manufacturing drawings, engineering dimensions shall be generated according to ISO standards and be specified in the format of "Metric (Imperial) units" for fabrication expected to occur outside of the US. Alternatively, dimensions shall be specified "Imperial (Metric) units" when expected to be fabricated within the US.	SYS6003, ETR1174

Parameter	Req. #	Value	Traceability
Engineering Tolerances	PSU1007	DC Power Supply system engineering tolerances shall be specified on reviewed manufacturing drawings utilizing the same notation as dimensions in ETR1174.	ETR1175
Version Control for Software and Firmware	PSU1008	All DC Power Supply system custom software and firmware delivered as part of the system shall be version controlled via a configuration management process.	SYS3602
Electronic Document Format	PSU1009	The DC Power Supply system electronic document formats are Microsoft Word and Adobe PDF.	SYS6005
Operations and Maintenance Manuals	PSU1010	The DC Power Supply system Operations and Maintenance Manuals shall be provided.	SYS6002
As-Built Drawings	PSU1011	The DC Power Supply system's preferred CAD system used is AutoDesk Inventor and/or AutoCAD.	SYS6001

7.11 Life Cycle Requirements

This section defines the DC Power Supply Life Cycle requirements, including design & development, AIV and CSV as derived from [AD03].

Parameter	Req. #	Value	Traceability
Design Life	PSU1101	The DC Power Supply system shall be designed to be operated and supported for a period of 30 years.	SYS2801
Cost Optimization	PSU1102	The DC Power Supply system design shall minimize its lifecycle cost for 20 years of operation.	SYS2802
Sustainability	PSU1103	The DC Power Supply system sustainability and long-term environmental impact shall be considered in any material or design trade-study.	SYS2803
Part Selection for Maintainability	PSU1104	The DC Power Supply system Individual component selection criteria shall include the projected continuity of support for the component or interchangeable equivalents over the system design life.	SYS2805
Critical Spares	PSU1105	The DC Power Supply system critical spares shall be identified and provided with sufficient inventory to support the facility for its operational life.	SYS2812

8 Key Performance Parameters (KPPs)

Key Performance Parameters (KPPs) identify critical subsystem capabilities or characteristics that may either have a detrimental impact on the effectiveness of efficiency of the system if not met, or could have a very large positive impact if the specification is exceeded. Subsystem KPPs typically support System KPPs and there should be traceability between them. Each KPP must have a threshold range and objective value. The responsible engineer designs the subsystem to meet the objective value, but performance within the threshold range is considered acceptable. During the design phase, there should be a concerted effort to optimize the KPPs. If the responsible engineer finds that the minimum threshold level of a KPP cannot be achieved the project office shall be notified immediately.

Key Performance Parameter	Req. #	Traceability L1 Req. #
KPP name/description: Power Plant Size Objective value: 100A to Antenna electronics Threshold range: Over 100A will require bigger Power Plant (>2U)	PSU0001	[AD20]
KPP name/description: Final Power Requirement and Battery Objective value: 80A to Antenna electronics Threshold range: Over 80A will require an additional battery	PSU0105	SYS2700, SYS2801, ETR0817

Table 4: Subsystem Key Performance Parameters.

9 Verification

The design will be verified to meet the requirements by analysis (A), inspection (I), demonstration (D), or test (T), each defined below.

Verification by Analysis: The compliance of the subsystem to the requirement is demonstrated by appropriate analysis (hand calculations, finite element analysis, modeling and simulation, etc.).

Verification by Inspection: The compliance of the subsystem to the requirement is determined by a simple inspection of the subsystem or of its design documentation.

Verification by Demonstration: The compliance of the subsystem to the requirement is determined by a demonstration.

Verification by Test: The compliance of the subsystem to the requirement is determined by means of a test with and associated analysis of test data.

Multiple verification methods are allowed over the course of the design phase. The primary (final) verification method to be used for the product during the qualification phase prior to its Critical Design Review is identified below.

9.1 Verification Methods

Req. #	Parameter/Requirement	A	I	D	T
PSU0001	AC to DC Conversion		*		
PSU0002	DC Power Supply Module Input Voltage		*		
PSU0003	LRU Power Input		*		

Req. #	Parameter/Requirement	A	I	D	T
PSU0004	RFI Emission Threshold				*
PSU0005	Number of Batteries Needed	*			
PSU0011	Altitude Range	*			
PSU0012	Thermal Protection				*
PSU0013	Thermal Protection Monitoring			*	
PSU0014	Thermal Analysis	*			
PSU0015	Lightning Protection, Electronics Systems	*			
PSU0016	Equipment Protection Against Dust		*		
PSU0017	Rodent Protection		*		
PSU0018	Vibration				*
PSU0021	Power Supply System Temperature (Except Batteries)	*			
PSU0022	Power Supply Battery Ambient Temperature	*			
PSU0031	Power Supply System Temperature (Except Batteries)	*			
PSU0032	Power Supply Battery Ambient Temperature	*			
PSU0041	Power Supply System Temperature (Except Batteries)	*			
PSU0042	Power Supply Battery Ambient Temperature	*			
PSU0051	Power Supply System Storage Temperature Requirements (Except Batteries)	*			
PSU0052	Battery Storage Requirements			*	
PSU0053	Storage Humidity	*			
PSU0054	ESD Packaging and Storage	*			
PSU0055	Transportation Temperature	*			
PSU0056	Design for Transportation				*
PSU0057	Mechanical Shock				*
PSU0101	AC Voltages Available			*	
PSU0102	AC Input Voltage Tolerance	*			
PSU0103	Battery Use		*		
PSU0121	–48 VDC Tolerance				*
PSU0122	DC Output Tolerance				*
PSU0201	AC to Power Plant				*
PSU0202	Power Plant to Batteries				*
PSU0203	Power Plant to Pedestal Power Supply Module				*
PSU0204	Power Plant to Auxiliary Power Supply Module				*
PSU0205	Power Plant to Front End Power Supply Module				*
PSU0206	Power Plant to CRYO/EEC Power Supply Module				*
PSU0207	Power Plant to Water Vapor Radiometer Power Supply Module				*
PSU0208	Power Plant to Digital BE & Data Transmission System				*
PSU0209	Power Plant to Fire Alarm				*
PSU0210	Power Plant to Ethernet Switch				*
PSU0221	Pedestal Power Supply Module to M&C Modules				*
PSU0222	Pedestal Power Supply Module to LO Reference Receiver Generator and Distribution Module				*
PSU0231	Auxiliary Power Supply Module to VFD M&C Modules				*
PSU0241	Front End Power Supply Module to Front End				*

Req. #	Parameter/Requirement	A	I	D	T
PSU0242	Front End Power Supply Module to Integrated Downconverter/Digitizer				*
PSU0243	Front End Power Supply Module to LO Clock Receiver and LO Reference Sample Clock Generator				*
PSU0244	Front End Power Supply Module to M&C Module				*
PSU0251	Cryo Power Supply Module to M&C Module				*
PSU0301	Watchdogs				*
PSU0302	M&C Commanded Reset			*	
PSU0303	M&C for DC Power Supply System			*	
PSU0304	Overcurrent Protection Device Monitoring				*
PSU0305	On-Site Reset/Start-Up Sequence				*
PSU0306	DC Power Supply System Alerts			*	
PSU0307	Subsystem Automation			*	
PSU0308	Fast Read-Out Modes			*	
PSU0309	Self-Diagnostic Function			*	
PSU0310	Engineering Console			*	
PSU0311	Monitor Data Stream			*	
PSU0312	Remote Identification			*	
PSU0313	Power Outage Behavior			*	
PSU0314	Automated Recovery Sequence			*	
PSU0401	Printed Circuit Board IPC Standard Compliance			*	
PSU0402	Printed Circuit Board RoHS Compliance			*	
PSU0403	Rigid Printed Circuit Board Material			*	
PSU0404	Flexible Printed Circuit Board Material			*	
PSU0405	Printed Circuit Board Plating/ Surface Finish Material			*	
PSU0406	Printed Circuit Board Solder Mask Material			*	
PSU0407	Printed Circuit Board Solder Mask Color			*	
PSU0408	Printed Circuit Board Marking Material			*	
PSU0409	Printed Circuit Board Fiducials & Alignment Markings		*		
PSU0410	PCB Identification Markings		*		
PSU0411	PCB Logos		*		
PSU0412	Overcurrent Protection				*
PSU0413	PCB Optimum High-Frequency Performance and Low Emission	*			
PSU0414	PCB Power Supply Test Points				*
PSU0415	PCB FPGA Test Points and/or Indicators				*
PSU0416	PCB Critical Signal Test Points				*
PSU0417	Color of LEDs Indicating Presence of Power				*
PSU0418	Color of LEDs Indicating Fault, Warning, or Abnormal Operation				*
PSU0419	LED Brightness				*
PSU0420	Solder Profiles for BGA Packages				*
PSU0421	PCB Design for Automated Assembly & Test				*
PSU0422	PCB Layouts		*		
PSU0423	Component Sources	*			
PSU0424	Standard Component Libraries	*			
PSU0425	Component Environmental Specifications	*			

Req. #	Parameter/Requirement	A	I	D	T
PSU0426	Soldering and Electrical Connections				*
PSU0427	Local Firmware				*
PSU0501	EMC/RFI Mitigation in Designs				*
PSU0502	Spurious Signal Level				*
PSU0503	Emission Verification Frequencies				*
PSU0504	Low Frequency Emission				*
PSU0521	Amplifiers & Oscillators				*
PSU0522	Silicone Controlled Rectifiers	*			
PSU0523	Gaseous Discharge Devices		*		
PSU0524	Static Discharge Mitigation	*			
PSU0525	Display Shielding		*		
PSU0526	Digital Equipment Shielding		*		
PSU0601	COTS Immunity Standards			*	
PSU0602	COTS Certification		*		
PSU0611	AC Input Voltage Fluctuation		*		
PSU0612	AC Supply Short Voltage Dip		*		
PSU0613	AC Supply Long Voltage Dip		*		
PSU0614	AC Supply Voltage Interruptions				*
PSU0615	AC Supply Burst Immunity		*		
PSU0616	AC Supply Conducted Noise Immunity				*
PSU0617	DC Input Voltage Fluctuation				*
PSU0618	DC Supply Short Voltage Dip				*
PSU0619	DC Supply Long Voltage Dip				*
PSU0620	DC Supply Voltage Interruptions				*
PSU0621	DC Supply Burst Immunity				*
PSU0622	DC Supply Conducted Noise Immunity				*
PSU0623	Transient Protection of LRU I/O & Power Connections	*			
PSU0624	Surge Protection at Equipment I/O Entry Points				*
PSU0631	ESD Low Air Discharge				*
PSU0632	ESD High Air Discharge				*
PSU0633	ESD Direct Contact Discharge				*
PSU0634	ESD Protection	*			
PSU0635	Prevention and Discharge of Electrostatic Charge Build-Up				*
PSU0701	AC Wiring Colors			*	
PSU0702	Power Plant –48V to -54 VDC Wire Color			*	
PSU0703	DC Power & Signal Return Wire Color			*	
PSU0704	+3.3 VDC Wire Color			*	
PSU0705	+5.0 VDC Wire Color			*	
PSU0706	+7.5 VDC Wire Color			*	
PSU0707	–5.0 VDC Wire Color			*	
PSU0708	–7.5 VDC Wire Color			*	
PSU0709	+12 VDC Wire Color			*	
PSU0710	+15 VDC Wire Color			*	
PSU0711	+17.5 VDC Wire Color			*	
PSU0712	–15 VDC Wire Color			*	
PSU0713	–17.5 VDC Wire Color			*	

Req. #	Parameter/Requirement	A	I	D	T
PSU0714	+30> VDC Wire Color			*	
PSU0715	–48 to –54 VDC Wire Color			*	
PSU0716	Earth, Chassis, Safety Ground Wire Color			*	
PSU0717	TTL Digital Signal (+5V based) Wire Color			*	
PSU0718	LVTTL Digital Signal (+3.3V) Wire Color			*	
PSU0719	LVDS Digital Signal Wire Color			*	
PSU0720	Low Voltage Analog Signal Wire Color			*	
PSU0721	AC Power and Grounding Design	*			
PSU0722	DC Power & Grounding Design	*			
PSU0723	Wiring Insulation Type	*			
PSU0724	Moisture Protection of Wire & Cables			*	
PSU0725	Riser Grade Cables			*	
PSU0726	Flexible Cables	*			
PSU0727	Bend Radius	*			
PSU0728	Bend Radius Control of Moving Cables	*			
PSU0729	Strain Relief and Retention of Wiring & Cables	*			
PSU0730	Connector Current Ratings	*			
PSU0731	Hot Swapping	*			
PSU0732	Hot Swap/Live Connection Pin Length	*			
PSU0733	Hot Connect & Disconnect Warning Labels			*	
PSU0734	Connections in Hot Swap Configuration			*	
PSU0735	Connector Environmental Ratings	*			
PSU0736	Connector Mating Cycles	*			
PSU0737	No Exposed Live Terminals	*			
PSU0738	Non-RF Connector Uniqueness & Keying			*	
PSU0739	Common Connectors	*			
PSU0740	Connector Alignment Guides	*			
PSU0741	High Insertion Force Connector & Device Support	*			
PSU0742	High Insertion Force Connector & Device Ejectors and Tooling	*			
PSU0743	Crimped Connectors			*	
PSU0744	Crimped Connector Installation Standard			*	
PSU0745	Cable and Connector Labeling		*		
PSU0746	Cable and Connector Documentation		*		
PSU0747	Power On Indicators			*	
PSU0748	Chromate Converted Surfaces			*	
PSU0749	Anodized Surfaces			*	
PSU0750	Metric Hardware			*	
PSU0751	Hardware Labeling			*	
PSU0752	Assembly Hardware: Galvanic/Corrosion Properties	*			
PSU0753	Assembly Hardware: Electrical Properties	*			
PSU0754	Assembly Hardware: Strength Properties	*			
PSU0755	Heads and Drivers for Pan Head Screws			*	
PSU0756	Heads and Drivers for Flat Head Screws			*	
PSU0757	Heads and Drivers for Cap Head Screws			*	
PSU0758	Hardware Retention			*	
PSU0759	Fastener Torque Specifications			*	

Req. #	Parameter/Requirement	A	I	D	T
PSU0760	Torque Tooling Calibration		*		
PSU0761	LRU Installation Force				*
PSU0762	LRU Ease of Replacement			*	
PSU0763	Accessibility for Adjustments & Measurements			*	
PSU0764	Assembly Cleaning		*		
PSU0765	Assembly Inspection		*		
PSU0766	LRU Orientation			*	
PSU0767	Fasteners in Electrically Conductive Applications			*	
PSU0801	Safe Under Hazardous Conditions	*			
PSU0802	Identify Residual Risks	*			
PSU0803	US National Electric Code Compliance	*			
PSU0804	LRU Physical Ground		*		
PSU0805	Grounding Conflict Resolution	*			
PSU0806	Power Supply Dedicated Returns			*	
PSU0807	Power Supply Returns Separate from Ground		*		
PSU0808	Safe Electrical Connections	*			
PSU0809	Electrical Contact Protection	*			
PSU0810	Electrical Contact during Diagnosis & Repair	*			
PSU0811	Discharge of Capacitors Operating at High Voltages	*			
PSU0812	Safety Interlocks			*	
PSU0813	Electrical Equipment Safe Use Labelling		*		
PSU0814	High Voltage Labels		*		
PSU0815	Battery Labels		*		
PSU0816	Power Switch Labels		*		
PSU0817	Safety Ground Labels		*		
PSU0818	LRU Weight Labels			*	
PSU0819	LRU Multiple Person Lift Labels			*	
PSU0820	LRU Physical Marking Label Contents			*	
PSU0821	LRU Physical Marking Label Ruggedness				*
PSU0822	Safety Instruction Labels		*		
PSU0823	Arc Flash Hazard Warning Labels			*	
PSU0824	Electrical and Optical Label Safety Standards				*
PSU0825	Dangerous Temperatures Prohibited	*			
PSU0826	Electrical Equipment: Environmental	*			
PSU0827	Use of PPE			*	
PSU0828	Hand Movable Equipment			*	
PSU0829	Design for Stability	*			
PSU0830	Design for Operation Stresses	*			
PSU0831	Identify Inspection Requirements			*	
PSU0832	Limit Sharp Edges		*		
PSU0833	Energy Source Safety	*			
PSU0834	Energy Source Isolation	*			
PSU0835	Color Code Safety Identifiers			*	
PSU0836	OSHA Standards	*			
PSU0901	Mean Time Between Maintenance (MTBM)	*			
PSU0902	Equipment Shielding			*	

Req. #	Parameter/Requirement	A	I	D	T
PSU0903	Modularization			*	
PSU0904	Preventive Maintenance Schedules	*			
PSU0905	Use of Failure Analysis in Spares Planning	*			
PSU0906	Electronic Test and Measurement Equipment – Maintenance & Calibration		*		
PSU0907	Operations and Maintenance: Transfer of Deliverables			*	
PSU0908	Remote Updates			*	
PSU0909	Periodic Self-Tests			*	
PSU0910	Local Control			*	
PSU0911	Antenna Maintenance Personnel			*	
PSU0912	Field Maintenance LRU			*	
PSU0913	LRU Interchangeability			*	
PSU0914	Reliability Analysis	*			
PSU0915	Robustness Analysis	*			
PSU0916	Report Failure Information	*			
PSU0917	Report Predicted Failures	*			
PSU1001	Identification by Serial Numbers			*	
PSU1002	LRU Physical Tracking Device			*	
PSU1003	LRU Tracking Label & Tag Specifications				*
PSU1004	Language			*	
PSU1005	Engineering Dimensions			*	
PSU1006	Engineering Dimension Units			*	
PSU1007	Engineering Tolerances			*	
PSU1008	Version Control for Software and Firmware			*	
PSU1009	Electronic Document Format			*	
PSU1010	Operations and Maintenance Manuals			*	
PSU1011	As-Built Drawings			*	
PSU1101	Design Life	*			
PSU1102	Cost Optimization	*			
PSU1103	Sustainability	*			
PSU1104	Part Selection for Maintainability	*			
PSU1105	Critical Spares	*			

9.2 Verification Requirements

Req. #	Parameter/ Requirement	Verification Requirement
PSU0004	RFI Emission Threshold	Confirm the DC Power Supply architecture meets RFI suppression requirements.
PSU0005	Number of Batteries needed	Verify the number of batteries used will allow the antenna electronics get into safe standby mode before shutting down.
PSU0011	Altitude Range	Verify the DC Power Supply system works from sea level to 2500 meters.
PSU0012	Thermal Protection	Verify the DC Power Supply LRUs are thermally protected.

Req. #	Parameter/ Requirement	Verification Requirement
PSU0014	Thermal Analysis	Verify the designer of the DC Power Supply system analyzed their designs and took steps to optimize thermal performance with a focus on proper cooling, thermal stability and the elimination of hot spots.
PSU0015	Lightning Protection, Electronics Systems	Verify the DC Power Supply systems is protected against Lightning Electromagnetic Impulse (LEMP) in accordance with IEC 62305-4.
PSU0018	Vibration	Verify the DC Power Supply system is designed to withstand persistent vibrations with a power spectral density defined in Figure 4. The system shall also be tested to this specification along all three axes as defined in the MIL-STD-810H Method 514.8 Procedure I for General Vibration for a period of 60 min.
PSU0021	Power Supply System Temperature (Except Batteries)	Verify the DC Power Supply system, except the batteries, is capable of operating normally at –20 C ≤ T ≤ 40 C.
PSU0022	Power Supply Battery Ambient Temperature	Verify the DC Power Supply system batteries are capable of operating normally at –20 C ≤ T ≤ 40 C.
PSU0031	Power Supply System Temperature (Except Batteries)	Verify the DC Power Supply system, except the batteries, is capable of operating in standby at –20 C ≤ T ≤ 40 C.
PSU0032	Power Supply Battery Ambient Temperature	Verify the DC Power Supply system batteries are capable of operating in standby at –20 C ≤ T ≤ 40 C.
PSU0041	Power Supply System Temperature (Except Batteries)	Verify the DC Power Supply system, except the batteries, is capable of surviving at –20 C ≤ T ≤ 40 C.
PSU0042	Power Supply Battery Ambient Temperature	Verify the DC Power Supply system batteries are capable of surviving at –20 C ≤ T ≤ 40 C.
PSU0051	Power Supply System Storage Temperature Requirements (Except Batteries)	Verify the DC Power Supply system, except the batteries, is capable of being stored at –20 C ≤ T ≤ 40 C.
PSU0053	Storage Humidity	Verify the DC Power Supply system batteries are capable of being stored at –20 C ≤ T ≤ 40 C.
PSU0054	ESD Packaging and Storage	Verify the DC Power Supply system is packaged, shipped, and stored in ESD protective packaging and/or equipped with shorting plugs and conductive caps on all external connections.
PSU0055	Transportation Temperature	Verify the DC Power Supply system is capable of being transported at –20 C ≤ T ≤ 40 C.
PSU0056	Design for Transportation	Verify all DC Power Supply system assemblies are designed to survive shipping and transportation. No fragile or insecure assemblies or wiring.

Req. #	Parameter/ Requirement	Verification Requirement
PSU0057	Mechanical Shock	Verify the DC Power Supply system packaged for transportation can survive mechanical shock levels from handling as defined in the MIL-STD-810H Method 516.8 Logistic Transit Drop Test, modified to use the drop heights specified in Table 1.
PSU0102	AC Input Voltage Tolerance	Verify the Power Plant system can tolerate AC voltage variations of +/– 10%.
PSU0121	– 48 VDC Tolerance	Verify the devices on the –48 VDC system can tolerate voltages from –42.0 VDC to –60.0 VDC.
PSU0122	DC Output Tolerance	Verify all DC Power Supply modules have an output tolerate +/– 10% of the rated voltages
PSU0201	AC to Power Plant	Verify the –48V Power Plant input can use 208V 3 Phase AC.
PSU0202	Power Plant to Batteries	Verify the Power Plant includes an Upper Voltage fail-safe limit of 53.5 VDC or lower and a fail-safe low voltage limit or Low Voltage Disconnect of 41.9VDC or higher to prevent over discharge.
PSU0203	Power Plant to Pedestal Power Supply Module	Verify the Power Plant delivers –48 VDC to the Pedestal Power Supply Module with tolerate voltages from –42.0 VDC to –60.0 VDC.
PSU0204	Power Plant to Auxiliary Power Supply Module	Verify the Power Plant delivers –48 VDC to the Auxiliary Power Supply Module with tolerate voltages from –42.0 VDC to –60.0 VDC.
PSU0205	Power Plant to Front End Power Supply Module	Verify the Power Plant delivers –48 VDC to the Front End Power Supply Module with tolerate voltages from –42.0 VDC to –60.0 VDC.
PSU0206	Power Plant to CRYO/EEC Power Supply Module	Verify the Power Plant delivers –48 VDC to the CRYO/EEC Power Supply Module with tolerate voltages from –42.0 VDC to –60.0 VDC.
PSU0207	Power Plant to Water Vapor Radiometer System	Verify the Power Plant delivers –48 VDC to the Water Vapor system with tolerate voltages from –42.0 VDC to –60.0 VDC.
PSU0208	Power Plant to Digital BE & Data Transmission System	Verify the Power Plant delivers –48 VDC to the Digital BE & Data Transmission system with tolerate voltages from –42.0 VDC to –60.0 VDC.
PSU0209	Power Plant to Fire Alarm	Verify the Power Plant delivers –48 VDC to the Fire Alarm with tolerate voltages from –42.0 VDC to –60.0 VDC.
PSU0210	Power Plant to Ethernet Switch	Verify the Power Plant delivers –48 VDC to the Ethernet Switch with tolerate voltages from –42.0 VDC to –60.0 VDC.
PSU0221	Pedestal Power Supply Module to M&C Modules	Verify the Pedestal Power Supply Module supplies M&C Modules with +17.5V @ ~1A, +7.5V @ ~1A, +5V @ ~2A and –17.5V @ ~1A.
PSU0222	Pedestal Power Supply Module to Lo Reference Receiver Generator and Distribution Module	Verify the Pedestal Power Supply Module supplies the LO Reference Receiver Generator and Distributor modules with +17.5V @ ~2.5A, +7.5V @ ~1.5A, +5V @ ~2A, –7.5V @ ~250 mA, and –17.5V @ ~250 mA.

Req. #	Parameter/ Requirement	Verification Requirement
PSU0231	Auxiliary Power Supply Module to VFD M&C Modules	Verify the Auxiliary Power Supply Module supplies the VFD M&C Module with +17.5V @ ~1A, +7.5V @ ~1A, +5V @ 2A, and –17.5V @ ~1A.
PSU0241	Front End Power Supply Module to Front End	Verify the FE Power Supply Module supplies the FE Module with +32V @ ~500 mA, +17.5V @ ~6A, +5V @ ~500 mA, and –7.5V @ ~500 mA.
PSU0242	Front End Power Supply Module to Integrated Downconvert/Digitizer	Verify the FE Power Supply Module supplies the IRD Modules with +17.5V @ ~10 mA, +7.5V @ ~1A, +5V @ ~1A, -7.5V @ ~100 mA, and –17.5V @ ~10 mA.
PSU0243	Front End Power Supply Module to LO Clock Receiver and LO Reference Sample Clock Generator	Verify the FE Power Supply Module supplies the LO Clock Modules with +17.5V @ ~2.5A, +7.5V @ ~1.5A, +5V @ ~2A, -7.5V @ ~250 mA, and –17.5V @ ~250 mA.
PSU0244	Front End Power Supply Module to M&C Module	Verify the FE Power Supply Module supplies M&C Modules with +17.5V @ ~1A, +7.5V @ ~1A, +5V @ ~2A, and –17.5V @ ~1A.
PSU0251	Cryo Power Supply Module to M&C Module	Verify the Cryo Power Supply Module supplies M&C Module with +17.5V @ ~1A, +7.5V @ ~1A, +5V @ ~2A, and –17.5V @ ~1A.
PSU0301	Watchdogs	Verify all complex DC Power Supply system programmable devices utilize watchdog timers and power supervisors to detect lockups and attempt self-recovery.
PSU0304	Overcurrent Protection Device Monitoring	Verify the DC Power Supply M&C system is able to monitor the state of overcurrent protection devices in an LRU. An exception is if the circuit protection device activated disables the LRUs M&C interface. In this situation, the LRU ceases to communicate and should be presumed as bad by the responding technician (i.e. they take a spare with them and swap the LRU after evaluating M&C connections).
PSU0305	On-Site Reset/Start-Up Sequence	Verify the DC Power Supply system is able to be started up and shut down locally at the antenna site with no intervention from operations, even in the event of no M&C and/or audio communications between the antenna and array operations.
PSU0412	Overcurrent Protection	Verify the DC Power Supply system implements overcurrent protection on LRUs.
PSU0413	PCB Optimum High-Frequency Performance and Low Emission	Verify the DC Power Supply PCB designer analyzed their designs and took steps to optimize PCB performance and minimize RF emission.
PSU0414	PCB Power Supply Test Points	Verify the DC Power Supply PCBs includes labeled and accessible Test Points to be used during development, maintenance and upgrades to verify and/or adjust on-board produced supply voltages.

Req. #	Parameter/ Requirement	Verification Requirement
PSU0415	PCB FPGA Test Points and/or Indicators	Verify the DC Power Supply PCBs utilizing FPGAs incorporate test points and/or LED indicators connected to spare pins of the FPGA. These are needed, during development, maintenance and upgrades to verify and debug operation of FPGA firmware.
PSU0416	PCB Critical Signal Test Points	Verify signals on the DC Power Supply PCBs critical for verifying proper operation of the board or calibrating the board are made available on labeled test points.
PSU0417	Color of LEDs Indicating Presence of Power	Verify all LEDs indicating the presence of power supply voltages are Blue. Blue LEDs are not be used for other purposes unless part of a multicolor RGB or RGBW type LED used to display many colors.
PSU0418	Color of LEDs Indicating Fault, Warning or Abnormal Operation	Verify all LEDs indicating Faults, Warnings, or Abnormal Operation are Red. Red LEDs are not be used for other purposes unless part of a multicolor RGB or RGBW type LED used to display many colors.
PSU0419	LED Brightness	Verify LEDs are operated at the minimum current required to perform their function and are not be set at a brightness level that causes safety concerns or discomfort to individuals.
PSU0420	Solder Profiles for BGA Packages	Verify DC Power Supply PCBs containing BGA or similar packages, sufficient spare PCBs and components are procured to be used for building soldering profiles for both assembly and long-term maintenance use.
PSU0421	PCB Design for Automated Assembly & Test	Verify the DC Power Supply PCBs are designed with the features needed to support mass production.
PSU0423	Component Sources	Verify the DC Power Supply system components are sourced from reputable, proven manufacturers, vendors, and/or distributors as determined in the purchase requisition process. The US Government GSA Federal Acquisition Regulations (FAR) in effect at the time of purchase are followed where applicable.
PSU0424	Standard Component Libraries	Verify managed libraries are kept of commonly used electronic components and hardware.
PSU0425	Component Environmental Specifications	Verify electronic and mechanical components used in the ngVLA system are always be used in accordance with their specified environmental specifications (storage/operation temperature, humidity, altitude derating, corrosion resistance, etc.)
PSU0426	Soldering and Electrical Connections	Verify all electronic connections follow Class 2 of the IPC J-STD-001G Requirements for Soldered Electrical and Electronic Assemblies. This standard describes the materials, processes and acceptability criteria for producing electronic assemblies. Class 3 may be utilized at the discretion of the Responsible Engineer.

Req. #	Parameter/ Requirement	Verification Requirement
PSU0427	Local Firmware	Verify all DC Power Supply system programmable devices have a local copy of the firmware at the antenna site. Firmware for basic functional and diagnostic purposes but that may be configured remotely for normal operation satisfies this requirement.
PSU0501	EMC/RFI Mitigation in Designs	Verify RFI/EMC requirements are in compliance with and tested per the ngVLA System Electromagnetic Compatibility and Radio Frequency Interference Mitigation Requirements
PSU0502	Spurious Signal Level	Verify the DC Power Supply spurious signals generated by the system are not exceed the equivalent isotropic radiated power limits in Table 2 and Table 3 at a distance of 10m from the nearest receiving element.
PSU0503	Emission Verification Frequencies	Verify the DC Power Supply spurious signal emission levels are verified by test over a minimum range of 1 GHz up to 12 GHz. Demonstration of EMC above 12 GHz is not required since mitigation at 12 GHz and below is expected to provide a strong indication of performance at higher frequencies. An exception is made for devices that may produce fundamental and harmonic frequencies of LO signals, which shall be tested up to 50 GHz.
PSU0504	Low Frequency Emission	Verify the DC Power Supply spurious signal emission levels are quantified by test over an extended frequency range of 5 MHz to 1 GHz. While there is no emission threshold within this range, this information shall be collected to inform future system expansion.
PSU0521	Amplifiers & Oscillators	Verify all amplifiers and oscillators used in the DC Power Supply are mounted in shielded enclosures that will provide effective shielding of radio frequency energy.
PSU0522	Silicone Controlled Rectifiers	Verify the DC Power Supply silicon-controlled rectifier switching devices are not used unless phase controlled and zero current crossing switching techniques are used.
PSU0524	Static Discharge Mitigation	Verify the means are employed to reduce static electricity and the consequent radio frequency noise generated in any rotating machinery.
PSU0614	AC Supply Voltage Interruptions	Verify the DC Power Supply system has an immunity limit for voltage interruptions on the AC supply lines be a voltage drop of 95% or more for a period of 5 seconds.
PSU0616	AC Supply Conducted Noise Immunity	Verify the DC Power Supply system conforms to MIL-STD-461G CS101 conducted susceptibility for all AC powered systems.
PSU0617	DC Input Voltage Fluctuation	Verify the DC Power Supply system has an immunity limit for rectangular (step) voltage changes on the DC supply lines be a ±12% change in supply voltage, for a duration of up to 3 sec.
PSU0618	DC Supply Short Voltage Dip	Verify the DC Power Supply system has an immunity limit for voltage dips on the DC supply lines be –30% change in supply for a period of 10 msec.

Req. #	Parameter/ Requirement	Verification Requirement
PSU0619	DC Supply Long Voltage Dip	Verify the DC Power Supply system has an immunity limit for voltage dips on the DC supply lines be –50% change in supply for a period of 100 msec.
PSU0620	DC Supply Voltage Interruptions	Verify the DC Power Supply system has an immunity limit for voltage interruptions on the DC supply lines be a voltage drop of 95% or more for a period of 5 seconds.
PSU0621	DC Supply Burst Immunity	Verify the DC Power Supply system conforms to MIL-STD-461G CS117 for transients and burst immunity.
PSU0622	DC Supply Conducted Noise Immunity	Verify the DC Power Supply system conforms to MIL-STD-461G CS101 conducted susceptibility.
PSU0623	Transient Protection of LRU I/O & Power Connections	Verify Transient Voltage Suppression devices are used on sensitive analog and digital I/O signals and power supplies entering or exiting an LRU.
PSU0624	Surge Protection at Equipment I/O Entry Points	Verify power and signal lines exposed to large potential gradients are protected by silicon avalanche diodes at I/O entry points to circuit boards and electronics.
PSU0631	ESD Low Air Discharge	Verify the DC Power Supply system conforms to MIL-STD-461G CS118 with an air discharge level up to 8kV while meeting performance criteria A. Testing to this discharge level at ESD Compliance Level 4 per IEC 61000-4-2 will also be accepted. Specific exceptions will be considered where components or sub-assemblies are present that are very high value or are known to be vulnerable. In these cases, evaluation will be through analysis of the design and a "best attempt" should be made in design to protect these vulnerable components in the LRUs.
PSU0632	ESD High Air Discharge	Verify the DC Power Supply system conforms to MIL-STD-461G CS118 with an air discharge level up to 15kV while meeting performance criteria B. Testing to this discharge level at ESD Compliance Level 4 per IEC 61000-4-2 will also be accepted. Specific exceptions will be considered where components or sub-assemblies are present that are very high value or are known to be vulnerable. In these cases, evaluation will be through analysis of the design and a "best attempt" should be made in design to protect these vulnerable components in the LRUs.
PSU0633	ESD Direct Contact Discharge	Verify the DC Power Supply system conforms to MIL-STD-461G CS118 with a direct contact discharge level up to 8kV while meeting performance criteria A. Testing to this discharge level at ESD Compliance Level 4 per IEC 61000-4-2 will also be accepted. Specific exceptions will be considered where components or sub-assemblies are present that are very high value or are known to be vulnerable. In these cases, evaluation will be through analysis of the design and a "best attempt" should be made in design to protect these vulnerable components in the LRUs.

Req. #	Parameter/ Requirement	Verification Requirement
PSU0634	ESD Protection	Verify ESD protection of equipment and workspaces are based on USDOD MIL-STD-1686C (RD08) and MIL-HDBK-263B or ANSI/ESD S20.20-2014.
PSU0635	Prevention and Discharge of Electrostatic Charge Build-Up	Verify the DC Power Supply system equipment and assemblies made using dielectric materials or coated with nonconductive coatings are designed to prevent build up or to dissipate excessive electrostatic charge.
PSU0721	AC Power and Grounding Design	Verify the Power Plant design and installation of all AC Power and Grounding wiring conform to US National Electrical Code NFPA 70.
PSU0722	DC Power & Grounding Design	Verify design and installation of all DC power distribution and grounding wiring conform to ngVLA System and RFI/EMC requirements.
PSU0723	Wiring Insulation Type	Verify low-voltage DC and signal wiring utilize Irradiated PVC type insulation certified to meet the UL 1430 specification. This shall be rated at 300 VDC minimum over a temperature range of –55° C to +105° C.
PSU0726	Flexible Cables	Verify wiring and cables installed in applications where repeated bending and/or small bend radii utilize materials specifically designed for this purpose.
PSU0727	Bend Radius	Verify the minimum bend radius of all cables are limited by the factory specifications for the cable.
PSU0728	Bend Radius Control of Moving Cables	Verify cables that move or flex, the minimum bend radius is maintained by mechanical means.
PSU0729	Strain Relief and Retention of Wiring & Cables	Verify all wiring and cables installed with ample cable retention and strain relief. Unless specifically needed to move, no cables shall be allowed to flex, dangle or present a tripping or entanglement hazard.
PSU0730	Connector Current Ratings	Verify all connector pin current limits are followed. Use of multiple pins to gain an increased current rating are not permitted. Where the use of multiple pins is required for signal performance, each pin shall be rated to handle the total current load.
PSU0731	Hot Swapping	Verify all connectors utilized in hot swap or live disconnect application have pins designed for this application and not allow exposure of dangerous voltages or currents to personnel.
PSU0732	Hot Swap/Live Connection Pin Length	Verify connectors used in hot swap or live disconnect applications are designed to avoid contact arcing, abnormal current flow and sequencing issues.
PSU0735	Connector Environmental Ratings	Verify all connectors are utilized in accordance with their designed environment.
PSU0736	Connector Mating Cycles	Verify the specified data sheet rating for mating cycles allowed for a connector type are followed.
PSU0737	No Exposed Live Terminals	Verify live signal or power pins in connectors are not exposed while connectors are unmated.

Req. #	Parameter/ Requirement	Verification Requirement
PSU0739	Common Connectors	Verify connectors used repeatedly across multiple devices have critical signal pinouts standardized.
PSU0740	Connector Alignment Guides	Verify connectors used in blind mate or back plane applications utilize some mechanism to ensure alignment of the connector during installation to avoid damage to the connector.
PSU0741	High Insertion Force Connector & Device Support	Verify connectors & devices requiring high insertion force are adequately supported to prevent damage to the device, connector, cable, chassis or PCB during insertion and removal.
PSU0742	High Insertion Force Connector & Device Ejectors and Tooling	Verify assemblies, cables, devices, and PCBs utilizing high insertion force components or connectors are equipped with ejectors or other tooling to aid in installation and removal. The design shall not depend on tools such as screwdrivers, pry bars, and hammers for assembly and disassembly.
PSU0752	Assembly Hardware: Galvanic/Corrosion Properties	Verify all assembly hardware are of a material, plating, and/or coating appropriate for its location based on galvanic corrosion properties.
PSU0753	Assembly Hardware: Electrical Properties	Verify all hardware are of a material, plating, and/or coating appropriate for its location based on electrical conductivity.
PSU0754	Assembly Hardware: Strength Properties	Verify all hardware are of an appropriate grade and material for its location based on strength.
PSU0761	LRU Installation Force	Verify LRU level assemblies fit together without applying excessive force.
PSU0801	Safe under hazardous conditions	Verify the DC Power Supply system is designed to be used and operable under expected conditions as identified in the hazard analysis. Refer to [AD12] for the procedure.
PSU0802	Identify residual risks	Verify the DC Power Supply system equipment that imposes a residual risk to operators and maintainers be labelled to indicate such risks using standard pictograms.
PSU0803	US National Electric Code Compliance	Verify all wiring operating at or above 50 Volts DC or 50 Volts RMS AC and all safety grounding follow the US NEC.
PSU0805	Grounding Conflict Resolution	Verify conflicts between safety grounding being compliant with the NEC and grounding designed for low noise be documented and brought to the attention of the Project Engineer and ECCB for analysis and resolution.
PSU0808	Safe Electrical Connections	Verify the DC Power Supply system equipment, together with its component parts, be safe to disconnect, disassemble, assemble and connect.
PSU0809	Electrical contact protection	Verify the DC Power Supply system equipment provide adequate protection to prevent injury from direct or indirect electrical contact during operation, inspection, and routine maintenance.

Req. #	Parameter/ Requirement	Verification Requirement
PSU0810	Electrical Contact during Diagnosis & Repair	Verify in situations where exposure to terminals or high voltages (i.e. at or above 50 Volts DC or 50 Volts RMS AC) must be possible during in-depth diagnosis and repair, procedures for minimizing risk of contact be provided in a maintenance manual for the subsystem or equipment under repair.
PSU0811	Discharge of Capacitors Operating at High Voltages	Verify any capacitor operating at 50 VDC or above be provided with a resistive path to discharge the capacitor to safe levels within 60 seconds of the circuit being de-energized. This discharge circuitry shall operate regardless of the condition of downstream electronics.
PSU0821	LRU Physical Marking Label Ruggedness	Verify the attached DC Power Supply system LRU Physical Marking Label comply with MIL-DTL-15024 ensure durability and longevity of the label.
PSU0824	Electrical and Optical Label Safety Standards	Verify all electrical and optical safety labels be compliant with applicable standards at the time of installation.
PSU0825	Dangerous temperatures prohibited	Verify the DC Power Supply system equipment provide adequate protection to prevent injury from high/low temperature, arcs and radiation.
PSU0826	Electrical equipment: environmental	Verify the DC Power Supply system equipment be safe for use in all operational environmental conditions, for the expected life of the product (e.g. UV radiation).
PSU0829	Design for stability	Verify the DC Power Supply system equipment be stable under all operating conditions without risk of overturning, falling or unexpected movement.
PSU0830	Design for operation stresses	Verify the DC Power Supply system equipment can withstand all stresses imposed on it during operational conditions.
PSU0833	Energy source safety	Verify the DC Power Supply system equipment design avoids hazards associated with all energy sources.
PSU0834	Energy source isolation	Verify the DC Power Supply system equipment be fitted with means to isolate it from all energy sources. Such isolators shall be clearly identified. Isolators shall be lockable in cases where isolation is provided for extended maintenance areas.
PSU0836	OSHA standards	Verify the DC Power Supply system equipment be compliant with applicable regulations from OSHA.
PSU0901	Mean Time Between Maintenance (MTBM)	Verify DC Power Supply system electronics have MTBM of 21,000 hours.
PSU0904	Preventive Maintenance Schedules	Verify the DC Power Supply system is designed with preventive maintenance (PM) interval no shorter than 1 year.
PSU0905	Use of Failure Analysis in Spares Planning	Verify the DC Power Supply system failure analysis be used in the planning of spares inventory.

Req. #	Parameter/ Requirement	Verification Requirement
PSU0914	Reliability Analysis	Verify a Reliability, Availability, Maintainability analysis be performed by the DC Power Supply designer at the LRU level to locate weak design points and determine whether the design meets the Maintenance and Reliability requirements. ngVLA suggests to apply the Parts Count Method for predicting the reliability of the system as described in the MIL-HDBK-217F, but the designer may propose to use other methods. For non-electronic parts, the values of NPRD-95 or data from manufacturers or other databases may be used. They shall publish these results in a memo and be prepared to discuss their analysis and the techniques used to address the results in the design reviews for their equipment and subsystems.
PSU0915	Robustness Analysis	Verify DC Power Supply system designs be subject to a robustness analysis. Results of this analysis are a required part of the design review process.
PSU0916	Report Failure Information	Verify DC Power Supply maintenance significant items report failures and failure isolation information and configuration information, via the M&C system.
PSU0917	Report Predicted Failures	Verify DC Power Supply maintenance significant items, where possible, report fault prediction sensor data via the M&C system.
PSU1003	LRU Tracking Label & Tag Specifications	Verify the physical tracking label and/or device attached to each LRU conform to the specifications outlined in US DoD Standards MIL-DTL-15024 and MIL-P-19834.
PSU1101	Design Life	Verify the DC Power Supply system is designed to be operated and supported for a period of 30 years.
PSU1102	Cost Optimization	Verify the DC Power Supply system design minimizes its lifecycle cost for 20 years of operation.
PSU1103	Sustainability	Verify the DC Power Supply system sustainability and long-term environmental impact be considered in any material or design trade-study.
PSU1104	Part Selection for Maintainability	Verify the DC Power Supply system Individual component selection criteria include the projected continuity of support for the component or interchangeable equivalents over the system design life.
PSU1105	Critical Spares	Verify DC Power Supply system critical spares be identified and provided with sufficient inventory to support the facility for its operational life.

10 Appendix

10.1 Abbreviations and Acronyms

Acronym	Description
A	Amps
AC	Alternating Current
AD	Applicable Document
AIV	Acceptance, Integration, and Verification
Aux	Auxiliary
C	Celsius
CAD	Computer Aided Design
CDR	Critical Design Review
CoDR	Conceptual Design Review
Cryo	Cryogenics
DBE	Digital Back End
DC	Direct Current
DTS	Data Transmission System
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
FE	Front End
Hr	Hour
Hz	Hertz
IF	Intermediate Frequency
IPT	Integrated Product Team
IRD	Integrated Downconverter/Digitizer
ICD	Interface Control Document
IPT	Integrated Product Team
KPP	Key Performance Parameter
L0	Science or Stakeholder Requirement
L1	System Level Requirement
L2	Subsystem Level Requirement
LED	Light Emitting Diode
LNA	Low Noise Amplifier
LO	Local Oscillator
LOIF	Local Oscillator Intermediate Frequency
LRU	Line Replaceable Unit
M&C	Monitor and Control
MIB	Module Interface Board
MTBF	Mean Time Between Failure
ngVLA	Next Generation Very Large Array
NRAO	National Radio Astronomy Observatory
PDF	Portable Document Format
PDU	Power Distribution Unit
RD	Reference Document
RFI	Radio Frequency Interference
RFID	Radio Frequency Identification

RH	Relative Humidity
Sec	Seconds
TBC	To Be Confirmed
TBD	To Be Determined
UPS	Uninterruptible Power Supply
WVR	Water Vapor Radiometer

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