DC Power Supply Preliminary Technical Requirements

020.30.50.00.00-0001-REQ-A-DC_POWER_SUPPLY_PRELIM_REQS

Status: **RELEASED**

PREPARED BY	ORGANIZATION	DATE
P. Lopez	Electronics Div., NRAO	2018-11-16
S. Durand, Antenna Electronics IPT Lead	Electronics Div., NRAO	2019-04-23

APPROVALS (Name and Signature)		ORGANIZATION	DATE
R. Selina, Project Engineer	R Selina 2019.07.17 16:26:28 -06'00'	Electronics Division, NRAO	2019-07-17
M. McKinnon, Project Director	Mark McKinnon Digitally signed by Mark McKinnon Date: 2019.07.17 16:40:25 -06'00'	Asst. Director for NM-Operations, NRAO	2019-07-17

RELEASED BY (Name and Signature)		ORGANIZATION	DATE
M. McKinnon, Project Director	Mark McKinnon Digitally signed by Mark McKinnon Date: 2019.07.17 16:40:42 -06'00'	Asst. Director for NM-Operations, NRAO	2019-07-17

Change Record

Version	Date	Author	Affected Section(s)	Reason
01	2018-05-15	P. Lopez	All	Initial draft
02	2018-06-07	S. Durand	All	Basic edits
03	2018-07-01	P. Lopez	2.2	Updated reference document titles and document numbers
04	2018-09-01	S. Durand	All	Basic edits
05	2018-09-25	P. Lopez	All	Basic edits
06	2018-11-16	P. Lopez	All 3.3 5.3 5.4 5.1 2.1 & 2.2	Document number update; removed "Not all antennas will have WVR"; corrected typos; updated document names and numbers
07	2019-04-23	S. Durand	All	Basic edits
08	2019-05-30	R. Selina	4, 5	Updated requirement numbering; other minor edits throughout
A	2019-07-17	A. Lear	All	Prepared document for approvals & release

Table of Contents

1 Introduction 4
1.1 Purpose 4
1.2 Scope 4
2 Related Documents and Drawings 4
2.1 Applicable Documents 4
2.2 Reference Documents 5
3 Overview of the DC Power Supply Technical Requirements 6
3.1 Document Outline 6
3.2 Project Background 6
3.3 General DC Power Supply System Description 6
3.4 Summary of DC Power Supply System Requirements 7
3.5 Definitions of External Environmental Conditions 7
3.5.1 Precision Operating Conditions 7
3.5.2 Normal Operating Conditions 7
3.5.3 Limits to Operating Conditions 7
3.6 General Technical Requirements 8
3.6.1 General Requirements 8
4 DC Power Supply Functional and Performance Requirements 9
4.1 Functional Requirements 9
4.1.1 P500 Functional Specifications 9
4.1.2 P501 Functional Specifications 10
4.1.3 P502 Functional Specifications 10
4.1.4 P503 Functional Specifications 11
4.2 Additional Requirements 11
4.3 Maintenance and Reliability Requirements 12
4.4 Monitor and Control Requirements 12
4.5 Lifecycle Requirements 12
5 Interface Requirements 13
5.1 Interface to Digital Back End and Data Transmission System Subsystems 13
5.2 Interface to Front End Subsystem 13
5.3 Interface to Integrated Downconverter/Digitizers Subsystem 13
5.4 Interface to the Local Oscillator subsystems 13
5.5 Interface to the WVR subsystem 14
5.6 Interface to the Antenna 14
5.6.1 Electrical Infrastructure 14
5.6.2 RFI Mitigation 14
5.6.3 HVAC and Cooling System 14
5.7 Interface to the M&C System 14
6 Appendix 15
6.1 Abbreviations and Acronyms 15
6.2 Maintenance Definitions 15
6.2.1 Maintenance Approach 15
6.2.2 Periodic Preventive Maintenance 15

1 Introduction

1.1 Purpose

This document presents a set of preliminary technical requirements for the ngVLA DC Power Supply system reference design. Many requirements flow down from the preliminary System Requirements [AD02], which in turn flow down from the preliminary Science Requirements [AD01].

The science goals are presently being elaborated by the Science Advisory Council (SAC) and Science Working Groups (SWGs), and are captured in a series of draft use cases. This draft reflects a preliminary analysis of these use cases, and the flow down recursively to the science, system, and subsystem requirements.

1.2 Scope

The ngVLA DC Power Supply system consists of the equipment that creates and provides the power to all Antenna Electronics deliverables on the ngVLA antennas. This requirements document establishes the performance, functional, design, and test requirements applicable to the DC Power Supply system. It also includes preliminary interface requirements that must be defined.

2 Related Documents and Drawings

2.1 Applicable Documents

The following documents are applicable to this Technical Specification to the extent specified. In the event of conflict between the documents referenced herein and the content of this Technical Specification, the content of this Technical Specification shall be considered as a superseding requirement.

Reference No.	Document Title	Rev/Doc. No.
AD01	Science Requirements	020.10.15.05.00-0001-REQ
AD02	System Requirements	020.10.15.10.00-0003-REQ
AD03	Operations Concept	020.10.05.00.00-0002-PLA
AD04	Protection Against Electric Shock: Common Aspects for Installation and Equipment	IEC 61140:2016
AD05	System-Level Electrical Requirements	020.10.15.10.00-0005-REQ
AD07	Insulation Coordination for Equipment within Low-Voltage Systems	IEC 60664
AD08	Occupational Safety and Health Standards for General Industry	29 CFR Part 1910
AD10	Military Handbook: Reliability Prediction of Electronic Equipment	MIL-HDBK-217F
AD11	Non-Electronic Parts Reliability Data	NPRD-95
AD12	Electromagnetic Compatibility	IEC 61000-3-5
AD13	System Electromagnetic Compatibility and RF Interference Mitigation Requirements	020.10.15.10.00-0002-REQ
AD14	Environmental Specifications	020.10.15.10.00-0001-SPE

2.2 Reference Documents

The following references provide supporting context:

Reference No.	Document Title	Rev/Doc. No.
RD01	Antenna Electronics 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	020.30.03.01.00-0001-REQ
RD06	Independent Phase Cal System Requirements	020.45.00.00.00-0001-SPE
RD07	Integrated Down Converter Requirements	020.30.15.00.00-0001-REQ
RD08	Monitor and Control Requirements	020.30.45.00.00-0002-REQ

3 Overview of the DC Power Supply Technical Requirements

3.1 Document Outline

This document presents the DC Power Supply system technical requirements, which determine overall form and performance.

Section 4 details the functional and performance specifications, along with explanatory notes. The notes elaborate on the requirements' meaning, intent, and scope. The notes form an important part of the requirements definition and should guide the verification procedures. In many cases, the notes contain explanation or analysis of how the numeric values of requirements were derived. Where numbers are not well substantiated, this is also documented in the notes. This makes the required analysis and trade-space available apparent to scientists and engineers guiding evolution of the DC Power Supply system concept.

Section 5 describes requirements pertinent to interfacing systems. Initial requirements are noted by interface, along with identified parameters for Interface Control Documents (ICDs) that will fully define the interfaces as the design progresses.

3.2 Project Background

The Next Generation Very Large Array is a project of the National Radio Astronomy Observatory to design and build an astronomical observatory that will operate at centimeter wavelengths (25 to 0.26 centimeters, corresponding to a frequency range extending from 1.2 GHz to 116 GHz). The observatory will be a synthesis radio telescope constituted of approximately 263 reflector antennas of 18 meters and 6 meters diameter, operating in a phased or interferometric mode.

The array signal-processing center will be located at the Very Large Array site on the Plains of San Agustin, New Mexico. The array will include stations in other locations throughout New Mexico, west Texas, eastern Arizona, northern Mexico, and across the US. Operations will be conducted from both the VLA Control Building and the Array Operations Center in Socorro, NM.

3.3 General DC Power Supply System Description

The DC Power Supply System (specifically, P500) receives 208V 3-phase AC @17A and converts it to –48V DC. Lithium batteries will be used as a backup source for the 48V if the AC is lost. A battery charger will be used to charge the batteries when AC is available. The batteries and battery charger will be located in the pedestal area of each antenna. The 48V is then fed into three power supply modules (P501, P502, and P503) that convert the 48V to +32.5V, ±17.5V, +15.5V, ±7.5V, ±5.5V, and +3.8V depending on the module. Each power supply module has monitor and control (M&C) and temperature sensors for shutdown in case of over current or over temperature. The P500 also powers the fire alarm, Ethernet switch, Digital Back End (DBE), and Data Transmission System (DTS).

The P501 module powers the Front End (FE) Low Noise Amplifier (LNA) noise diodes, and bias voltages for Bands 1–6. The P501 also powers the Local Oscillator (LO) Reference Sample Clock Generator and LO A–K Generator modules as well as the Integrated Downconverter/Digitizers (IRD) for Bands 1–6. The P501 will be located next to the IRDs in the Front End Enclosure.

The P502 module powers the LO Clock Receiver module, two Band 4 IRDs, the Water Vapor Radiometer (WVR) antenna amplifier, and cooling system. The P502 will be located in the WVR Enclosure.

The P503 module powers the LO Reference Receiver Generator and Distribution module and the four Monitor & Control modules located in the pedestal area of each ngVLA antenna.

3.4 Summary of DC Power Supply System Requirements

The following sections summarize the major requirements to provide a high-level view of the desired system. Should a conflict exist between the requirements listed here and the descriptions in Sections 4 and 5, the latter shall take precedence.

3.5 Definitions of External Environmental Conditions

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

3.5.1 Precision Operating Conditions

The precision operating environment defines the conditions under which the system is expected to meet the most stringent requirements and provide optimal system performance.

Parameter	Req. #	Value
Solar Thermal Load	ENV0311	Nighttime only; no solar thermal load within last 2 hours
Wind Speed	ENV0312	0 ≤ W ≤ 5 m/s average over 10 min; 7 m/s peak gusts
Temperature	ENV0313	–15 C ≤ T ≤ 25 C
Temperature Rate of Change	ENV0314	1.8°C/Hr.
Precipitation	ENV0315	No precipitation.

The solar thermal load requirement limits this environment to two hours after sunset through sunrise, so long as other requirements of this section are met. The two-hour restriction is intended to allow sufficient time for the system to equilibrate.

3.5.2 Normal Operating Conditions

When the environment meets normal operating constraints, system performance requirements are relaxed but are still expected to provide adequate performance for operation below 50 GHz.

Parameter	Req. #	Value
Solar Thermal Load	ENV0321	Exposed to full sun, 1200 W/m²
Wind Speed	ENV0322	W ≤7 m/s average over 10 mins; 10 m/s peak gusts
Ambient Temperature	ENV0323	–15 C ≤ T ≤ 45 C
Ambient Temperature Rate of Change	ENV0324	3.6°C/Hr
Precipitation	ENV0325	No precipitation

3.5.3 Limits to Operating Conditions

A third category establishes hard limits to the operating conditions. While outside the bounds of the normal operating environment but within this regime, no performance guarantees are expected, but the system shall still be capable of safe operation. Once these limits are exceeded, the antenna will be moved to its stow-survival orientation to prevent damage. The relevant performance specifications are discussed in the ngVLA Environmental Specifications document [AD14].

3.6 General Technical Requirements

The DC Power Supply system receives 208V 3-phase AC @17A and converts it to –48VDC. Lithium ion batteries will be used as a backup source for the 48V if AC is lost. A battery charger will be used to charge the batteries when AC is available. The batteries and battery charger will be located in the pedestal area of each antenna. The 48V is then regulated and power is delivered to all antenna electronics equipment. Each power supply module has M&C, power control relays, and temperature sensors so it can be shut down for over-current or over-temperature.

3.6.1 General Requirements

Parameter	Req. #	Summary of Requirement	Reference Reqs.
AC Input	PSU0001	208V 3 Phase AC @17A	
AC to DC Conversion	PSU0002	208V 3 Phase AC to –48VDC	
DC Regulation	PSU0003	–48V DC will be regulated down to voltages that each module as required.	
M&C for Battery System	PSU0004	Required to monitor battery system health	SYS2701
M&C for Power Supply Modules	PSU0005	Required to monitor power supply module health	SYS2701
Design Life	PSU0006	Design for an expected operational life no less than 20 years, excluding batteries	SYS2701
Maintenance Interval	PSU0007	Preventive maintenance interval of no shorter than 2 years, with a goal of 4 years	SYS2401
Mean Time Between Failure (MTBF)	PSU0008	Antenna electronics: MTBF of 35,040 hrs each	SYS2402
Modularization	PSU0009	Line Replaceable Units (LRUs) to facilitate site maintenance	SYS2403
Altitude Range	PSU0010	Sea level to 2500 meters	ENV0351
Lightning Protection	PSU0011	Protect against lightning electromagnetic impulse	ENV0512
Equipment Protection Against Dust	PSU0012	Exposed equipment shall be protected against windblown dust, ashes, and grit	ENV0541
Rodent Protection	PSU0013	Exposed equipment shall be designed to prevent rodent damage	ENV0551
Transportation Environment	PSU0014	Designed to withstand typical loads and environments encountered during transportation	ENV0581
Mechanical Shock	PSU0015	Designed to survive mechanical shock levels	ENV0582
Equipment Shielding	PSU0016	All equipment shall be shielded and have AC power line and communication lines filtered at the chassis	ENC0327
EMC Test Frequencies	PSU0017	RFI suppression shall extend from 50 MHz up to 12 GHz	NRAO IPG Memo 34, EMC0328
Hazard Analysis	PSU0018	Hazard analysis shall be performed for all high-power systems; include lock-outs for service by technicians	SYS2703
Storage Requirements	PSU0019	10 °C to 25 °C for batteries –5 °C to 45 °C for power supply modules	

4 DC Power Supply Functional and Performance Requirements

These requirements apply to a properly functioning system under normal operating environmental conditions unless otherwise stated.

4.1 Functional Requirements

4.1.1 P500 Functional Specifications

Parameter	Req. #	Value	Traceability
AC Input Requirements	PSU0101	208V 3 Phase @17Amps AC	
AC to DC Conversion	PSU0102	208V 3 Phase AC to –48 VDC (–46.0 to –54.2 VDC) Maximum –60 ADC	[AD05]
DBE Load Power Requirements	PSU0103	–46 to –54.2 VDC, 5 ADC	
Fire Alarm Load Power Requirements	PSU0104	–46 to –54.2 VDC, 2 ADC	
Ethernet Switch Load Power Requirements	PSU0105	–46 to –54.2 VDC, 2 ADC	
P501 Load Power Requirements	PSU0106	–46 to –54.2 VDC, 18 ADC	
P502 Load Power Requirements	PSU0107	–46 to –54.2 VDC, 14 ADC	
P503 Load Power Requirements	PSU0108	–46 to –54.2 VDC, 14 ADC	
Battery System Capacity (Li-ion batteries)	PSU0109	40 Ah @20-hour rate	
Battery Lifetime	PSU0110	3–6 Years	
Backup Power Available	PSU0111	40 Ah assuming fully charged	
Battery-Only Load Support	PSU0112	10 minutes	
Low Voltage Disconnect Voltage	PSU0113	40.5 VDC	
Pedestal Environmental Temp	PSU0114	$15^{o}C \leq T \leq 20^{o}C$	
Forced Air Inlet Temp	PSU0115	$4^{o}C \leq T \leq 14^{o}C$	
Forced Air Outlet Temp	PSU0116	$T \leq 18^{o}$	
P500 Dissipation Including Battery	PSU0117	165 Watts	
Fire Alarm Shunt Trip	PSU0118	Disconnects AC & DC loads	
Emergency Communication Time Battery Backup	PSU0119	Min 1 Minutes Max 2 Minutes	

4.1.2 P501 Functional Specifications

Parameter	Req. #	Value	Traceability
Input Power Requirement	PSU0201	–46 to –54.2 VDC, 18 ADC	
FE (Band 1–6) Load Power Requirements	PSU0202	+32V (28V) @ 0.5 A, +17.5V (+15V, +12V) @ 6 A (2.5A, 3.5A) +5.5V (3.3V) @ 0.5 A –5.5V (–3.3V) @ 0.5 A	[AD05]
IRD (x13) Load Power Requirements	PSU0203	+5.5V (+5V) @ 1 A +3.8 (+3.5V) @ 1 A –5.5V (–5V) @ 0.1 A	
LO Modules Load Power Requirements	PSU0204	+17.5V (+15V) @ 2.5 A +5.5V (+5V) @ 1.5 A –5.5V (–5V) @ 0.25 A –17.5V (–15V) @ 0.25 A	
SA501 Environmental Temperature	PSU0205	14°C ≤ T ≤ 16°C	
Cooling Technique	PSU0206	Single cold plate; temp 4–14 °C	
P501 Dissipation	PSU0207	~195 Watts	
M&C for Power Supply Modules	PSU0208	Required to monitor power supply module health	

4.1.3 P502 Functional Specifications

Parameter	Req. #	Value	Traceability
Input Power Requirement	PSU0301	–46 to –54.2 VDC, 14 ADC	
Load Power Requirements for FE (Band 4)	PSU0302	+32 (28V) @ 0.3 A +17V (+12V) @ 0.3 A +5.5V (3.3V) @ 0.01 A –5.5V (–3.3V) @ 0.5 A	[AD05]
Load Power Requirements for IRD (x2)	PSU0303	+5.5V (+5V) @ 1 A +3.8 (+3.5V) @ 1 A –5.5V (–5V) @ 0.1 A	
Load Power Requirements for LO Module	PSU0304	+17.5V (+15V) @ 2.5 A +5.5V (+5V) @ 1.5 A –5.5V (–5V) @ 0.25 A –17.5V (–15V) @ 0.25 A	
WVR Cooling System	PSU0305	+15.5V (+12V) @11.4 A	
SA502 Environmental Temperature	PSU0306	14 °C ≤ T ≤ 16°C	
Cooling technique	PSU0307	Single cold plate Temp 4–14 °C	
P502 Dissipation	PSU0308	~145 Watts	
M&C for Power Supply Modules	PSU0309	Required to monitor power supply module health	

4.1.4 P503 Functional Specifications

Parameter	Req. #	Value	Traceability
Input Power Requirement	PSU0401	–46 to –54.2 VDC, 14 ADC	
Load Power Requirements for LO System	PSU0402	+17.5V (+15V) @ 2.5 A +7.5V (5V) @ 1.5 A –7.5V (–5V) @ 0.25 A –17.5V (–15V) @ 0.25 A	[AD05]
Load Power Requirements for M&C System	PSU0403	+17.5V (+15V) @ 1 A +7.5V (5V) @ 2 A –17.5V (–15V) @ 1 A	
SA503 Environmental Temperature	PSU0404	14°C ≤ T ≤ 16°C	
Cooling Technique	PSU0405	Forced air in pedestal rack; Temp 4–14 °C	
P503 Dissipation	PSU0406	~145 Watts	
M&C for Power Supply Modules	PSU0407	Required to monitor power supply module health	

4.2 Additional Requirements

Parameter	Req. #	Value	Traceability
Battery System Location	PSU0501	Antenna Pedestal	
Battery Operating Temperature Requirements	PSU0502	10°C to 25°C for batteries (15°C ≤ T ≤ 20°C is specified for the pedestal environment)	[AD05]
DC Filtering on Outputs	PSU0503	Hermetically glass sealed High EMI feedthrough data line filters Max operating range: 100 VDC @ 20 A Capacitance of 2.6 µF	

The weight of the batteries and battery charging system require that the battery system be located in the equivalent of the antenna pedestal room. The lithium batteries require that the operating temperature be 10°C to 25°C to maintain battery lifecycle.

4.3 Maintenance and Reliability Requirements

Parameter	Req. #	Value	Traceability
MTBF	PSU0601	Antenna electronics: 35,040 hours each	SYS2402
Modularization	PSU0602	Replaceable by 2 qualified technicians with minimal tools	Ops Con

The maintenance and reliability requirements support high-level requirements that limit total array operating cost.

4.4 Monitor and Control Requirements

Parameter	Req. #	Value	Traceability
Self-Monitoring	PSU0701	The DC Power Supply system shall measure, report, and monitor a set of parameters that allow for determination of its status and may help predict or respond to failures	SYS2601

The self-monitoring expectation is that the M&C system expose lower-level sensors to the M&C system when queried. The access cadence 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 M&C interface features will be specified in the Monitor and Control ICD.

4.5 Lifecycle Requirements

Parameter	Req. #	Value	Traceability
Design Life	PSU0801	The DC Power Supply system shall be designed to be operated and supported for 20 years, excluding batteries	SYS2701
Lifecycle Optimization	PSU0802	The DC Power Supply design shall minimize its lifecycle cost for 20 years of operation, including batteries	SYS2701

Lifecycle costs include manufacturing, transportation, construction/assembly, operation, maintenance, and decommissioning.

5 Interface Requirements

This section describes the DC Power Supply system interfaces. ICDs are required between the DC Power Supply and all connecting systems. In many cases, interface specifications are not yet available, but the broad scope of the ICD can be defined. These interfaces shall be developed and documented by the DC Power Supply system designer and approved by ngVLA as part of the DC Power Supply system reference and conceptual design efforts, and updated throughout the design. Post CoDR, the ICD shall only be updated through formal project change control processes.

5.1 Interface to Digital Back End and Data Transmission System Subsystems

The Digital Back End (DBE) and Data Transmission System (DTS) request –48V from the DC Power Supply. The total current requested is 5 amps. The DBE/DTS system is located in the pedestal room and will receive power from the P500.

5.2 Interface to Front End Subsystem

The Front End (FE) system requests +32V, +17V, +5V, and –5V from the DC Power Supply for Bands 1–6. The FE system will receive power from the P501, located in the FE Enclosure.

- The +32V will be regulated down to +28V with a current draw around 0.5A for the noise diodes.
- The +17V will be regulated down to +15V and +12V. The +15V current draw will be about 2.5A. The +12V current draw will be about 3.5A. The total current draw from the +17V will be about 6A.
- The +5V will be regulated down to +3.3V. The +3.3V current draw will be around 0.5A. The total current draw for the +5V will be 0.5A.
- The –5V will be regulated to –3.3V. The –3.3V current draw will be about 0.5A. The total current draw for the –5V will be 0.5A.

5.3 Interface to Integrated Downconverter/Digitizers Subsystem

The Integrated Downconverter/Digitizers (IRD) system request +5V, +3.3V, and –5V from the DC Power Supply. Thirteen of the IRDs will receive power from the P501 in the FE Enclosure and the two WVR IRDs will receive power from the P502 in the WVR Enclosure.

- The +5V will be regulated down to multiple internal voltages. The IRD will draw 1A from the +5V.
- The +3.3V will be regulated down to an internal voltage that it can use. The +3.3V will draw 1A.
- The –5V will also be regulated down to an internal voltage it can use. The –5V current draw will be about 100 mA.

5.4 Interface to the Local Oscillator subsystems

The Local Oscillator (LO) system Reference Sample Clock Generator, A-K LO Generator, and LO Clock Receiver modules request +17V, +5V, –5V, and –17V from the DC Power Supply. The Reference Sample Clock Generator module and A-K LO Generator module are located in the FE enclosure and will be powered by the P501. The other LO Clock Receiver module is located in the WVR enclosure and will be powered by the P502.

- The +17V will be regulated down to +15V and will draw about 2.5A.
- The +5V will be regulated down to multiple internal voltages and will draw about 1.5A.
- The –5V will be regulated down to an internal voltage that it can use, and will draw about 0.25A.
- The –17V will be regulated down to –15V and will draw about 0.25A.

The LO system Reference Receiver, Generator, and Distributor module requests +17V, +7V, –7V, and –17V from the DC Power Supply System. This module is located in the pedestal room and will be powered by the P503.

- The +17V will be regulated down to +15V and will draw about 2.5A.
- The +7V will be regulated down to multiple internal voltages and will draw about 1.5A.
- The –7V will be regulated down to an internal voltage that it can use and will draw about 0.25A.
- The –17V will be regulated down to –15V and will draw about 0.25A.

5.5 Interface to the WVR subsystem

The Water Vapor Radiometer (WVR) system uses an LO Sample Clock Generator and Distributor (see Section 5.4), two Band 4 IRDs (see Section 5.3), the Band 4 receiver, and a cooling system.

The Band 4 receiver is powered by the P502 located in the WVR Enclosure and requests +32V, +17V, +5.5V, and –5.5V from the DC Power Supply.

- The +32V will be regulated down to +28V and will draw about 0.03A.
- The +17V will be regulated down to +12V and will draw about 0.3A.
- The +5V will be regulated down to +3.3V. The +3.3V current draw will be about 0.01A.
- The –5V will be regulated to –3.3V. The –3.3V current draw will be about 0.5A.

The WVR cooling system requests +15V from the DC Power Supply. The +15V will be regulated down to +12V @ around 12A. The WVR cooling system will receive power from the P502 that is located in the WVR Enclosure.

5.6 Interface to the Antenna

5.6.1 Electrical Infrastructure

208V 3-Phase AC @17A is required for the AC to DC battery charging system. The ICD shall describe both the mechanical and electrical specifications of the electrical interfaces.

5.6.2 RFI Mitigation

RFI suppression shall extend from 50 MHz up to 12 GHz (NRAO IPG Memo 34).

5.6.3 HVAC and Cooling System

The P500 located in the antenna pedestal room rack requires 165 Watts of cooling and will be cooled via forced air.

The P501 in the antenna FE Enclosure requires 195 Watts of cooling and will be cooled via cold plate.

The P502 in the antenna WVR Enclosure requires 145 Watts of cooling and will be cooled via cold plate.

The P503 in the antenna pedestal room rack requires 145 Watts of cooling and will be cooled via forced air.

5.7 Interface to the M&C System

The DC Power Supply will use a Module Interface Board (MIB) to interface with the M&C system. Each power supply module will be capable of remote power on/off and powering down due to over-current or over-temperature conditions. Each module will have a different set of over-current specifications depending on the electronics connected to it. Other conditions that power the module on/off will be listed in the ICD.

6 Appendix

6.1 Abbreviations and Acronyms

Acronym	Description
AD	Applicable Document
CDR	Critical Design Review
CoDR	Conceptual Design Review
DBE	Digital Back End
DTS	Data Transmission System
FE	Front End
HVAC	Heating, Ventilation & Air Conditioning
ICD	Interface Control Document
IRD	Integrated Downconverter/Digitizers
LO	Local Oscillator
LNA	Low Noise Amplifier
LRU	Line Replaceable Unit
M&C	Monitor and Control
MIB	Module Interface Board
MTBF	Mean Time Between Failure
ngVLA	Next Generation VLA
NRAO	National Radio Astronomy Observatory
PPE	Personal Protective Equipment
RD	Reference Document
RFI	Radio Frequency Interference
SAC	Science Advisory Council
SWG	Science Working Group
VLA	Jansky Very Large Array
WVR	Water Vapor Radiometer

6.2 Maintenance Definitions

6.2.1 Maintenance Approach

Maintenance shall be mainly performed at assembly and subassembly level by exchange of Line Replaceable Units (LRUs). LRUs are defined as units that can be easily exchanged by technician-level maintenance staff.

LRU exchange shall be possible by two trained/qualified people within four working hours. It is desirable that LRU replacement be possible using only standard tools identified in a maintenance manual for the DC Power Supply. A step-by-step procedure for safe exchange of every LRU shall also be provided in the maintenance manual and will list Personal Protective Equipment (PPE). The LRUs will be maintained by the ngVLA project (without industrial support).

6.2.2 Periodic Preventive Maintenance

The Power Supply system will use monitor points to check on the health of the batteries and Power Supply. These monitor points will help determine when maintenance is required for each antenna's Power Supply system. Monitor point thresholds will be listed in the Power Supply Manual.