DC Power Supply Reference Design Description

020.30.50.00.00-0002-DSN-A-DC_POWER_SUPPLY_REF_DESIGN

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 2019.07.18 08:46:55 -06'00'	Electronics Division, NRAO	2019-07-18
M. McKinnon, Project Director Mark McKinnon Digitally signed by Mark McKinnon Date: 2019.07.18 11:50:22 -06'00'	Asst. Director for NM-Operations, NRAO	2019-07-18

RELEASED BY (Name and Signature)	ORGANIZATION	DATE
M. McKinnon, Project Director Mark McKinnon Digitally signed by Mark McKinnon Date: 2019.07.18 11:50:39 -06'00'	Asst. Director for NM-Operations, NRAO	2019-07-18

Change Record

Version	Date	Author	Affected Section(s)	Reason
01	2018-05-15	P. Lopez	All	Initial draft
02	2018-06-13	S. Durand	All	Small edits
03	2018-07-01	P. Lopez	2.2	Updated reference document titles and document numbers
04	2018-09-21	S. Durand P. Lopez	All	More small edits
05	2018-09-24	S. Durand	All	More small edits
06	2018-10-24	P. Lopez	All 4, 5.2.3 4 2.1 & 2.2	Document number update Removed “Not all antennas will have WVR” Updated P500 – P503 descriptions Updated document names and numbers
07	2018-11-13	S. Durand	All	Small edits
08	2019-05-30	R. Selina	All	Minor edits throughout for release
A	2019-07-17	A. Lear	All	Prepared document for approvals & release

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1 Introduction

1.1 Purpose

This document describes the DC Power Supply subsystem reference design and covers the design approach, functions, key components, interfaces, and associated risks. This document forms part of the ngVLA design documentation package submission.

1.2 Scope

The scope of this document is the entire design of the DC Power Supply system as part of the ngVLA design. It details the subsystem design, how it functions, and interfaces with the necessary hardware and software systems. This document does not include specific technical requirements, which are documented in [AD14].

2 Related Documents and Drawings

2.1 Applicable Documents

The following documents may not be directly referenced herein but provide necessary context or supporting material.

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
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	DC Power Supply Preliminary Technical Requirements	020.30.50.00.00-0001-REQ

2.2 Reference Documents

The following documents are referenced within this text:

Reference 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	020.30.03.01.00-0001-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 DC Power Supply System Overview

A block diagram of the DC Power Supply system is shown in Figure 1. The 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 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 so they can be shut down for over-current or over-temperature conditions. The P500 is also used to power the fire alarm, Ethernet switch, Digital Back End (DBE), and Data Transmission System (DTS).

The P501 power supply module powers the Front End (FE) Low Noise Amplifier (LNA) noise diode, 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 and the Integrated Downconverter/Digitizers (IRD) for Bands 1–6. The P501 will be located next to the IRDs in the FE Enclosure.

The P502 power supply 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 powers the LO Reference Receiver Generator and Distribution module and the four M&C Modules located in the pedestal area of each ngVLA antenna.

4 DC Power Supply System Design

The ngVLA DC Power Supply System design considered two existing designs: those at the Atacama Large Millimeter Array (ALMA) and the Jansky Very Large Array (VLA). Both observatories bring in AC and use commercial off-the-shelf (COTS) parts to convert the AC power to DC power. Both supply DC power to the antenna electronics where each module regulates the DC power to voltages that they can use inside the module.

The two observatories differ when it comes to backup power and the input to the module power supplies. ALMA uses Uninterruptible Power Source (UPS) and feeds the modular power supplies AC power. The VLA uses four 12V lead-acid in series to make up the 48V, which is then fed into the modular power supplies.

Because the ngVLA antenna electronics, environment, and specifications more closely resemble that of the VLA, the ngVLA DC Power Supply system logically follows the VLA design. The ALMA design has had several issues, including operation site altitude and the reliability of the COTS AC-to-DC power supplies. The manufacturer was not helpful pinpointing causes or sources of failures with the module power supplies. The VLA DC Power Supply modules, by contrast, have been highly reliable and experience few failures.

The VLA design was also chosen because it provides multiple stages of regulation. This allows the power going into the antenna electronics to be clean. The ALMA design only has two stages of regulation, one at the power supply module and another inside the antenna electronics. The VLA design has an extra stage of regulation at the AC to 48VDC sub-assembly. Finally, the DC distribution system is more conducive to supporting the system-level RFI emission requirements [AD13].

4.1 DC Power Supply System Block Diagram

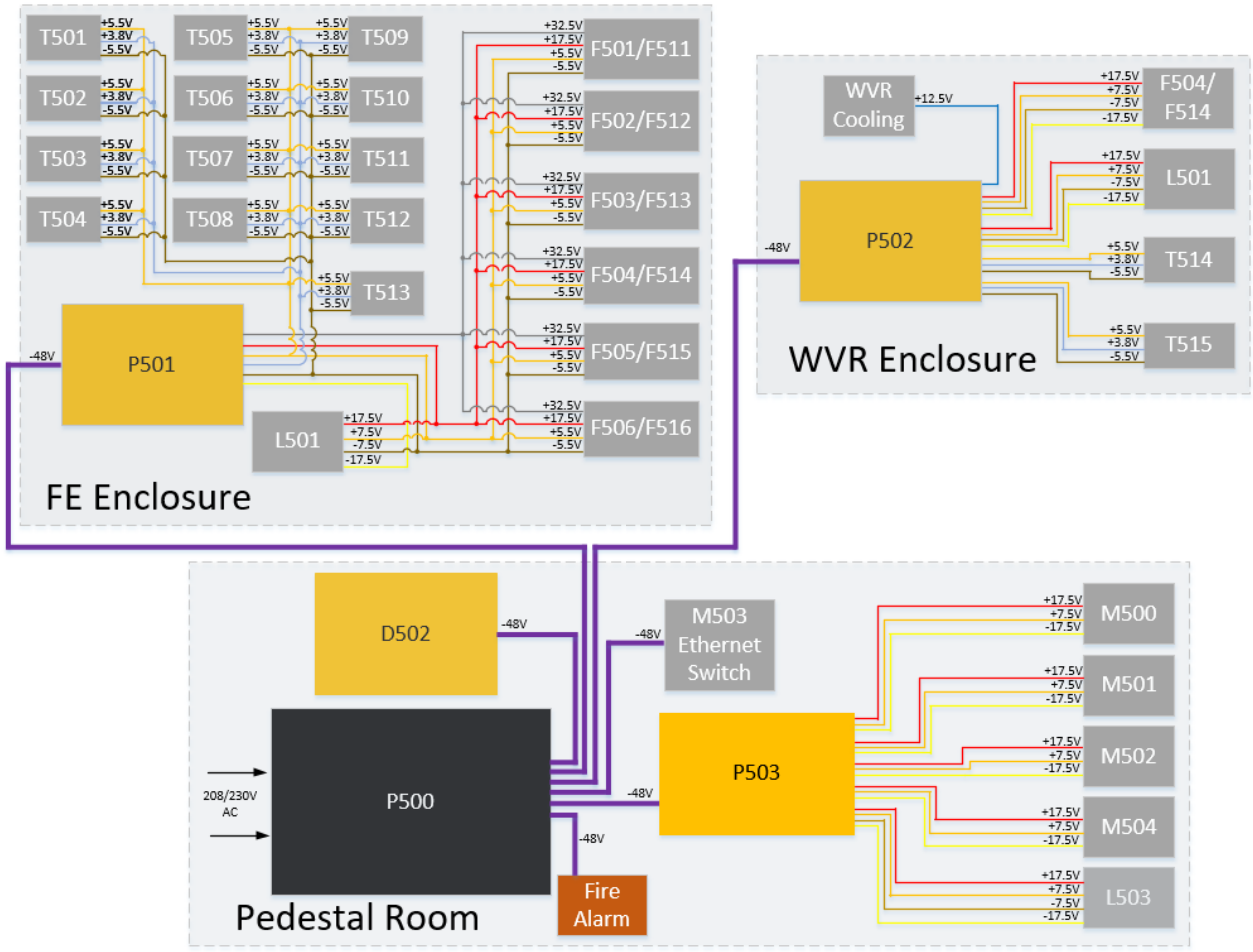

Figure 1 - Block diagram of DC Power Supply system.

4.2 DC Power Supply System Components

4.2.1 P500 Power Supply

The P500 receives 208V 3-phase AC and converts it to –48V DC. The P500 requires 3.2 kW of input power. Lithium batteries will be used as a backup source for the 48V in the event the AC is lost. A battery charger will be used to charge the batteries when AC is available. The batteries and battery charge will be located in the pedestal area of each antenna.

As Figure 1 shows, the P500 feeds 48V 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. The P500 has M&C so it can be shut down for over-current or over-temperature conditions. P500 also powers the fire alarm, Ethernet switch, Digital Back End (DBE), and Data Transmission system (DTS). Figure 2 (next page) shows the P500 block diagram.

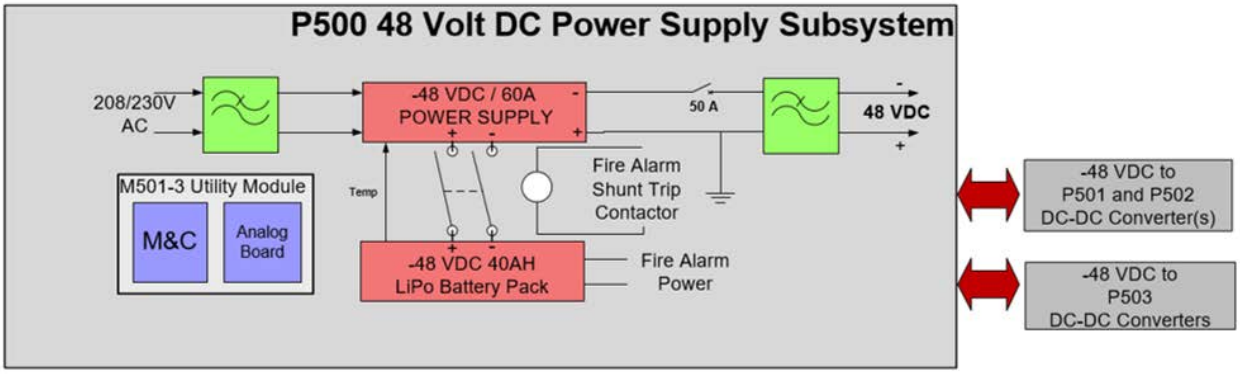

Figure 2 - P500 block diagram.

4.2.2 P501 Power Supply

The P501 power supply module receives –48V @18A from the P500. The P501 uses Vicor DC-DC converter modules to convert the 48V into +3.8V, ±5.5V, ±17.5V, and +32.5V. The P501is used to power the Front End (FE) Low Noise Amplifier (LNA) noise diodes, and bias voltages for Bands 1–6.

The P501 also powers the LO Clock Receiver module and the Integrated Downconverter/Digitizers (IRD) for Bands 1–6. The P501 will be located next to the IRDs in the Front End Enclosure. Figure 3 shows the P501 block diagram.

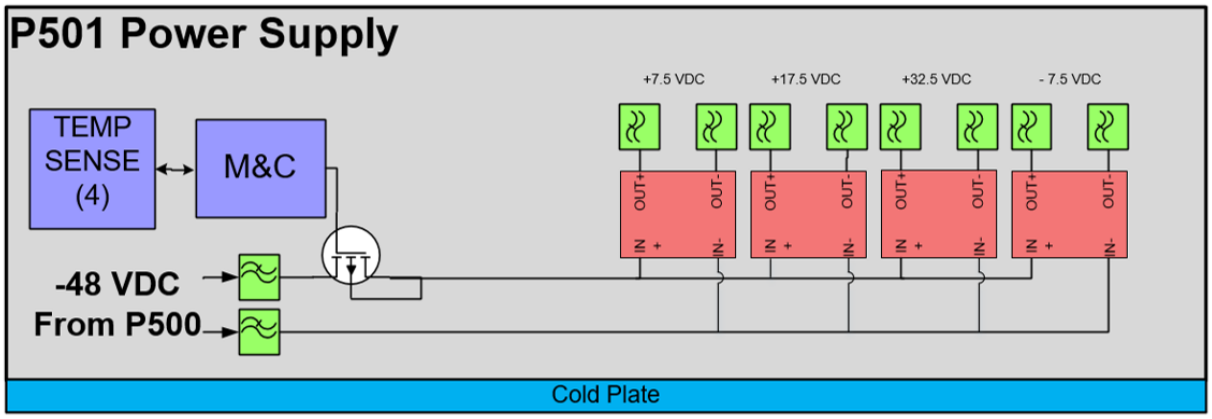

Figure 3 - P501 block diagram.

4.2.3 P502 Power Supply

The P502 power supply module receives –48V @14A from the P500. The P502 uses Vicor DC-DC converter modules to convert the 48V into 3.8V, ±5.5V, +15.5V, ±17.5V, and +32.5V. The P502 power supply module is used to power the LO Clock Receiver, two Band 4 IRDs, the Water Vapor Radiometer (WVR) antenna amplifier, and cooling system. It will be located in the WVR Enclosure. Figure 4 (next page) shows the P502 block diagram.

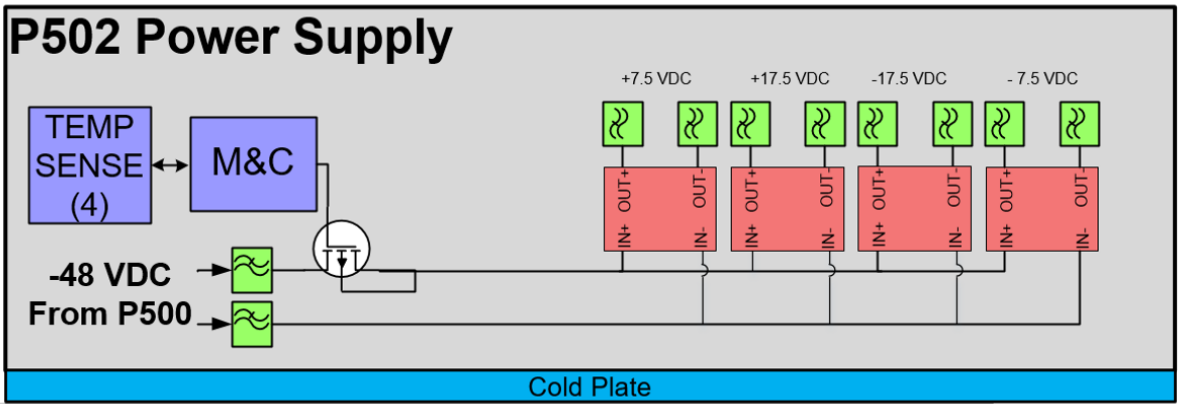

Figure 4 - P502 block diagram.

4.2.4 P503 Power Supply

The P503 power supply module receives –48V @14A from the P500. The P503 uses Vicor DC–DC converter modules to convert the 48V into ±7.5V and ±17.5V. The P503 is used to power the LO Reference Receiver Generator and Distribution module and four Monitor Control modules. The P503 module will be located in the pedestal area of each ngVLA antenna. Figure 5 shows the P503 block diagram.

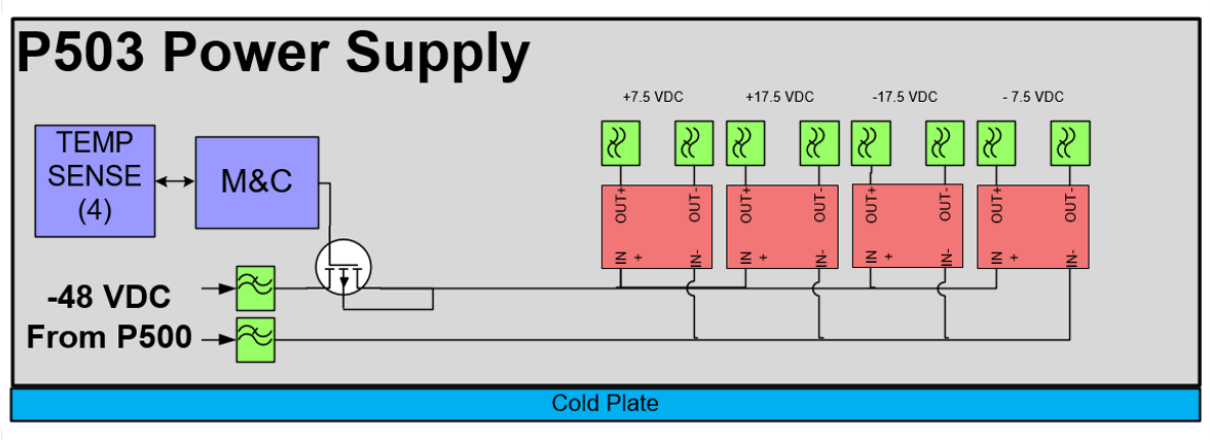

Figure 5 - P503 block diagram.

4.3 DC Power Supply System Interfaces with Other Subsystems

Below are other subsystem requirements from the DC Power Supply system.

4.3.1 Antenna Non-Electronics

4.3.1.1 Antenna AC

The P500 requires 208V 3-phase AC @3.2 kW. The P500 will supply the fire alarm system –48V @2A.

4.3.1.2 Antenna HVAC

The P500 requires cooling for 165W of heat dissipation. The P501 requires cooling for 195W of heat dissipation. The P502 requires cooling for 145W of heat dissipation. The P503 requires cooling for 145W of heat dissipation.

4.3.1.3 WVR Cooling System

The P502 will supply +15.5 V @11.4A to the WVR cooling system, which will then regulate that voltage down to the voltage that it requires.

4.3.2 Digital Back End (DBE)/Data Transmission Systems (DTS)

The whole DBE/DTS requires –48V @10A from the P500. The DBE/DTS system will have its own power system inside that regulates the –48V down to voltages it requires.

4.3.3 Front End (FE)

The Front End consists of six bands. The P501 will supply the FE with +32.5V @0.5A, +17.5V @6A, +7.5V @0.5A, and –7.5V @0.5A for all six bands.

4.3.4 Integrated Downconverter/Digitizers (IRD)

The IRDs consist of 13 modules. Each requires +5.5V @1A, +3.8V @1A and –5.5V @0.1A from P501.

4.3.5 LO Reference Receiver, Generator, and Distributor

4.3.5.1 LO Clock Module

The LO Clock Module is located in the FE Enclosure and in the WVR Enclosure. These modules require +17.5V @2.5A, +5.5V @1.5A, –5.5V @0.25A, and –17.5V @–0.25A from the P501 and P502.

4.3.5.2 LO Reference Receiver, Generator, and Distributor Module

The Reference Receiver, Generator, and Distributor module in the pedestal room requires +17.5V @2.5A, +7.5V @1.5A, –7.5V @0.25A, and –17.5V @0.25A from the P503.

4.3.6 Monitor and Control (M&C)

The monitor and control system requires that a Module Interface Board (MIB) be used inside the P500, P501, P502, and P503 modules.

The P500 will power the Ethernet switch located in the pedestal room with –48V @2A.

The P503 will also power the four M&C modules located in the pedestal room of the antennas. The P503 will supply each M&C module with +17.5V @1 A, +7.5V @2A, and –17.5V @1A.

4.3.7 Water Vapor Radiometer (WVR)

The WVR will use two Band 4 IRDs. The IRDs will only require +5.5V @2A, +3.8V @2A and –5V @0.2A from the P502.

The P502 will also be used to power the amplifiers and other electronics in the WVR antenna. The P502 will supply the antenna with +32.5V @30 mA, +17.5V @30 mA, +5.5V @10 mA, and –5.5 @0.5A.

5 Abbreviations and Acronyms

Acronym	Description
AD	Applicable Document
ALMA	Atacama Large Millimeter Array
DBE	Digital Back End
DTS	Data Transmission System
FE	Front End
HVAC	Heating, Ventilation, and Air Conditioning
IRD	Integrated Downconverter/Digitizers
LNA	Low Noise Amplifier
LO	Local Oscillator
M&C	Monitor and Control
ngVLA	Next Generation VLA
RD	Reference Document
UPS	Uninterruptible Power Source
VLA	Jansky Very Large Array
WVR	Water Vapor Radiometer