National Aeronautics and
Space Administration

CPF-02-024
PRELIMINARY
RELEASE DATE: TBD

Draft

Climate Absolute Radiance and Refractivity Observatory (CLARREO) Pathfinder

Power Converter Unit Interface Control Document

18 May 2018

Approved for Public Release; Distribution is Unlimited

The electronic version is the official approved document.
Verify this is the correct version before use.

SIGNATURE PAGE

Prepared By:

Craig Hutchinson
Systems Engineer

Concurred By:

Stephen Bowen
Power Converter Unit Subsystem Lead

Brian Boland
Lead Systems Engineer

Aref Nammari
CPRS Electrical Lead at LASP

Ryan Lewis
CPRS Mechanical Lead at LASP

Approved By:

James Corliss
Chief Engineer

Gary Fleming
Project Manager

Draft

REVISION HISTORY PAGE

Revision No.	Description	Release Date
Preliminary	Draft Work in Progress	TBD

Draft

TBX LIST

Item	Description	Page
TBR	Delivery destination and role of PCU in CPRSP testing	10
TBR	Pending thermal analysis of whether survival heaters are necessary for PCU	11
TBR	Pending thermal analysis of whether there is thermal interface with Adaptor Plate	11
TBR	Undervoltage range	13
TBR	Voltage of Discrete Input Signals	~~13~~ 15
TBR	Minimum Output Power	18
TBR	Value of Bus A maximum current	~~15~~ 19
TBR	Value of Bus B maximum current	~~18~~ 19
TBR	Value of Bus C maximum current	~~19~~ 19
TBD	~~Drawing from LASP showing PCU positioning on ExPA~~ Future LASP Agile document that will specify load impedance model	~~19~~ 21
~~TBD~~ TBR	PCU mass value	~~Molecular Deposition onto Other Payloads Limit~~ 23
TBR	~~19~~ PCU dimension allocation along X-axis	24
~~TBD~~ TBR	~~Molecular Deposition onto Other ISS Elements Limit~~ PCU dimension allocation along Y-axis	~~21~~ 24
TBD	Axial Launch Load Limit	~~23~~ 28
TBD	Lateral Launch Load Limit	~~24~~ 28
TBR	Minimum Natural Frequency	~~24~~ 28
TBD	~~Tolerance of thermal mass~~ Molecular Deposition onto Other Payloads Limit	~~28~~ 30
TBD	~~Thermal Testing Temperature~~ Molecular Deposition onto Other ISS Elements Limit	~~28~~ 30
TBR	Flight Operational Allowable Temperature Range	31
TBR	Non-Operational Survival Temperature Range	32
TBR	Ground Operation Relative Humidity	34

Draft

TABLE OF CONTENTS

SECTION **PAGE**

1.0 Introduction . . . 7
1.1 Purpose and Scope . . . 7
1.2 Document Organization . . . 7
2.0 Documents . . . 8
2.1 Applicable Documents . . . 8
2.2 Reference Documents . . . 8
2.3 Document Control . . . 8
2.4 Order of Precedence . . . 9
3.0 Concept of Operations . . . 10
4.0 External Interfaces . . . 11
4.1 External Interfaces by Function . . . 11
4.2 External Interface Boundaries . . . 11
5.0 Requirements . . . 13
5.1 Accepts 120 VDC Input . . . 13
5.2 Accepts Discretes . . . 15
5.3 Outputs 28 VDC . . . 17
5.4 Outputs Analog Signals . . . 18
5.5 Provides Current Protection . . . 19
5.6 Matches Impedance . . . 21
5.7 Isolates DC Power . . . 21
5.8 Structural . . . 23
5.9 ~~External Contamination~~ . . . 26
5.9 ~~Thermal~~ . . . 30
5.9 External Contamination . . . 30
5.10 ~~Operational Environment~~ . . . 31
5.10 Thermal . . . 31
5.11 Operational Environment . . . 32
5.12 Ground Test Environment . . . 33
5.13 EMI/EMC . . . 34
5.14 ~~Safety~~ . . . 35
5.14 ~~Test~~ . . . 35
5.14 ~~Test~~ . . . 36

TABLE OF APPENDICES

Appendix A Acronyms . . . 37

TABLE OF TABLES

Table 4.2-1 External Interface Boundaries . . . 12

Draft

Table 5.8-1 Connector Specifications 24

TABLE OF FIGURES

Draft

1.0 Introduction

1.1 Purpose and Scope

This document establishes the Power Converter Unit (PCU) requirements, which specify the subsystem that converts 120 Volts direct current (VDC) Operational Power to 28 VDC power suitable for the other CLARREO Pathfinder Reflected Solar Payload (CPRSP) subsystems.

1.2 Document Organization

Section 2 lists applicable and reference documents. Section 3 provides the PCU concept of operations. Section 4 discusses the external interfaces and boundaries of the PCU. Section 5 contains the technical requirements. Appendix A defines acronyms.

Draft

2.0 Documents

This section identifies documents that are applicable to this document and assumes the current version unless otherwise noted. Reference documents are for information only.

2.1 Applicable Documents

Document Number	Document Title
CPF–02–002	CLARREO Pathfinder Systems Engineering Management Plan
CPF–02–009	CLARREO Pathfinder Mission Concept of Operations
CPF–02–011	CLARREO Pathfinder Science and Mission Requirements Document
CPF–03–001	CLARREO Pathfinder Mission Assurance Requirements
LASP Document No. 154920	CLARREO–Pathfinder PCU Electrical Interface Control Document

2.2 Reference Documents

Document Number	Document Title
~~D683–9747–01~~ D683–97497–01 Revision E	Expedite the Processing of Experiments to Space Station (ExPRESS) Pallet Adapter (ExPA) Interface Definition Document (IDD)
Forgrave, Man, and Newell (1999)	Spacecraft Acoustic and Random Vibration Test Optimization
GSFC–STD–1000G	Goddard Space Flight Center Rules for the Design, Development, Verification, and Operation of Flight Systems
GSFC–STD–7000A	General Environmental Verification Standard
SpX–00036031	Dragon FRAM Payloads Interface Requirements Document (IRD)
SSP 30237	Space Station Electromagnetic Emission and Susceptibility Requirements
SSP 30245	Space Station Electrical Bonding Requirements
SSP 30512	Space Station Ionizing Radiation Design Environment
SSP 51700	Payload Safety Policy and Requirements for the International Space Station
SSP 52005	Payload Flight Equipment Requirements and Guidelines for Safety–Critical Structures
SSP 57003 Revision L	External Payload Interface Requirements Document

2.3 Document Control

This document is managed by the CPF Project and, after initial approval, will be placed under configuration control using the change management processes defined in the CLARREO Pathfinder Configuration Management Operating Procedure (CPF-01–005).

Draft

2.4 Order of Precedence

The Program-Level Requirements and Project-Level plans listed in the applicable documents section take precedence over the PCU Interface Control Document (ICD). Nothing in this document, however, supersedes applicable laws and regulations.

Draft

3.0 Concept of Operations

The Power Converter Unit is a part of the CPRSP, along with the HySICS Instrument-Spacecraft Interface Electronics (HISIE), HySICS Pointing System (HPS), HyperSpectral Imager for Climate Science (HySICS) Instrument, and ExPRESS Pallet Adapter (ExPA). The PCU's primary role is to convert 120 VDC Operational Power provided by the ExPRESS Logistics Carrier (ELC) to 28 VDC Power to service the remaining elements of the CPRSP when the discrete data input is activated.

The PCU operates in a host of different scenarios during its lifetime from integration through disposal. Following assembly, the PCU completes functional and environmental testing at Langley Research Center (LaRC).

The PCU is shipped to LASP, where it is functionally tested with the CPRSP subsystems other than the the ExPA (TBR). The 28 VDC output of the PCU is connected to the HISIE and HPS via three buses and connect 120 VDC and discrete data test lines to the PCU's input ports. The PCU provides analog signal and thermistor outputs to enable troubleshooting and monitoring of PCU operations during CPRSP testing at LASP, all other ground testing, and on-orbit operations. The PCU may be used during thermal vacuum chamber testing. ~~As a programmatic alternative to integration with the other CPRSP elements at LASP, the PCU may travel directly from LaRC to Kennedy Space Center for subsequent CPRSP integration.~~

After completion of the testing at Kennedy Space Center (KSC), the PCU remains unpowered until the CPRSP is attached to ELC-1. During installation when the CPRSP is attached to the Enhanced ORU Temporary Platform (EOTP), the discrete is not asserted, and the PCU does not draw power from the EOTP.

Following installation, the PCU power is nominally enabled by International Space Station (ISS) controllers performing two actions. The first action is activating the 120 VDC Operational Power bus, allowing that power to flow via the J1 port on the ExPA. The relay's switch is normally open and closes only when the discrete data line is activated. The second action is activating the commanding discrete, at which point the PCU energizes the voltage conversion circuitry to output 28 VDC.

When either the 120 VDC Operational Power is removed or the discrete data line is deactivated, the PCU ceases outputting 28 VDC power. When science operations are complete or for other scenarios requiring planned deactivation of the PCU, the nominal order of controller operations for de-energizing the PCU is deactivating the commanding discrete, followed by deactivating the 120 VDC Operational Power bus. In the event of an unplanned power outage of the 120 VDC Operational Bus, controllers deactivate the commanding discrete as soon as possible if power had not yet been restored. Both planned and unplanned power outages remove all power to the CPRSP.

Draft

4.0 External Interfaces

4.1 External Interfaces by Function

The PCU maintains external interfaces across the following functions:

- Structural
  - ExPA Attachment
- Power
  - 28V Power Output
    - 28 VDC Bus A Power Out
    - 28 VDC Bus B Power Out
    - 28 VDC Bus C Power Out
  - 120V Power Input
- Data or signal
  - Analog Signals /Thermistor Output
    - Thermistor Out x 6
    - Bus A Current Analog Out
    - Bus B Current Analog Out
    - Bus C Current Analog Out
    - Bus Voltage Analog Out
- Thermal
  - ExPA Heat Rejection
  - Survival Heaters (TBR)
  - Adaptor Plate (TBR)
- Command
  - Discrete Enable Input

4.2 External Interface Boundaries

Table 4.2-1 shows the boundaries between each of the external interfaces. The External Subsystem identifies the subsystem to which the PCU shares an interface. CPRSP ancillary refers to hardware that is not yet specifically allocated to CPRSP subsystems, generally the wiring harnesses in the context of the PCU. The PCU Items belong to, and will be delivered with the PCU. The External Items belong to the External Subsystem, and the PCU design assumes their presence and availability for connection. LASP Document Number 154920 provides specific pinout information on the interfaces with the CPRSP ancillary external item.

Draft

Table 4.2-1: External Interface Boundaries

Interface	**External Subsystem**	**PCU Item**	**External Item**
ExPA Attachment	ExPA	Holes	Fasteners
28V Power Output (J20)	CPRSP ancillary	PCU Jack	Mating Connector
120V Power Input (J21)	CPRSP ancillary	PCU Jack	Mating Connector
Analog Signals /Thermistor Output (J22)	CPRSP ancillary	PCU Jack	Mating Connector
Discrete Enable Input (J23)	CPRSP ancillary	PCU Jack	Mating Connector
ExPA Thermal	ExPA	PCU −Z surface	ExPA surface
Survival Heaters (TBR)	CPRSP ancillary	PCU surface	Survival Heater
Adaptor Plate Thermal (TBR)	CPRSP ancillary	PCU +Z surface	Adaptor Plate

Draft

5.0 Requirements

This section contains the requirements that define the performance of the PCU, its interface with the other CPRSP subsystems, and the testing of the delivered article.

5.1 Accepts 120 VDC Input

[PCU.10000] Input 120 VDC

The PCU shall operate nominally given a steady-state voltage between ~~106.5~~ 102 VDC and 126.5 VDC on the Operational Power input in accordance with LASP Document No. 154920.

> Rationale: *The PCU converts the 120 VDC Operational Power supplied by the ExPA into 28 VDC. Document No. 154920 identifies the pins, part number, manufacturer, and description of the 120V Power Input interface jack and mating connector. This derives from the ELC 120 VDC Power Interface requirements of section E.3.2.1.1.1 of SSP 57003 Rev L. Figure E.3.2.1.1.2–1 implies that the PCU could see a minimum of 102 VDC.*

[PCU.10005] Exposure to ~~Brownout~~ Undervoltage

The PCU shall operate nominally after exposure to input voltages from 0 to ~~120 VDC during brownout~~102 VDC (TBR).

> Rationale: *The PCU needs to be resilient to times when the ELC may provide less voltage than the advertised nominal value. This derives from engineering best practices to ensure that the PCU continues to operate after exposure to voltages less than the minimum nominal voltage of 102VDC. Exposure to lower voltage might result in high current draw, which could damage or stress components within the PCU.*
>
> ~~Comments: **What is the LASP rationale for this requirement? Given the nominal input voltage range of 102V-126.5V, the brownout range cannot be all the way up to 120V. It seems like there should be more specifics to account for a particular condition. How does LASP want LaRC to verify this requirement?**~~

[PCU.10010] Survival Following Unannounced Removal of Power

The PCU shall ~~survive~~ operate nominally after exposure to an unplanned removal of power.

> Rationale: *The PCU needs to be resilient to times when the ISS removes 120V Operational Power from the ELC prior to notifying the CPOC due to operational constraints.*

[PCU.10015] Protection from Input Polarity Reversal

Draft

The PCU shall protect itself from damage due to reversed polarity at the PCU 120 VDC input.

Rationale: *During integration and test, there is a possibility that technicians may attach the wrong connectors to the 120 VDC inputs, and the PCU design need to accommodate this situation.*

[PCU.10020] 120 VDC Non-Normal Voltage Transients

The PCU shall operate nominally following exposure to transient voltage conditions as specified by SSP 57003 Rev L Figure E.3.2.1.1.2–1.

Rationale: *This requirement protects the ISS in the event of a transient voltage condition. Loads may be exposed to transient overvoltage conditions during operation of the power system's fault protection components. This derives from the ELC 120 VDC Power Interface requirements of section E.3.2.1.1.2 of SSP 57003 Rev L.*

[PCU.10025] Reverse Current

The PCU shall limit reverse current transients in accordance with Figures E.3.2.1.1.4–1, E.3.2.1.1.4–2, E.3.2.1.1.4–3 of SSP 57003 Rev L when exposed to a hard fault across the power source, as specified by section E.3.2.1.1.4 of SSP 57003 Rev L.

Rationale: *This requirement prevents current from entering an output and damaging components. For purposes of this interface definition, the fault is 10 milliohms or less applied within 2 micro-seconds or less. For the ELC Payload/payload exhibiting reverse current transient peaks within +/-100 Amperes, the fault resistance is 40 milliohms or less. This derives from the ELC 120 VDC Power Interface requirements of section E.3.2.1.1.4 of SSP 57003 Rev L.*

[PCU.10030] 120 VDC Operational Power Ripple Voltage and Noise

The PCU shall operate and be compatible with the EPS time domain ripple voltage and noise level of 2.5 Vrms maximum within the frequency range of 30 Hz to 1 MH when connected to 120 VDC Operational Power.

Rationale: *This requirement precludes damage to ExPCA and ORUs. Derives from the ELC 120 VDC Power Interface requirements of section E.3.2.1.1.6.2 of SSP 57003 Rev L.*

[PCU.10035] 120 VDC Operational Power Ripple Voltage Spectrum

Draft

The PCU, connected to ELC 120 VDC output, shall operate and be compatible with the EPS ripple voltage spectrum of a maximum as shown in SSP 57003 Rev L Figure E.3.2.1.1.6.3–1.

Rationale: *This requirement precludes damage to ExPCA and ORUs. Note: This limit is 6 decibels (dB) below the Electromagnetic Compatibility (EMC) CS-01, 02 requirement in SSP 30237, Space Station Requirements for Electromagnetic Emission and Susceptibility Requirements, up to 30 MHz. Derives from the ELC 120 VDC Power Interface requirements of section E.3.2.1.1.6.3 of SSP 57003 Rev L.*

[PCU.10040] 120 VDC Operational Power Surge Current

The PCU shall limit in-rush current at power input connected to ELC 120 VDC output interface in accordance with Table E.3.2.1.1.6.4–1 of SSP 57003 Rev L.

Rationale: *This requirement prevents a hazard due to circuit overload. Derives from the ELC 120 VDC Power Interface requirements of section E.3.2.1.1.6.4 of SSP 57003 Rev L.*

5.2 Accepts Discretes

[PCU.11000] Input Discrete Power-on Command

The PCU shall recognize a digital logic zero (VIL) and digital logic one (VIH) for +5 V or +28 V ~~TBR~~(TBR) logic levels from the ExPCA as defined in Table L.3.7.4.1.1–1, Discrete Output Logic Levels, between the payload input pins.

Rationale: *The discrete signal conveys the power on command to the PCU. Document No. 154920 identifies the pins, part number, manufacturer, and description of the Discrete Enable Input interface jack and mating connector. Derives from Discrete Output Logic Levels (from ExPCA) requirements of section L.3.7.4.1.1 of SSP 57003 Rev L.*

[PCU.11005] Output Power with Discrete Present

The PCU shall activate its output voltage when the discrete Power-on signal is logic one and when 120 VDC is applied to the PCU input.

Rationale: *The PCU output power is normally off and enabled when the discrete signal is present (logic one).*

[PCU.11010] No Output Power without Discrete

Draft

The PCU shall cease outputting power when the discrete Power-on signal is logic zero.

Rationale: *The PCU output power is normally off and only enabled when the discrete signal is present (logic one). This prevents the PCU from drawing a significant load unless the CPRSP is attached to the ELC and commanded on by the CPOC.*

[PCU.11015] Discrete Returns

The PCU shall provide an individual return for each ISS low level discrete signal.

Rationale: *A dedicated return ensures that return currents are routed with supply leads, thus minimizing radiation due to differential mode currents and aids in crosstalk reduction. Not sharing returns minimizes the chances of common impedance noise coupling. This derives from the Analog, Differential Circuit Return requirement in section 3.2.3.3.2.6 of SSP 57003 Rev L.*

[PCU.11020] Discrete Loading - Capacitance

The PCU shall prevent the maximum capacitive loading on the ExPA discrete outputs from exceeding 1 microFarad.

Rationale: *This requirement ensures that discrete signals (including those used to control a hazard) are received. This derives from the Payload Discrete Loading Requirements in section L.3.7.4.6.A of SSP 57003 Rev L.*

[PCU.11025] Discrete Loading - Inductance

The PCU shall prevent the maximum inductive loading the ExPA discrete outputs from exceeding 10mH.

Rationale: *This requirement ensures that discrete signals (including those used to control a hazard) are received. This derives from the Payload Discrete Loading Requirements in section L.3.7.4.6.A of SSP 57003 Rev L.*

[PCU.11031] Discrete Loading - Resistance 28 V

The PCU shall ensure that the maximum resistive loading on the ExPCA +28V discrete output exceeds 700 Ohm, except for when used for switch closure detection.

Rationale: *This requirement ensures that discrete signals (including those used to control a*

Draft

hazard) are received. The ExPCA discrete output voltage span of +28 Vdc +2.6/-4.0 Vdc is not guaranteed when loading exceeds 35mA (current-limiting will occur with FRAM-based Payload loads drawing about 35 mA). This derives from the Payload Discrete Loading Requirements in section L.3.7.4.6.B of SSP 57003 Rev L.

5.3 Outputs 28 VDC

[PCU.12000] Output 28 VDC

The PCU shall output 28 VDC Power nominal on three power buses in accordance with LASP Document No. 154920.

Rationale: *The PCU generates 28 VDC and then splits it into three different nets (busses), which are routed to various sub-systems within the CPRSP.*

[PCU.12005] Minimum Output Voltage

The PCU shall output electrical power at a voltage greater than or equal to 22 VDC.

Rationale: *Aref Nammari, Lead EE for CLARREO at LASP, stated in 24OCT2017 e-mail "CPRS DC-DC converters have a wide input range: 22V to 40V."*

[PCU.12010] Maximum Output Voltage

The PCU shall output electrical power at a voltage less than or equal to 40 VDC.

Rationale: *Aref Nammari, Lead EE for CLARREO at LASP, stated in 24OCT2017 e-mail "CPRS DC-DC converters have a wide input range: 22V to 40V."*

[PCU.12015] Maximum Output Ripple Voltage

The PCU shall output a DC voltage with a peak-to-peak ripple voltage less than or equal to 400 mV.

Rationale: ~~*Aref Nammari, Lead EE for CLARREO at LASP, stated in*~~ *The EPIC power converter used with the TSIS payload specified 400mVpp output ripple voltage. The HPS controller is a* ~~*24 OCT 2017 e-mail, "Ripple of <= 500mV*~~ *rebuild as is* ~~*reasonable*~~ *from TSIS TPS ISIE and* ~~*should work: I*~~ *was successfully tested with the EPIC. The HISIE power board will* ~~*take a closer look at*~~ *leverage the HPS controller design and uses the same type of DC-DC converters. The LCCE (cryo-cooler controller) and other subsystems are also*

verified to ~~*confirm but I don't think there would be a problem*~~*operate without fault or degradation of performance when subjected to ripple voltage of 200mVp up to 150kHz (consistent with CS01/CS101 per MIL-STD-461F).*"

~~Comments: **Request more detailed rationale from LASP.**~~

[PCU.12020] Minimum Output Power

The PCU shall output electrical power greater than or equal to ~~20 W~~ 10 W (TBR).

Rationale: ~~*This*~~ *Verification of this requirement* ~~*serves as the minumum expected load from the CPRSP. It does not mean*~~ *ensures that the PCU* ~~*must have*~~ *remains stable at a* ~~*minimum*~~ *low load.*~~*Aref Nammari, Lead EE for CLARREO at LASP, agreed to this value in in 24OCT2017 e-mail.*~~

5.4 Outputs Analog Signals

[PCU.13000] Output Analog Signals

The PCU shall output thermistor and analog signals in accordance with LASP Document No. 154920.

Rationale: *The PCU transmits engineering data for diagnostic testing via a set of analog lines. Document No. 154920 identifies the pins, part number, manufacturer, and description of the Analog Signals /Thermistor Output interface jack and mating connector.*

[PCU.13005] Transmit Bus A Current Signal

The PCU shall transmit the Bus A current telemetry via an analog signal.

Rationale: *Transmitting the Bus A current to the HISIE enables CPOC monitoring and troubleshooting of the PCU.*

[PCU.13010] Transmit Bus B Current Signal

The PCU shall transmit the Bus B current telemetry via an analog signal.

Rationale: *Transmitting the Bus B current to the HISIE enables CPOC monitoring and troubleshooting of the PCU.*

[PCU.13015] Transmit Bus C Current Signal

Draft

The PCU shall transmit the Bus C current telemetry via an analog signal.

Rationale: *Transmitting the Bus C current to the HISIE enables CPOC monitoring and troubleshooting of the PCU.*

[PCU.13018] Transmit Bus Output Voltage Signal

The PCU shall transmit the bus output voltage telemetry via an analog signal.

Rationale: *Transmitting the output voltage to the HISIE enables CPOC monitoring and troubleshooting of the PCU*

[PCU.13020] Thermistor Output

The PCU shall transmit six internal temperatures to the HISIE using no more than six thermistors.

Rationale: *The thermistors provide the HISIE information into PCU internal temperatures, which may constrain certain operations of the PCU.*

5.5 Provides Current Protection

[PCU.14000] Bus A Maximum Current

The PCU shall fuse Bus A to 10 amperes ~~TBR~~(TBR).

Rationale: *Calculated from max expected power of 132W at 30V, derated at 50%, and choosing next higher current fuse.*

[PCU.14003] Bus B Maximum Current

The PCU shall fuse Bus B to 7.5 amperes ~~TBR~~(TBR).

Rationale: *Calculated from max expected power of 107W at 30V, derated at 50%, and choosing next higher current fuse.*

[PCU.14006] Bus C Maximum Current

The PCU shall fuse Bus C to 15 amperes ~~TBR~~(TBR).

Draft

Rationale: *Calculated from max expected power of 168W at 30V, derated at 50%, and choosing next higher current fuse.*

[PCU.14010] Bus A Maximum Output Power

The PCU shall output electrical power to Bus A with a power less than or equal to 132 W.

Rationale: *Bus A powers the HISIE, and the value is provided by Aref Nammari during meeting on 07FEB2018.*

[PCU.14013] Bus B Maximum Output Power

The PCU shall output electrical power to Bus B with a power less than or equal to 107 W.

Rationale: *Bus B powers the HPS, and the value is provided by Aref Nammari during meeting on 07FEB2018.*

[PCU.14016] Bus C Maximum Output Power

The PCU shall output electrical power to Bus C with a power less than or equal to 168 W.

Rationale: *Bus C powers the gimbal motors, and the value is provided by Aref Nammari during meeting on 07FEB2018.*

[PCU.14020] Circuit Protection Trip Coordination

The PCU shall provide trip coordination such that sub-system over-current protection nearest to the fault will activate prior to over-current protection further upstream.

Rationale: *This requirement ensures operability of the CPRSP without tripping upstream protection devices. This derives from the Electrical Power System Circuit Protection Characteristics requirements in section 3.2.2.A of SSP 57003 Rev L.*

[PCU.14025] Circuit Protection for Overcurrent

The PCU shall provide overcurrent protection at all points where power is distributed to lower level feeder and branch lines as specified by Tables 3.2.2–3, 3.2.2–4, 3.2.2–5, 3.2.2–6, and 3.2.2–7 of SSP 57003 Rev L.

Draft

Rationale: *This requirement prevents overload of wiring within the CPRSP. This derives from section 3.2.2.B of SSP 57003 Rev L.*

[PCU.14100] EOTP Current Draw

The PCU shall not draw current from the EOTP.

Rationale: *The EOTH electrical interface is only defined for resistive heater power loads. Non-resistive electrical logs,* e.g. *motors, computers, capacitors,* etc*., are not supported by the EOTP. Payloads must have inhibits in place for all non-resistive electrical loads such that no power is being drawn from the EOTP power buses when they are energized (SSP 57003, 3.7.3.5.3). ExPA-based Payloads need to be aware that the EOTP Primary Heater Power (120 VDC Bus 1) use the same lines as the ELC operational power lines. Note that the EOTP has no command or telemetry for payloads.*

5.6 Matches Impedance

[PCU.15000] Downstream Impedance

The PCU shall output power compatible with the specified load impedance model (Agile # TBD).

Rationale: *The PCU design accounts for a stable impedance interface between the load and the source across frequencies of interest. Load impedance model is from LTspice model with filename* `CPRS_PWR_input_impedance_NO_PCU.asc` *delivered by LASP on 21 February 2018.*

~~Comments:~~ **~~Request that LASP place LTspice model under configuration control and provide a reference to which requirement can refer.~~**

5.7 Isolates DC Power

[PCU.15100] Payload Power Isolation

The PCU shall isolate its DC power from chassis, structure, equipment conditioned power return/reference, and signal returns by a minimum of 1 MegaOhm.

Rationale: *The 120 VDC or 28 VDC source is referenced to structure at its output. The payload power input must be isolated to prevent ground loops and intentional current flow through structure. This derives from the Payload Power Isolation requirements in section 3.2.3.3.1 of SSP 57003 Rev L.*

Draft

Comments: **Need to resolve this comment from Aref: "CPRS will implement a single point ground where the returns from all subsystems will connect to 28V return which will connect to chassis therefore making chassis the single point ground and this single point ground would be the PCU chassis. The requirement PCU.15100 is not quite consistent with either PCU.15110 or PCU.15115 which allow for returns to be connected to chassis if it is the single point ground."**

[PCU.15105] Single Point Ground

The PCU shall connect each electrically isolated power source to the structure at no more than one point.

Rationale: *A single reference to structure prevents the flow of intentional and noise currents which could have an adverse impact on ISS and other equipment operations. This derives from the Single Point Ground requirement in section 3.2.3.3.2.1 of SSP 57003 Rev L.*

[PCU.15110] Electrical Power Isolation

The PCU shall isolate each isolated electrical DC power source from chassis, structure, equipment-conditioned power return/reference, and signal circuits by a minimum of 1 MegaOhm, individually, except at the single point ground.

Rationale: *A single reference to structure prevents the flow of intentional and noise currents which could have an adverse impact on ISS and other equipment operations. This derives from the Electrical Power Isolation requirements in section 3.2.3.3.2.2 of SSP 57003 Rev L.*

[PCU.15115] Signal Circuit Return Grounding

The PCU shall DC isolate circuit conductors from chassis, structure, and equipment conditioned power return/reference, by a minimum of 1 MegaOhm, individually, when not terminated by the signal circuit's single point ground/reference.

Rationale: *A single reference to structure prevents the flow of intentional and noise currents which could have an adverse impact on ISS and other equipment operations. Balanced, differential circuits isolated from chassis, structure, and user conditioned power return/reference by a minimum of 6000 ohms complies with this requirement. Note: Signals circuits with frequency components equal to or above four megahertz may use controlled impedance transmission and reception media such as (but not limited to): –1) shielded twisted 72 ohm cable–; 2) "twin ax" cable balanced and referenced to primary structure at a single point–; 3) "triax" cable using the center and inner shield conductors for*

Draft

unbalanced transmission, referenced to primary structure at a single point with the outer shield multipoint grounded as an "overshield". ; or 4) "coax" cable with the shield terminated 360 degrees at each end and at available intermediate point (permitted for signals with the lowest frequency component equal to or above 4 MHz). This derives from the Signal Circuit Returning Grounding requirement in section 3.2.3.3.2.3 of SSP 57003 Rev L.

[PCU.15120] Analog, Differential Circuit Return

The PCU shall provide a separate return for each differential analog circuit.

Rationale: *A dedicated return ensures that return currents are routed with supply leads, thus minimizing radiation due to differential mode currents and aids in crosstalk reduction. Not sharing returns minimizes the chances of common impedance noise coupling. This derives from the Analog, Differential Circuit Return requirement in section 3.2.3.3.2.5 of SSP 57003 Rev L.*

5.8 Structural

[PCU.16000] Mass Limit

The PCU shall have a mass less than or equal to 8.77 kg (TBR).

Rationale: *This value is the 6.9 kg current best estimate as of APR2018 along with a 27% mass growth allowance.*

Comments: **15MAY18: Awaiting approval by Tim Holden.**

[PCU.16005] Input Connector Location

The PCU shall have input connectors along its `-Y` face in the ExPA Reference Coordinate System.

Rationale: *This is an interpretation of a drawing that Aref Nammari, Lead EE for CLARREO at LASP, sent in 24OCT2017 e-mail. Reference: D683–97497–01.*

[PCU.16010] Output Connector Location

The PCU shall have output connectors along its `-X` face in the ExPA Reference Coordinate System.

Rationale: *This is an interpretation of a drawing that Aref Nammari, Lead EE for CLARREO at LASP, sent in 24OCT2017 e-mail. Reference: D683–97497–01 Revision E.*

Draft

[PCU.16015] Connector Types

The PCU shall implement external interface connectors in accordance with LASP Document Number 154920 “PCU Electrical Interface Control Document.”

Rationale: *LASP’s PCU ICD specifies the PCU connectors as follows:*

Table 5.8-1: Connector Specifications

Reference Designator	Description	Part Number
J20	28V Power Output	TVPS00RF–11–98S(453)
J21	120V Power Input	TVPS00RF–15–4P(453)
J22	Analog Signals /Thermistor Output	TVPS00RF–13–35S(453)
J23	Discrete Enable Input	311P407–1P–B–12

[PCU.16020] Dimension in X axis

The PCU dimension along the X-axis in the ExPA Reference Coordinate System shall be less than 34.00 inches (TBR).

Rationale: *This is the dimension of the ExPA Payload envelope along the X-axis. Reference: D683–97497–01.*

Comments: **15MAY2018: Ryan Lewis will redo X-axis allocation that accounts for flexures and mechanical considerations.**

[PCU.16025] Dimension in Y axis

The PCU dimension along the Y-axis in the ExPA Reference Coordinate System shall be less than 46.00 inches (TBR).

Rationale: *This is the dimension of the ExPA Payload envelope along the Y-axis. Reference: D683–97497–01.*

Comments: **15MAY2018: Ryan Lewis will redo Y-axis allocation that accounts for flexures and mechanical considerations.**

[PCU.16030] Dimension in Z axis

The PCU shall be less than 2.3 inches along the Z-axis in the ExPA Reference Coordinate System.

Draft

Rationale: *This is the maximum allowable value provided by LASP on 5 April 2018. Reference: D683–97497–01. This is the most binding spatial/mass requirement on the design.*

~~Comments: **Verify with LASP that 2.3 inches accommodates human factors "working volume" to make integration tasks feasible.**~~

[PCU.16100] Structural Interface

The PCU shall ~~compy~~ comply with the ExPA Interface Definition Document (IDD) (D683–97497–01) at the structural interface to the ExPA.

Rationale: *This IDD applies to all FRAM-based payloads. Section E.3.1.4.2.3 of SSP 57003 Rev L (FRAM Fastener Installation) describes how external payloads are attached to the FRAM and references the ExPA IDD.*

~~**PCU.16105** PCU Positioning on ExPA~~

~~The PCU shall comply with LASP interface drawing TBD.~~

~~Rationale: *This drawing shows how the PCU should be positioned on ExPA to ensure interface compatibility with the rest of the CPRSP.* Comments: **Request LASP provide a drawing specifying any positioning constraints for PCU on ExPA.**~~

[PCU.16110] Threaded Fasteners with Locking Features

The PCU shall use threaded fasteners that implement locking features.

Rationale: *The locking features decreases the risk that threaded fasteners will unseat themselves. LASP recommends Nitronic 60 or stainless steel locking helicoils. This derives from a GOLD rule 4.20 (Fastener Locking) that flows down to the PCU.*

~~Comments: **Clarify rationale with LASP**~~

[PCU.16115] Covered Holes

The PCU shall incorporate covers on all round or slotted holes in the range of 0.5 inch to 1.4 inch.

Rationale: *This requirement prevents EVA crew entrapment or injury. This derives from an EVA Human Engineering Safety requirement in section 3.8.3.2 of SSP 57003 Rev L.*

[PCU.16120] Burrs

Draft

The PCU shall have exposed surfaces free from burrs.

Rationale: *This requirement protects EVA crew from injury due to burrs. This derives from an EVA Human Engineering Safety requirement in section 3.8.3.4 of SSP 57003 Rev L.*

[PCU.16125] Sharp Edges and Protrusion Criteria

The PCU shall meet sharp edge and protrusion criteria specified by Figure 3.8.3.7–1 and Tables 3.8.3.7–1 and 3.8.3.7–2 from SSP 57003.

Rationale: *This requirement protects crew from injury due to sharp edges. This derives from the Sharp Edges and Protrusion Criteria requirement in section 3.8.3.7 of SSP 57003 Rev L.*

[PCU.16130] Component Hazardous Energy Provision

The PCU shall prevent a crewmember from releasing any hazardous energy potential.

Rationale: *This requirement protects EVA crew from injury due to hazardous energy. This derives from an EVA Human Engineering Safety requirement in section 3.8.3.9 of SSP 57003 Rev L.*

[PCU.16135] EVA Induced Loads

The PCU shall maintain positive margins of safety for any components exposed to EVA crew loads as defined in Table 3.1.3–1 of SSP 57003 Rev L.

Rationale: *CPRSP hardware structure must be designed to withstand on-orbit crew loads and to prevent structural failure of the payload, which could pose a risk to the ISS or crew. Derives from Extravehicular Activity On-Orbit Induced Loads requirements of section 3.1.3 of SSP 57003 Rev L.*

5.9 ~~External Contamination~~

~~**PCU.16205** Molecular Deposition onto Other Payloads~~

~~The PCU shall limit cumulative contaminant deposit on other Payloads, using the nominal operating temperature of the contamination source materials (emitters) and nominal operating temperatures of other Attached Payloads (receivers), to less than TBDgcm^2s.~~

Draft

Rationale: *This requirement prevents molecular deposition on ISS and other payloads. Derives from External Contamination Requirements of section 3.5.3.2.A of SSP 57003 Rev L.*

PCU.16210 Molecular Deposition onto ISS Elements

The PCU shall limit cumulative contaminant deposit on ISS elements, using the nominal operating temperature of the contamination source materials (emitters) and nominal operating temperatures of other Payloads (receivers), to less than TBDgcm^2s.

Rationale: *This requirement prevents molecular deposition on ISS and other payloads. Derives from External Contamination Requirements of section 3.5.3.2.B of SSP 57003 Rev L.*

PCU.16215 Particulates

The PCU shall limit any activate venting release of particulates to less than 100 microns in size.

Rationale: *This requirement protects the external environment. Derives from External Contamination Requirements of section 3.5.3.3 of SSP 57003 Rev L.*

PCU.16220 Visible Clean-Sensitive

The PCU shall have visibly clean external surfaces at an incident light level of at least 50 foot-candles and at a distance of 2 to 4 feet.

Rationale: *This requirement reduces the amount of contamination that the PCU might induce in the rest of the CPRSP, launch vehicle, or ISS environments. This derives from the Cleanliness requirement in section 3.6.2 of SSP 57003 Rev L.*

PCU.16225 Structural Materials Criteria and Selection

The PCU shall incorporate structural materials in accordance with Section 5.4.1 of SSP 52005.

Rationale: *SSP 52005 is the Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures.*

[PCU.16400.16140] Acceleration Environment

The PCU shall meet structural integrity requirements in an On-Orbit acceleration environment having peak transient accelerations of up to 0.4 g, a vector quantity acting in any direction.

Draft

Rationale: *This criterion is to be used to assess the effects of the impact during payload installation. This acceleration is not intended to be used to calculate interface loads. One "g" is equivalent to 9.8 m/s^2. Derives from Acceleration Environment requirements of section 3.5.9B of SSP 57003 Rev L.*

[PCU~~.16410~~.16145] Launch Loads - Axial

The PCU shall ~~survive~~ operate nominally after exposure to axial random vibration loads of TBD.

Rationale: *The PCU will be subjected to significant random vibration loads during launch. Requirement levied by LASP via spreadsheet dated 05MAR2018.*

[PCU~~.16415~~.16150] Launch Loads - Lateral

The PCU shall ~~survive~~ operate nominally after exposure to lateral random vibration loads of TBD.

Rationale: *The PCU will be subjected to significant random vibration loads during launch. Requirement levied by LASP via spreadsheet dated 05MAR2018.*

[PCU~~.16420~~.16155] Structural Loading

The PCU shall ~~survive~~ operate nominally after exposure to a static load of 60g applied in each of the X, Y, and Z axes in the ExPA Reference Coordinate System.

Rationale: *The PCU will be subjected to significant structural loads during launch. Requirement levied by LASP via spreadsheet dated 05MAR2018. Reference: D683–97497–01. One "g" is equivalent to 9.8 m/s^2.*

[PCU~~.16425~~.16160] Minimum Natural Frequency

The PCU shall have a minimum natural frequency of 250 Hz ~~TBR~~(TBR).

Rationale: ~~*Setting a*~~ *The standard minimum* ~~*natural*~~ *fundamental frequency* ~~*above that expected*~~ *for a board and box assembly at LASP is 250 Hz to* ~~*be encountened prevents the PCU from experiencing induced resonance*~~*allow separation betweeen structural modes and box modes.* ~~*Requirement levied by LASP via spreadsheet dated 05MAR2018*~~*The CPRSP has many structural frequencies around 60 Hz.*

~~Comments: **A typical value is 60Hz. What is the rationale for 250Hz and opposed to 60Hz?**~~

Draft

[PCU~~.16430~~.16165] Acoustics

PCU enclosure components shall have a "break even" ~~value~~ area/mass ratio of 150in^2/lb or less, as defined by Forgrave, Man, and Newell (1999).

Rationale: ~~*Requirement levied by LASP via spreadsheet dated 05MAR2018*~~*The "break even" area/mass ratio represents the regime in which both acoustic and random vibration tests induce equal stochastic acceleration responses. Refer to: Forgrave, J.C. & Man, K.F. & Newell, J.M.. (1999). Spacecraft acoustic and random vibration test optimization. 33. 28–31.*

~~Comments: **Ask LASP to clarify the requirement and provide rationale for the value. Show the units be "lbin^2" as opposed to "in^{2}lb"?**~~

[PCU~~.16435~~.16170] On-Orbit Loads

The PCU shall maintain positive structural margins of safety when exposed to the loading induced by plate deformations in bending.

Rationale: ~~*LASP original: "PCU shall be designed to maintain positive structural margins of safety when exposed to the loading induced by plate deformations in bending"*~~*nan*

Comments: **Request clarification and rationale from Ryan Lewis at LASP.**

[PCU~~.16440~~.16175] Pressure Decay Rate during Launch

The PCU shall maintain positive structural margins of safety when exposed to a pressure decay rate of 0.4 lb/in^2 per second.

Rationale: *The PCU needs to maintain structural integrity in an environment of decreasing of local atmospheric pressure during launch. This decay rate is comprehensive and envelopes low and high fill factors. This is derived from requirement SPX-FRAM-030-REQ from section 2.5.9 of the Dragon FRAM Payloads Interface Requirements Document (SPX-0003603, version 3.0)*

[PCU~~.16445~~.16180] Pressure Decay Rate during Launch Transonic Regime

The PCU shall maintain positive structural margins of safety when exposed to a pressure decay rate of 1.0 lb/in^2 per second for a duration of 7.0 seconds.

Rationale: *The PCU needs to maintain structural integrity in an environment of decreasing of local atmospheric pressure during launch. This decay rate is comprehensive and*

Draft

envelopes low and high fill factors. This is derived from requirement SPX-FRAM-030-REQ from section 2.5.9 of the Dragon FRAM Payloads Interface Requirements Document (SPX-0003603, version 3.0)

5.9 ~~Thermal~~

[PCU.16185] Structural Analysis/Design Factors of Safety

~~**PCU.17000** Thermal Mass~~ The PCU shall comply with the structural analysis and design factors of safety, as defined in GSFC-STD-7000A.

~~The PCU thermal mass shall be 4475 +~~

Rationale: *GSFC-STD-7000A contains environmental verification standards for space flight hardware.*

5.9 External Contamination

[PCU.16205] Molecular Deposition onto Other Payloads

The PCU shall limit cumulative contaminant deposit on other Payloads, using the nominal operating temperature of the contamination source materials (emitters) and nominal operating temperatures of other Attached Payloads (receivers), to less than TBD g/~~- TBDJ~~cm^2/~~K~~s.

Rationale: ~~*CPRSP subsystem designs are based on their equivalent subsystems from TSIS, which interfaced with the EPIC converter.*~~ *This requirement* ~~*simplifies the thermal analysis*~~ *prevents molecular deposition on ISS and other payloads. Derives from External Contamination Requirements of* ~~*the CPRSP element interfaces with the PCU*~~*section 3.5.3.2.*~~*Aref Nammari, Lead EE for CLARREO at LASP, stated in a 24 OCT 2017 e-mail, "We would like the thermal mass*~~ *A of* ~~*the covert to be the same as EPIC which was about 4475 Jdeg C"*~~*SSP 57003 Rev L.*

[PCU.16210] Molecular Deposition onto ISS Elements

The PCU shall limit cumulative contaminant deposit on ISS elements, using the nominal operating temperature of the contamination source materials (emitters) and nominal operating temperatures of other Payloads (receivers), to less than TBD g/cm^2/s.

~~Comments: **Ask LASP for a reasonable range of thermal mass and a technical rationale.**~~ Rationale: *This requirement prevents molecular deposition on ISS and other*

Draft

payloads. Derives from External Contamination Requirements of section 3.5.3.2.B of SSP 57003 Rev L.

5.10 ~~Operational Environment~~

[PCU.16215] Particulates

~~**PCU.18005** Functional Lifetime of Parts~~ The PCU shall limit any activate venting release of particulates to less than 100 microns in size.

Rationale: *This requirement protects the external environment. Derives from External Contamination Requirements of section 3.5.3.3 of SSP 57003 Rev L.*

[PCU.16220] Visible Clean-Sensitive

The PCU shall ~~contain only items whose expected function life exceeds 14 months~~have visibly clean external surfaces at an incident light level of at least 50 foot-candles and at a distance of 2 to 4 feet.

Rationale: ~~*The SMRD RS.21040 specifies prime mission opereation period*~~ *This requirement reduces the amount of* ~~*1 year following 2 months*~~ *contamination that the PCU might induce in the rest of* ~~*commissioning activities*~~*the CPRSP, launch vehicle, or ISS environments. This derives from the Cleanliness requirement in section 3.6.2 of SSP 57003 Rev L.*

[PCU~~.18100~~.16225] Structural Materials Criteria and Selection

The PCU shall incorporate structural materials in accordance with Section 5.4.1 of SSP 52005.

Rationale: *SSP 52005 is the Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures.*

5.10 Thermal

[PCU.17100] Flight Operational Allowable Flight Temperature

The PCU shall operate nominally between the temperatures -30 deg C and +50 deg C (TBR), measured at the mounting surface.

Draft

Rationale: *This represented the expected temperature regime on orbit in which the PCU needs to function. This is the range of temperatures expected to be encountered during operations on the ELC. This imposes an operational constraint on turning on and turning off the PCU.*

~~Comments: **Ask LASP for the rationale for the -30 to +50 values.**~~

[PCU~~.18105~~.17105] Non-Operational Survival Temperature

The PCU shall ~~survive~~ operate nominally after exposure to temperatures of -50 deg C to +75 deg C (TBR), measured at the mounting surface.

Rationale: *This ~~represented~~ represents the expected temperature regime on orbit to which the PCU may be exposed to and subsequently operate when returned to the allowable flight temperature defined by PCU.17100. This considers the thermal state of 6 hour unpowered condition during installation activities.*

5.11 Operational Environment

[PCU.18005] Functional Lifetime of Parts

The PCU shall contain only items whose expected function life exceeds 14 months.

~~Comments: **Ask LASP for the rationale for the -50 to +75 values.**~~ Rationale: *The SMRD RS.21040 specifies prime mission opereation period of 1 year following 2 months of commissioning activities.*

[PCU.18110] Total Ionizing Dose

The PCU shall operate nominally while exposed to the total ionizing dose levels as specified by SSP 30512.

Rationale: *The design of the PCU needs to account for the expected radiation in its operational environment, which could threaten its operations.*

[PCU.18115] Trapped Electron Exposure

The PCU shall operate nominally while exposed to the trappeed electron flux levels as specified by SSP 30512.

Draft

Rationale: *The design of the PCU needs to account for the expected radiation in its operational environment, which could threaten its operations.*

[PCU.18120] Trapped Proton Exposure

The PCU shall operate nominally while exposed to the trappeed proton flux levels as specified by SSP 30512.

Rationale: *The design of the PCU needs to account for the expected radiation in its operational environment, which could threaten its operations.*

[PCU.18125] Single Event Upset

The PCU shall operate nominally without sustaining permanent damage following exposure to single event upsets as specified by SSP 30512.

Rationale: *The design of the PCU needs to account for the expected radiation in its operational environment, which could threaten its operations.*

[PCU.18130] Single Event Latchup

The PCU shall operate nominally without sustaining damage following exposure to single event latchup events as specified by SSP 30512.

Rationale: *The design of the PCU needs to account for the expected radiation in its operational environment, which could threaten its operations.*

[PCU.18135] Material Breakdown Voltages

The PCU shall incorporate materials, including surface coatings, with breakdown voltages in excess of +20/-80 volts on all components directly exposed to the plasma environment.

Rationale: *This requirement protects the ISS and EVA crewmembers from electrostatic discharges and prevents arcing. This derives from Plasma requirements of section 3.5.4.1A of SSP 57003 Rev L.*

~~**PCU.18200** Structural AnalysisDesign Factors of Safety~~

5.12 Ground Test Environment

Draft

~~The PCU shall comply with the structural analysis and design factors of safety, as defined in GSFC-STD-7000A.~~

> ~~Rationale: *GSFC-STD-7000A contains environmental verification standards for space flight hardware.*~~

[PCU~~.18205~~.18150] ~~E Minimum Workmanship Vibroacoustic Test Levels~~ Relative Humidity during Ground Test

The PCU shall ~~meet minimum workmanship test levels specified by Section 2.4.2.5 of GSFC-STD-7000A~~operate nominally following exposure to 30–60% (TBR) relative humidity during ground testing.

> Rationale: ~~*Section 2.4.2.5 of GSFC-STD-7000A*~~ *This specifies the expected relative humidity during ground testing, which the PCU is* ~~*CompomentUnit Vibroacoustic Tests section of GEVS*~~*not expected to encounter during on-orbit operations.*

5.13 EMI/EMC

[PCU.19005] Conducted Susceptibility (CS06) Limits

The PCU shall prevent any malfunction, degradation of performance, or deviation that exceeds tolerances when subjected to test spikes, in accordance with Figure 3.2.4.2.3–1 of SSP 57003 Rev L, applied to DC power input leads.

> Rationale: *This requirement is to ensure that payload equipment does not experience damage or degraded performance when subjected to transients that may be expected on the power bus. Longer duration transients are covered by power quality requirements. Note: CS06 is applicable to dc power leads of equipment and subsystem powered by 120 Vdc sources, including grounds and returns, which are not grounded internally to the equipment or subsystem. (From SSP 30237, 3.2.2.3) Note: Both the positive and negative spike will be applied to each lead under test. Each spike will be applied one time per lead instead of multiple spikes over the course of two minutes. This derives from the Conducted Susceptibility (CS06) Limits requirements in section 3.2.4.2.3 of SSP 57003 Rev L.*

[PCU.19105] ~~Shock Hazard - Class H, Static Bond - Class S~~ Bonding with ExPA

~~The PCU shall comply with the coating requirement for mating surfaces, such that the mechanical bonding surface between the PCU and the ExPA is conductive (conversion coated) to MIL-DTL-5541 class 3 Type 1 (SSP 30245 Revision P).~~

> ~~Rationale: *nan* Comments: **Request LASP clarify requirement and provide rationale.**~~

Draft

5.14 Safety

PCU.19500 Safety - Circuit Protection 1

PCU shall incorporate circuit protection devices to protect against damage normally associated with an electrical fault when such a fault could result in damage to the visiting launch vehicleISS or present a hazard to the crew by direct of propagated effects

Rationale: *Derives from Electrical Systems General section 3.14.1 of SSP 51700.*
Comments: **Not in AVM. Is this a unique applicable requirement?**

PCU.19505 Safety - Circuit Protection 2

PCU shall incorporate circuit protective devices that comply with SSP 57000, Pressurized Payload Interface Requirements Document (IRD) or ISS approved International Partner equivalent, at the payload power distribution interface with ISS.

Rationale: *Derives from Electrical Systems General section 3.14.1 of SSP 51700.*
Comments: **Not in AVM. Is this a unique applicable requirement?**

PCU.19509 Safety - Circuit Protection 3

The PCU shall incorporate circuit protective devices sized such to preclude steady state currents in excess of those allowed by TM 102179, Selection of Wires and Circuit Protective Devices of Orbiter Vehicle Payload Electrical Circuits are precluded.

Rationale: *Derives from Electrical Systems General section 3.14.1 of SSP 51700.*
Comments: **Not in AVM. Is this a unique applicable requirement?**

PCU.19510 Safety - Wire Sizing

The PCU shall incorporate wire sizes that conform to the requirements of SSP 57000, Pressurized Payload Interface Requirements Document (IRD) or ISS approved International Partner equivalent, at the payload power distribution interface with ISSThe PCU shall have a low resistance bond of less than 0.1 ohm to the ExPA.

Rationale:

Comments: **Not in AVM. Is this a unique applicable requirement?**

5.14 Test

PCU.20005 Testing - Random Vibration

Draft

~~The PCU shall be tested to random vibration loads for a duration of 1 minute per axis~~

~~Rationale: *Requirement levied by LASP via spreadsheet dated 05MAR2018.*~~

~~Comments: **Is this a unique requirement, or a verification requirement linked to some of the acceleration requirements in PCU.164XX?**~~

~~**PCU.20010** Testing - Thermal~~

~~The PCU shall be tested in a thermal vacuum chamber to TBD~~57003 3.2.4.8.1 (Shock Hazard — Class H).

~~Rationale: *Requirement levied by LASP via spreadsheet dated 05MAR2018.*~~

~~Comments: **Is this a unique requirement, or a verification requirement linked to PCU.162XX, PCU.181XX, or additional requirements?** *Derives* This specifies the Class H bond characteristics that enable the PCU exterior to conduct directly to ExPA plate. Flowed down from ~~*Electrical Systems General section 3.14.1 of* SSP *51700.*~~

~~*Comments: **Not in AVM. Is this a unique applicable requirement?***~~

5.14 ~~Test~~

~~***PCU.20005** Testing - Random Vibration~~

~~*The PCU shall be tested to random vibration loads for a duration of 1 minute per axis*~~

~~*Rationale:* Requirement levied by LASP via spreadsheet dated 05MAR2018.~~

~~*Comments: **Is this a unique requirement, or a verification requirement linked to some of the acceleration requirements in PCU.164XX?***~~

~~***PCU.20010** Testing - Thermal~~

~~*The PCU shall be tested in a thermal vacuum chamber to TBD*~~57003 3.2.4.8.1 (Shock Hazard — Class H).

~~*Rationale:* Requirement levied by LASP via spreadsheet dated 05MAR2018.~~

~~*Comments: **Is this a unique requirement, or a verification requirement linked to PCU.162XX, PCU.181XX, or additional requirements?***~~

Draft

APPENDIX A

Acronyms

Acronym	Complete Term
CLARREO	Climate Absolute Radiance and Refractivity Observatory
CPF	CLARREO Pathfinder
CPRSP	CLARREO Pathfinder Reflected Solar Payload
ELC	ExPRESS Logistics Carrier
EOTP	Enhanced ORU Temporary Platform
ExPA	ExPRESS Pallet Adapter
FRAM	Flight Releasable Attach Mechanism
GSFC	Goddard Space Flight Center
HISIE	HySICS Instrument-Spacecraft Interface Electronics
HPS	HySICS Pointing System
HySICS	HyperSpectral Imager for Climate Science
ICD	Interface Control Document
IDD	Interface Definition Document
ISS	International Space Station
KSC	Kennedy Space Center
LaRC	Langley Research Center
LASP	The University of Colorado Laboratory for Atmospheric and Space Physics
PCU	Power Converter Unit
VDC	Volts direct current

Draft