



OPEN
Compute Project

Open Rack V3 HVDC-LVDC 100kW Power Shelf Design Specification
Version: 1.0.0

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Revision History

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1. Scope

This document defines the technical specifications for Open Rack V3 HVDC 100kW Power Shelf used in the Open Compute Project.

1.1 Glossary of Acronyms

The following acronyms and abbreviations are used throughout this specification:

Acronym	Definition
AC	Alternating Current
ABS	Acrylonitrile Butadiene Styrene
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
BBU	Battery Backup Unit
C2B	Connector-to-Board
CAD	Computer-Aided Design
CISPR	Comite International Special des Perturbations Radioelectriques
CLA	Contributor License Agreement
CPK	Process Capability Index
CSA	Canadian Standards Association
DC	Direct Current
DFMEA	Design Failure Mode and Effects Analysis
DMTBF	Demonstrated Mean Time Between Failures
ECHA	European Chemicals Agency
EEPROM	Electrically Erasable Programmable Read-Only Memory
EMC	Electromagnetic Compatibility
EPA	Environmental Protection Agency
EU	European Union
EVT	Engineering Validation Test
FA	Failure Analysis
FAI	First Article Inspection
FCC	Federal Communications Commission
FET	Field-Effect Transistor
FW	Firmware
HPR	High Power Rack
HVDC	High Voltage Direct Current
HW	Hardware
I2C	Inter-Integrated Circuit
IEC	International Electrotechnical Commission

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IPC	Institute for Printed Circuits
ISHARE	Current Share
ISH	ISHARE Port
JIS	Japanese Industrial Standards
KOZ	Keep-Out Zone
LDO	Low-Dropout Regulator
LMFB	Low-Side MOSFET Bridge
LVDC	Low Voltage Direct Current
NPI	New Product Introduction
NRTL	Nationally Recognized Testing Laboratory
OCP	Open Compute Project
ORV3	Open Rack Version 3
OU	Open U (Rack Unit)
PCB	Printed Circuit Board
PCBA	Printed Circuit Board Assembly
PCN	Process Change Notification
PCR	Process Change Request
PDU	Power Distribution Unit
PFAS	Per- and Polyfluoroalkyl Substances
PFMEA	Process Failure Mode and Effects Analysis
PMI	Power Monitoring Interface
PMM	Power Monitoring Module
PSKILL	Power Supply Kill Signal
PSU	Power Supply Unit
PVT	Production Validation Test
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RMA	Return Merchandise Authorization
RoHS	Restriction of Hazardous Substances
RS485	Recommended Standard 485 (Serial Communication)
SN	Serial Number
SOH	State of Health
SPC	Statistical Process Control
TOR	Top of Rack
UL	Underwriters Laboratories
WEEE	Waste Electrical and Electronic Equipment

2. Overview

The Open Rack Power Architecture is a centralized scalable power shelf that distributes power over a common bus bar to the payload devices (IT Gear). This specification defines the power shelves that fits into the Open Rack. The power shelves shall house several PSUs to provide the DC power to all the payload inside the rack. Single shelf or multi-power shelves shall be used in a rack depending on the power rating of the rack and power shelf.

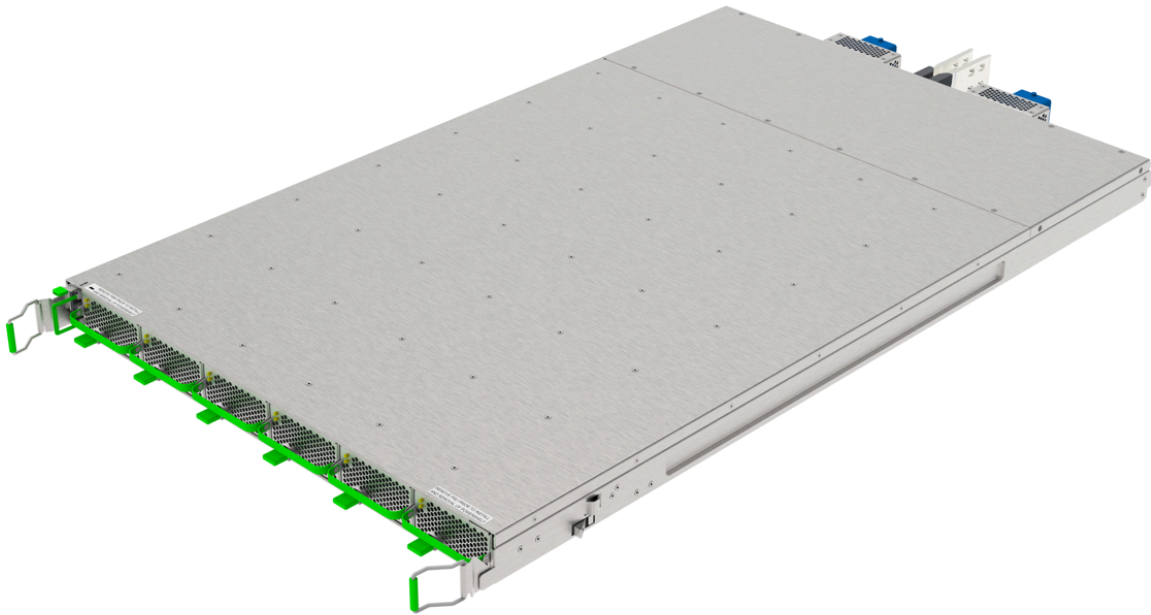


Figure 1: ORV3 HVDC-LVDC 100kW Power Shelf

3. Power shelf

The following power shelf is introduced in this Specification according to the application:

3.1 Power shelf – 6x 18kW PSU with 2x HVDC cords

1 OU shelf with 2 DC power inputs.

6x 18kW PSU slots.

Input power: 100kW (limited by input connector)

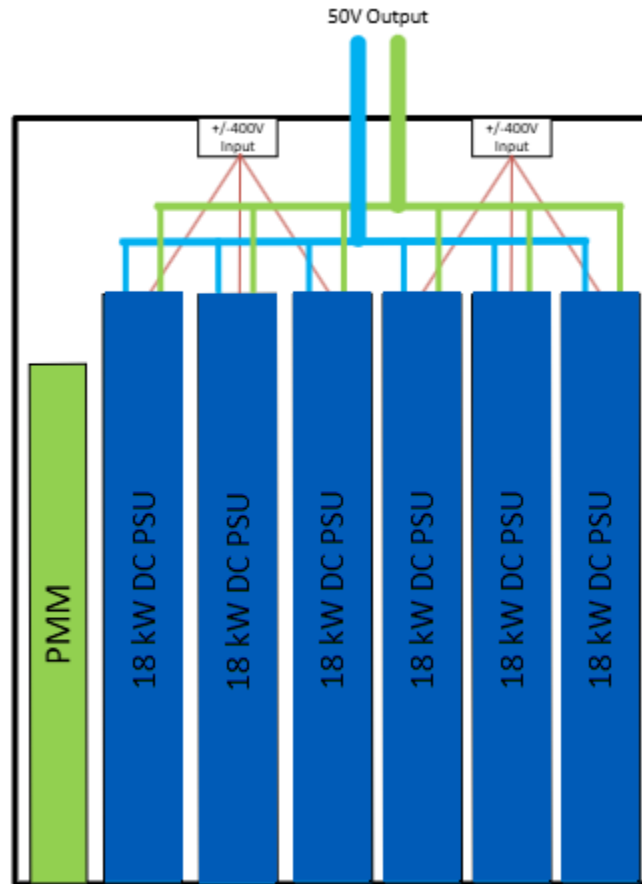


Figure 2: 100kW Power Shelf Block Diagram

4. Electrical requirements

4.1 HVDC Input Electrical requirements

There are 2x HVDC 6 pin connectors at the rear panel of this 100kW power shelf: +400V, -400V, Return, earth, Sense1 and sense 2. For details, see the DC input connector section.

- The input voltage: +/- 400Vdc to +/- 410Vdc nominal.
- The input current: 2x 62.5A

DC input shall have its earth ground connected to the chassis.

4.1.1 HVDC Power Rack PDU Protection

HVDC PDU protection rating is 2x 80A fuses for 2-feed 10U shelf (subject to change)

4.2 DC Electrical requirements

Power shelf output voltage is specified as “Narrow-range 48V system.”

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Power shelf shall have an output voltage with ripple & noise less than 500mV peak-to-peak with a 20MHz bandwidth. This applies along the entire length of the busbar without respect to the load or physical distribution of the trays. Compliance will be verified using a 0.1uF capacitor connected locally to the oscilloscope probe tips during this measurement. Ripple and noise are defined as periodic or random signals over a frequency band of 5Hz to 20MHz measured across a steady-state resistive load. Measurements shall be made differentially using an oscilloscope with 20Mhz bandwidth limit enabled.

48V return (negative) shall NOT be grounded to the power shelf frame.

4.3 PSU physical addressing

Four PSU signal pins are used for physical addressing. These are digital signals that must have internal pull up resistors inside the PSU. On the power shelf, these pins can be grounded (0) or left open (1) to determine PSU location.

4.4 Monitoring & Control Interface

Each Power shelf shall include a monitoring module (PMI/PMM) to monitor and control various PSU parameters. The monitoring module is connected to rack management controller or facility level monitoring through a monitoring & control interface.

There should be no RS485/CAN termination resistor installed inside the shelf. The RS485/CAN termination resistors are added in PMI and will be set according to the shelf position when installed into the rack.

Note it is required that if the monitoring module fails, the power system shall be able to operate normally.

Refer to Open Rack V3 HPR V2 Power Monitoring Interface Module (PMM) specification for details of communication requirements.

4.4.1 Shelf Manufacturer EEPROM with I2C

Each power shelf shall include an EEPROM(address 0b100) so that the PMI/PMM is able to read the shelf manufacturing data through the I2C bus. The same I2C bus can also be used to access the manufacturing EEPROM on the PMI/PMM itself.

Shelf EEPROM write protection signal shelf_EEPROM_WP (x1) is connected to PMI/PMM. (Please refer to Open Rack V3 HPR V2 Power Monitoring Interface Module (PMM) specification for the detailed pin out of the PMM edge connector).

To help the interoperability,the shelf EEPROM shall be *M24128-BR* (128-kbits) or equivalent.

Each address pin (A3,A2,A1 and A0) shall be pulled low to GND through 0 ohm resistors, with the option to pull high to the 3.3V power supply (VCC to the chip) through 0 ohm resistors, but not installed. The default address is 0x50.

The I2C bus pull up resistors shall be placed next to the EEPROM. The target I2C bus mode is 100KHz.

The register map should include all key manufacturing information, such as vendor name, shelf type, manufacturer part number, hardware revision, serial number, manufacturing date etc.

4.4.2 PSKILL

This is an LMFB short pin for hot swap arcing mitigation on the PMI/PMC interface connector. The PSKILL is grounded on shelf board to provide quick turn on/off PMI/PMC auxiliary power supply.

4.4.3 Present_L

There is an individual PSU/BBU module present signal PRESENT_L from each PSU/BBU to PMC/PMI. (Please refer to Open Rack V3 HPR V2 Power Monitoring Interface Module (PMC) specification for the detailed pin out of the PMC edge connector).

4.5 Peak Load requirements

The power supply unit (PSU) should be capable of supporting the following repetitive peak load while maintaining output within regulation and input power within the maximum limit.
≤140%, ≤50ms moving average.

4.6 Parallel Operation Mode with Multiple Shelves

The PSU shelves shall support at least 10x power shelves in parallel operation within one rack.

4.7 Grounding

The PSU Shelf output return (negative) must be floating to the PSU shelf chassis, which is tied to the earth ground. Instead, 4X~50kΩ bleeder resistors should be connected in series (total resistance around 200kΩ) across the 50VRTN and shelf chassis. These resistors and 50VRTN to chassis circuit should be capable of withstanding a 500V hi-pot test. Signal ground coming from TOR shall be isolated from the PMI/PMC signal ground through a 10 ohm resistor. Please check the “Open Rack V3 HPR V2 Power Monitoring Interface Module (PMC)” specification for more detailed ground connection with the shelf.

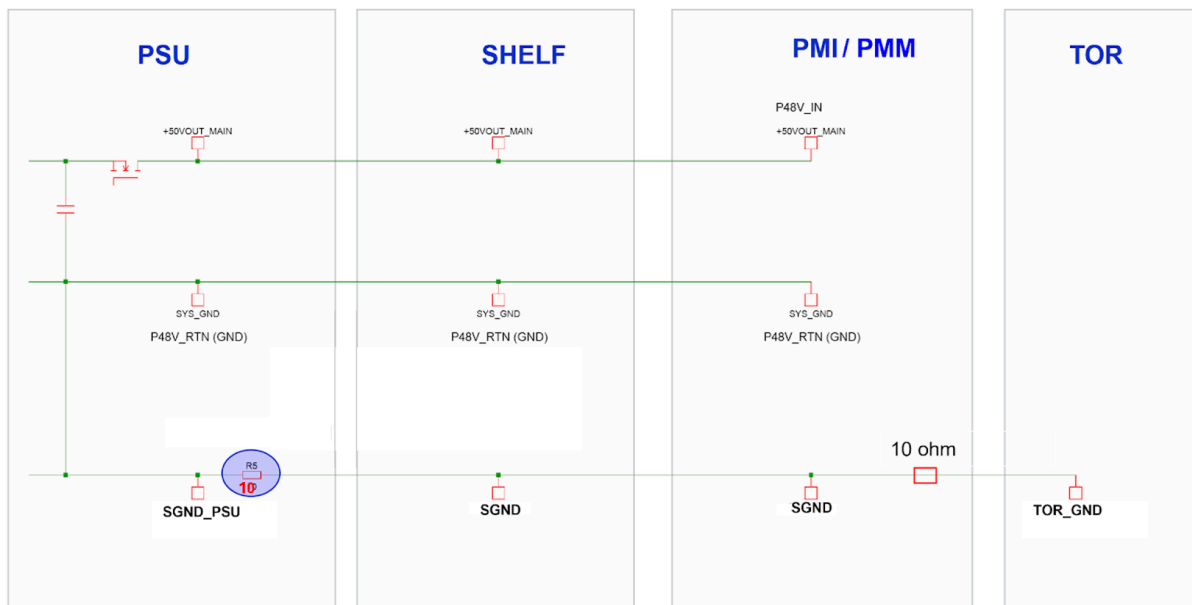


Figure 3: Power Shelf Grounding Diagram

4.8 Y-cap

There should be no Y-caps placed outside the Oring FET between 50V and chassis. This measure is taken to prevent single faults, hot plug inrush currents, and static state leakage currents.

4.9 Shelf Output Busbar Temperature Sensing Circuit

There are two thermistors attached to the DC output connector for sensing the busbar temperature. One thermistor is in contact with the positive (+) metal contact, and the other thermistor is in contact with the negative (-) metal contact. The thermistors must support a maximum temperature of at least 150C. Recommended thermistors are listed below:

- JOYIN JAS103G398FB240001RH
- Vishay NTCALUG54A
- TDK EPCOS B57881S0123F000
- THINKING TTC3A123G3742EY3
- EXSENSE TS103F25C3977FB-NL700A
- EXSENSE TS103F25C3977FB-NL800A

Voltage divider circuit is implemented on the shelf board for the busbar temperature sensing. Each thermistor is grounded and connected in series with a pull-up resistor 2K $\pm$ 0.1% to a regulated power supply (3.3V). The sensed voltage signals (for +-bus temperatures) are sent to each PSU module for further control and protection. The bias power supply shall be converted from the 48V bus voltage through a high-accuracy ($\pm$ 0.5%) LDO regulator.

5. Mechanical Requirements

5.1 Power Shelf Assembly Dimensions

The overall dimensions of the 1OU power shelf are 537.0mm x 46.2mm x 867.5mm [Width x Height x Depth]

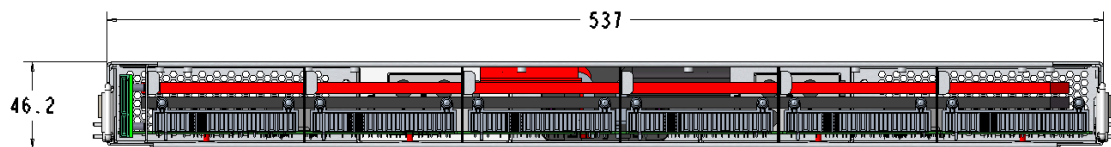


Figure 4: Power Shelf Assembly Dimensions (Front View)

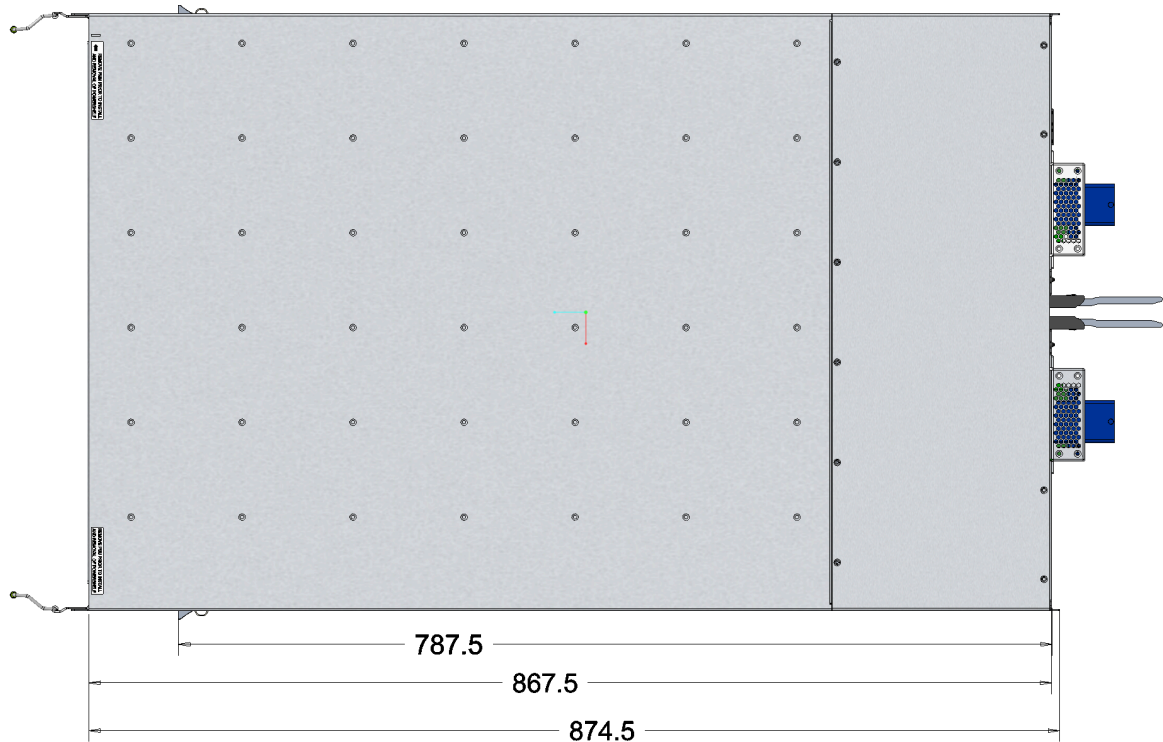


Figure 5: Power Shelf Assembly Dimensions (Side View)

5.2 ORV3 Rack Mounting Feature

The power shelf will be front mounted in predesignated locations in the Rack on OU pitch rails. The design of the bolted 48V output connector requires it to be placed in specific locations in the rack due to the way it interfaces with the vertical busbar.

Rack mounting features are of particular importance in the power shelf design since they assist in constraining the power shelf in X, Y, and Z directions and promote solid electrical contact with the 48V busbar.

5.2.1 Front Latch & Bumper

Please refer to the mechanical CAD for the locations of the front latch and bumper. Note that these serve separate functions and should not be a single part.

Latch shall be designed to withstand shocks seen during fully loaded rack shipping testing in a populated shelf. This shock limit is 16G, including margin. It is highly suggested to use SUS301 Stainless Steel, ¾ Hard. The ring for the latch material is suggested to use SUS304.

Due to the lack of space between PSU modules/PMM and shelf side, it is recommended to utilize a “pull” style latch design. This latch design features a diecast wedge which, when pulled via the front handles, moves along the angled surface of the latch block, forcing the latch to displace inwards.



Figure 6: Front Latch and Bumper Assembly

Due to the lack of space between PSU modules/PMM and shelf side, it is recommended to utilize a “pull” style latch design. This latch design features a diecast wedge which, when pulled via the front handles, moves along the angled surface of the latch block, forcing the latch to displace inwards.

Left image below shows the shelf in its “latched” position. Right image below represents the “unlatched” position, where the handle is pulled and the latch block actuates inwards, enabling shelf removal from rack.



Figure 7: Latch Positions (Latched and Unlatched)

5.2.2 Rear Stop

Please refer to the mechanical CAD for the geometry of the rear stop. This is required to interface properly with the ORV3 rack



Figure 8: *Rear Stop Geometry*

5.3 Connectors

5.3.1 DC Input connector

The shelf HVDC input connections are for the entry of the input power to the PSUs. It's a pluggable 6-pin connector which contains +400V, -400V, Return, Earth, Sense1 and Sense2. There are 2 connectors per shelf. Drawing of Panel Mount, PCB Soldered: Amphenol 10184015-002LF is shown below.

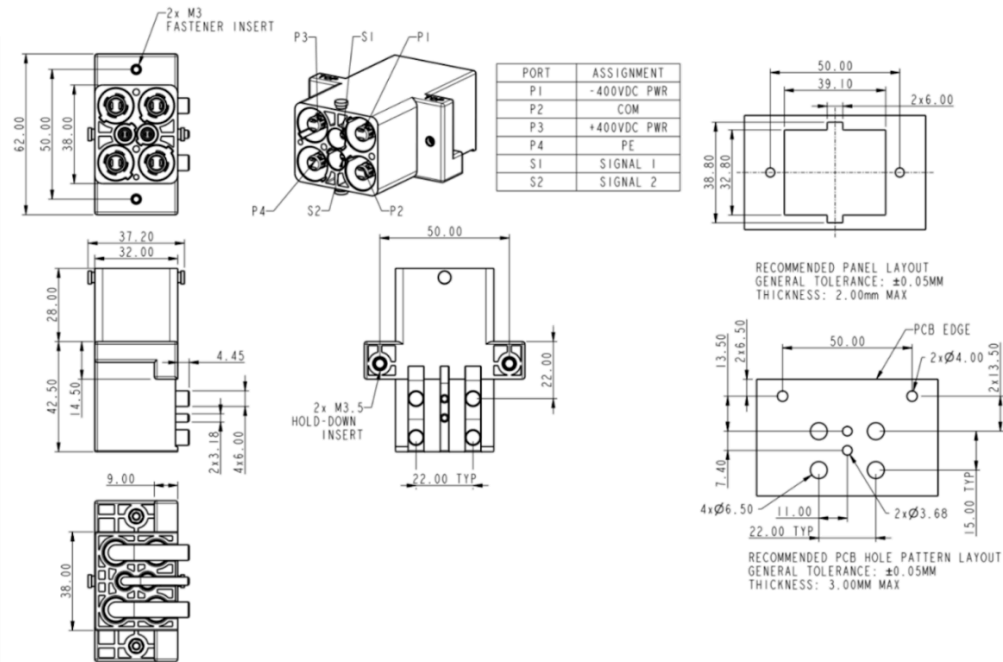


Figure 9: HVDC Input Connector

- Pin assignment

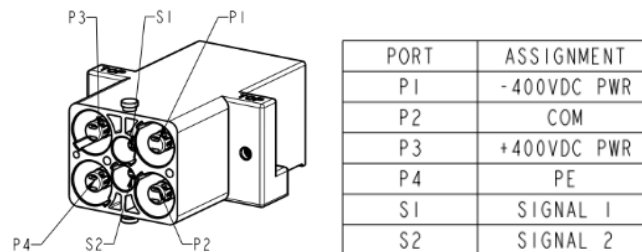


Figure 10: HVDC Input Connector Pin Assignment

5.3.2 DC Output

The HVDC power shelf output busbars will extend outwards and fasten onto the vertical busbar at the rear of the cabinet.

The vertical busbar includes modified mounting geometry & 4 x M5 standoffs. The slot holes on the powershell output busbars will interface with these standoffs. Chamfers on the powershell output busbars will interface with chamfers on the vertical busbar to align the output busbars into position. Bolts (recommend using Grade 8.8 or higher, torqued to 5.6Nm) will be used to secure the connection. See “OCP ORv3 HPR 2000A DC Power Output Connector” for more details.

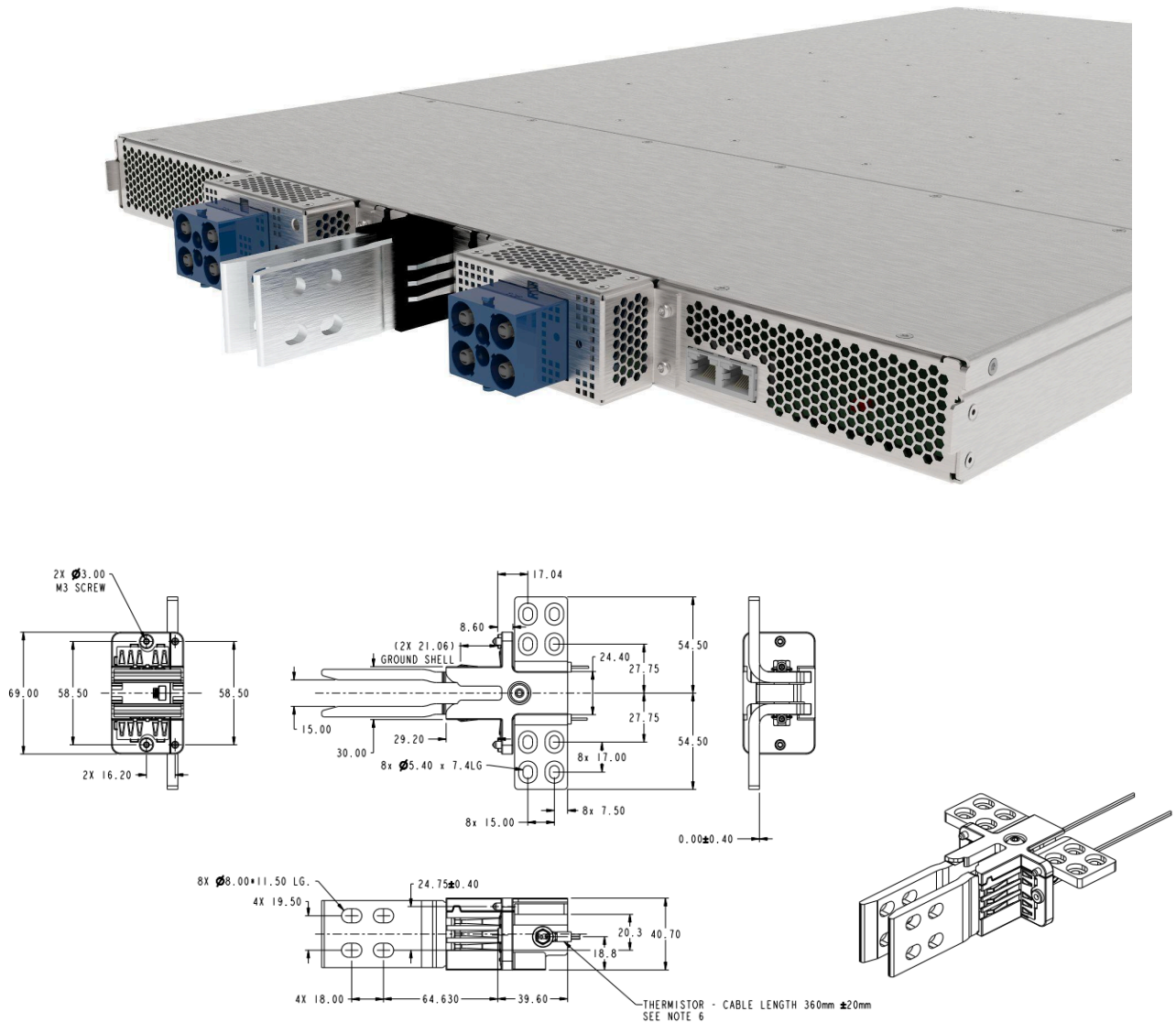


Figure 11: DC Output Busbar Assembly

5.3.3 Power Supply Connector

The chassis side of the rear blind mate connector of the PSU shall be Amphenol 10169892-843201SLF. This is a R/A connector with 5 low power pins, 24 signal pins, and 8 high power pins. Please refer to the drawing for more details. The connector positions (in all 6 locations) within the power shelf are fixed in x, y, and z direction according to the 3D drawing. This cannot be altered due to mix-and-match requirements for the power supplies into the shelf.

PSUs plug into the power shelf directly, and they shall be hot swappable while the rack is powered. Please refer to “Open Rack V3 ± 400V to 48V 18kW PSU” for pinout signals.

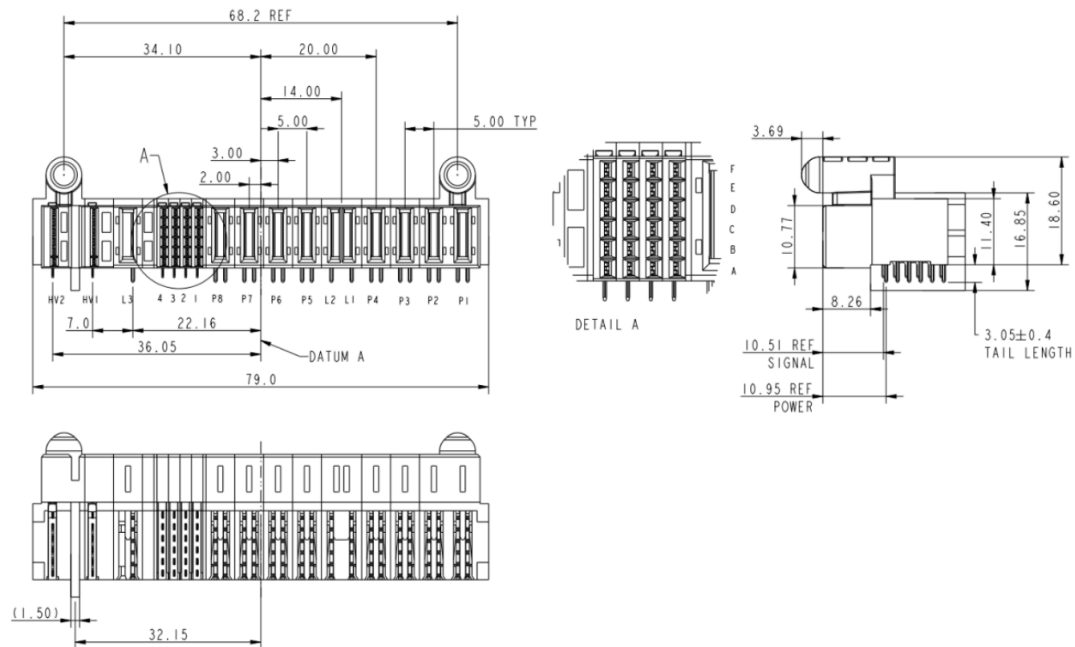


Figure 12: Power Supply Connector Interface

5.3.4 PMM Connector

The PMM is a blind-mate module with an edge card on one end. The shelf side features a card edge connector. The location of this connector is fixed, but the connector itself may either be mounted on a PCB or a panel-mounted cable. There are no specific requirements for the interface of this blind mate connector to the main shelf PCB. Please refer to the 3D drawing for the precise position.

The PMM plugs into the PSU/BBU shelf directly, and it shall be hot swappable while the rack is powered. Please refer to Open Rack V3 HPR V2 Power Monitoring Interface Module (PMM) specification for connector pinout signals.

Approved connectors are:

- Amphenol Mini Cool Edge 1008410201071
- TE Sliver 2.0 2331813-3
- Molex 208610-4157

Drawing of Amphenol Mini Cool Edge 1008410201071 is shown below.

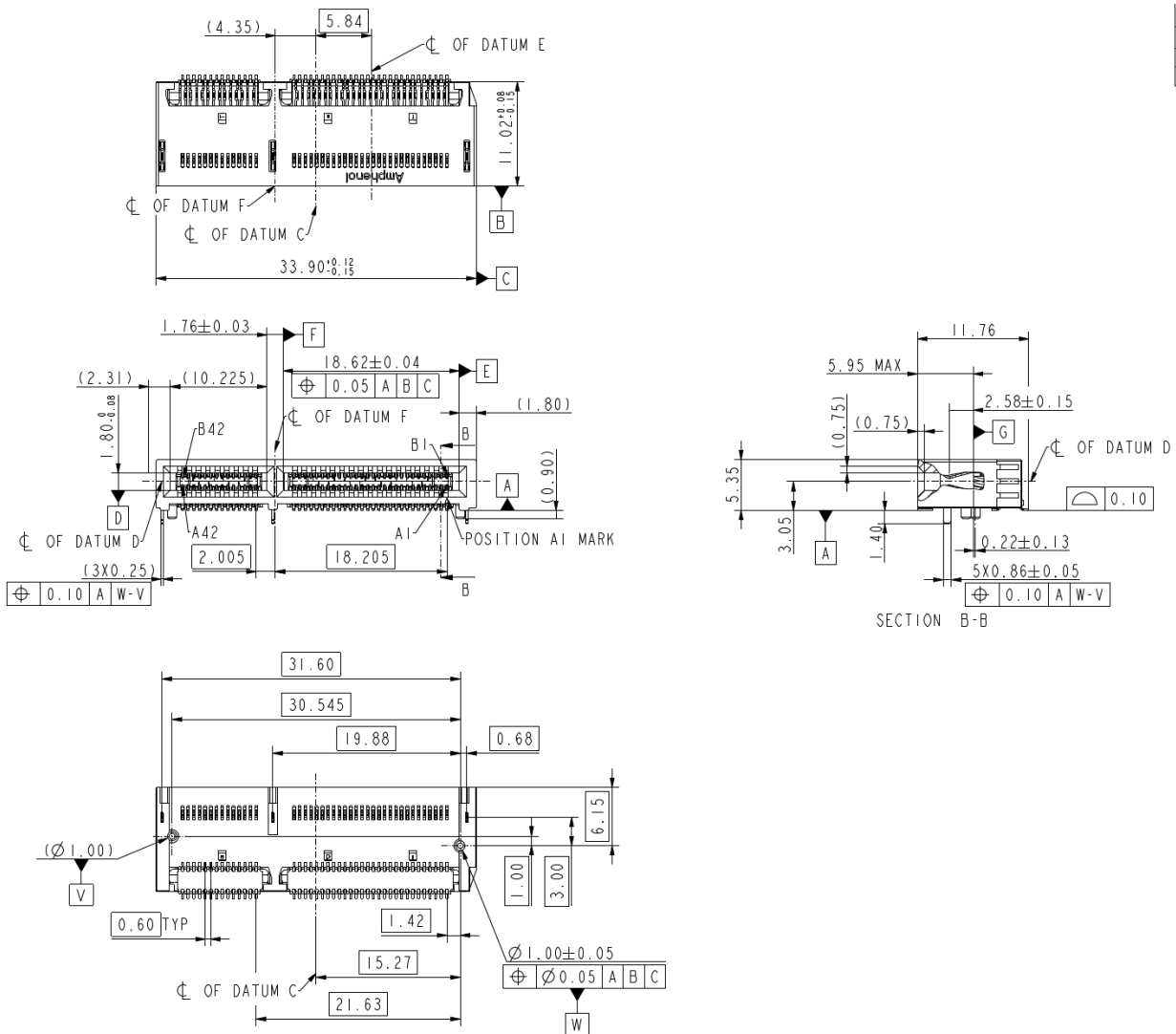


Figure 13: PMM Connector (Amphenol Mini Cool Edge)

5.3.5 ISHARE Port connectors

There shall be a 2 port high speed RJ-45 8p8c shielded connector on the rear of the PSU shelf to allow for PSU inter shelf control signal cable to be plugged in between the PSU shelves. Connections between the different types of shelves are NOT allowed.

The location of this connector is not fixed, but needs to be on the left side of the shelf (right side if looking from the rear) and must honor manifold keepout. The connector shall be board mounted using through hole pins. Contact plating thickness to be 30 μ thick minimum. Please refer to the 3D drawing for the suggested position.

The suggested connectors are:

- Amphenol: RJHSE-J380-02
- Molex: 44248-0085
- TE: 6116522-1/2

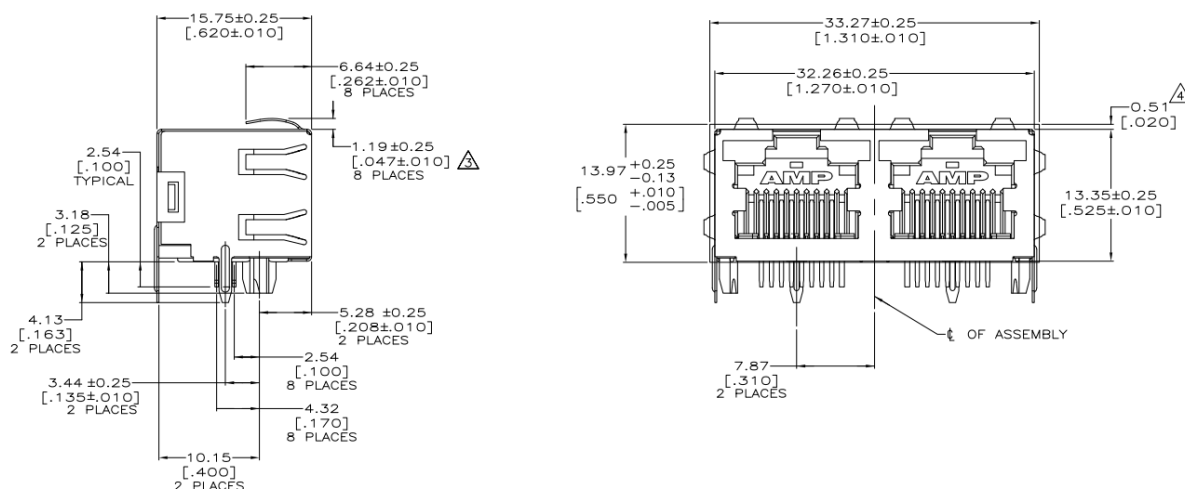


Figure 14: ISHARE Port RJ45 Connector

ISHARE RJ45 port 1 (ISH-1):

connect to port 2 (ISH-2) of the previous PSU shelf on the rack, add 120 termination plug it is the last PSU shelf on the rack.

Table 1: ISHARE RJ45 Port 1 (ISH-1) Pin Assignment

Pin	Wire color	Signal Name	Function
1	White/Orange	ISHARE	PSU ISHARE
2	Orange	GND	SGND
3	White/Green	SYNC_START_L	PSU sync start signal
4	Blue	CAN_H	Not used for PSUs, CAN bus among BBUs
5	White/Blue	CAN_L	Not used for PSUs, CAN bus among BBUs
6	Green	DC_Fault_CLR	clear latch off flag after DC fault event
7	White/Brown	SOH_L	Not used for PSUs, SOH indicator for BBUs
8	Brown	Missing_Daisy_Chain_Cable	ISHARE cable connection detection

For ISHARE RJ45 port 2 (ISH-2),

Connect to port 1 (ISH-2) of the next PSU shelf on the rack, add 120 termination plug it is the last PSU shelf on the rack.

Table 2: ISHARE RJ45 Port 2 (ISH-2) Pin Assignment

Pin	Wire color	Signal Name	Function
1	White/Orange	ISHARE	PSU ISHARE
2	Orange	GND	SGND
3	White/Green	SYNC_START_L	PSU sync start signal
4	Blue	CAN_H_OUT	Not used for PSUs, CAN bus among BBUs
5	White/Blue	CAN_L_OUT	

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6	Green	DC_Fault_CLR	clear latch off flag after DC fault event
7	White/Brown	SOH_L	Not used for PSUs, SOH indicator for BBUs
8	Brown	GND	SGND

5.4 Front Access

All 6 power supplies shall be toollessly accessible from the front and located in the positions defined in the 3D drawing. The PMI shall also be toollessly accessible from the front and located in the position defined on the 3D drawing.

5.5 Construction

The power shelf can be welded, riveted or screwed together, consistent with meeting shock, vibration and maximum allowable deflection requirements. There shall be no corners or edges with a radius less than 0.5 mm; all edges shall be deburred and free of burrs.

When assembled into a rack, with PSUs installed, maximum deflection of the PSU shelf shall be less than 1 mm.

The rear cover of the power shelf shall be assembled using flathead screws. No rivets are allowed as the rear must be accessible for assembly and serviceability with a screwdriver.

5.6 Materials and Fasteners

The sheet metal material shall be steel, pre-plated hot-dip zinc coated, with 0.8mm - 2mm of thickness unless otherwise specified. Any plastic material used should meet UL 94-V0 specifications. The system shall contain a minimum of 40% post-consumer-recycled (PCR) plastic content and 15% recycled steel content. However, functionality and reliability are paramount. 65% recycled PC/ABS and 20% recycled SGCC shall be qualified and used in applicable parts to meet the overall recycled content requirement. The following PCR plastics have been qualified for use:

- GLite MBS-200BKR01
- GLite MBS-200GNR01
- Kingfa JH960-6950 C2B-S0759
- Kingfa JH960-6950 C7G-S0023
- Wistron WAM NCT50T#

5.7 Labeling & Markings

Markings shall be placed on the rear of the power shelf that which terminal of the DC output connector on the shelf is - and which is +. Also, AC Input Connector (s) shall be marked accordingly. Markings are to be used as an assembly aid to ensure cables are assembled correctly. The preferred method is silk screening / pad printing.

Shelf labeling to be placed on the top side or other approved location.

5.8 PSU Slot Blanks

Any configuration that dictates the use of less than 6 PSUs in one shelf must include a PSU slot blank in order to properly channel airflow through the operating PSUs. The PSU slot blank features a latch identical to those used on the PSU module.

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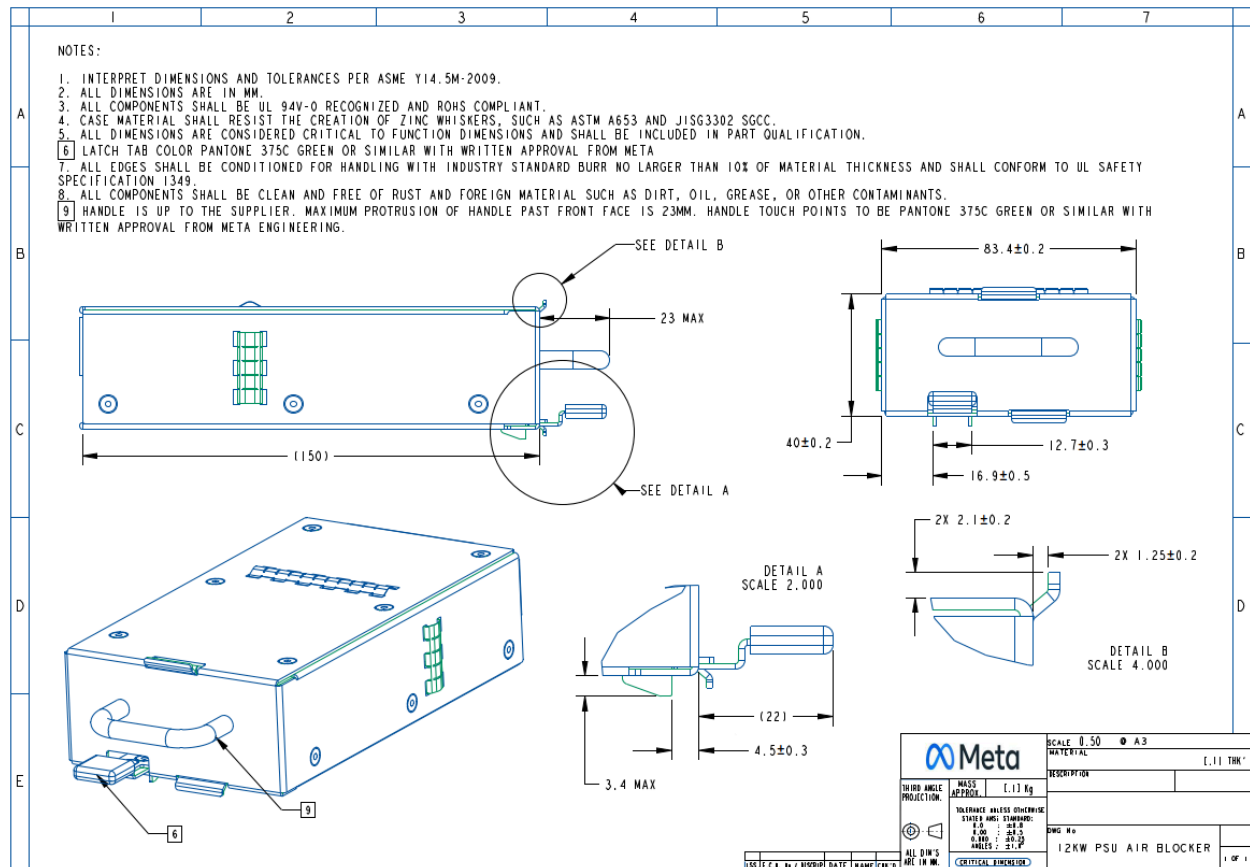


Figure 15: PSU Slot Blank

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5.9 Mechanical Drawings

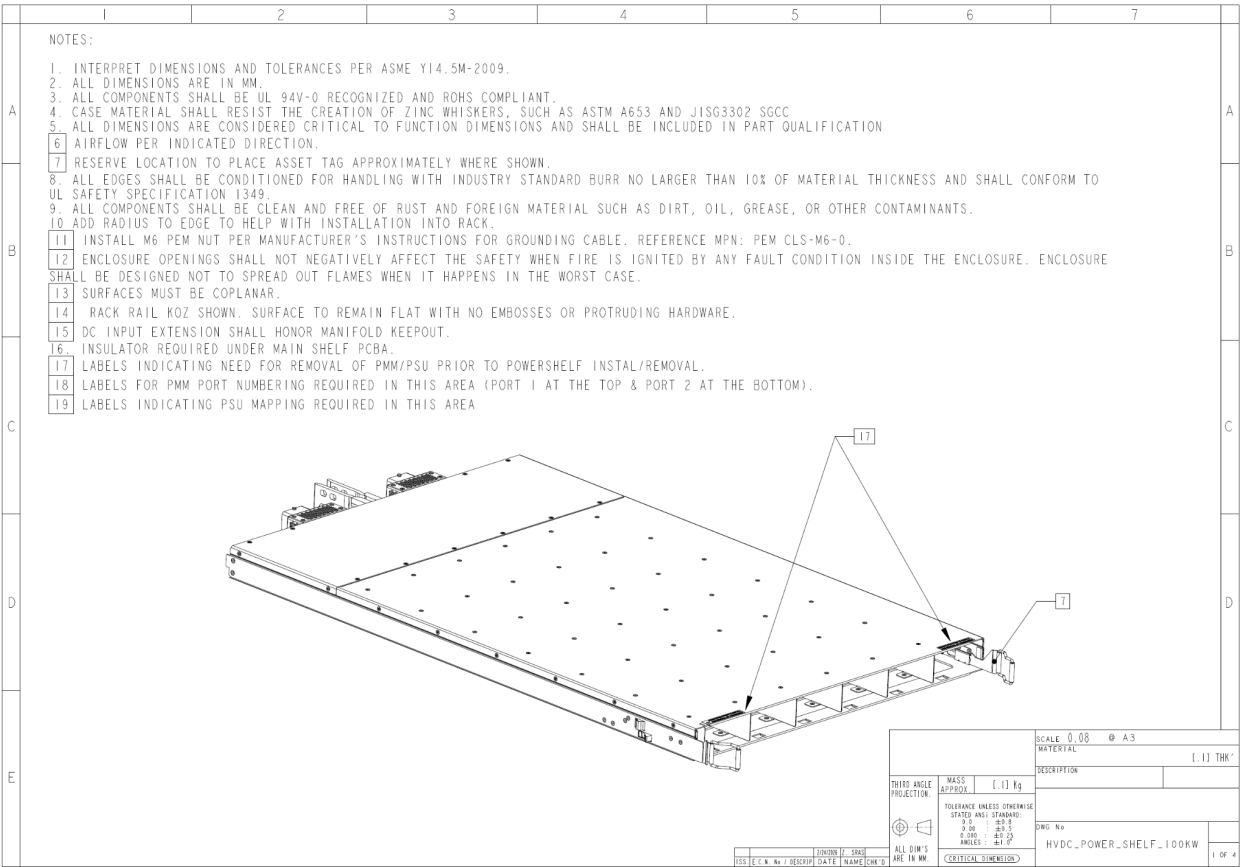


Figure 16: Mechanical Drawing - Power Shelf Assembly

1 2 3 4 5 6 7

A

DETAIL C
SCALE 1.000

13

2X 17±0.15

13.5±0.25

B

6X 42.1±0.5 CONNECTOR CL TO BAY WALL

6X 21.77 PSU BAY BOTTOM TO PSU CONNECTOR GUIDE CL

1.67±0.25 PMM BAY SIDE TO KEYING FEATURE EDGE

PMM KEYING FEATURE

120°±2°

DETAIL J
SCALE 2.000

8±0.5

18.78±0.2 PMM BAY BOTTOM TO CONNECTOR INTERFACE CENTER

SEE DETAIL J

14.51±0.5 PMM BAY SIDE TO PMM LATCH CUTOFF CL

DETAIL A
SCALE 1.000

11.62±0.2 PMM SIDE TO CONNECTOR INTERFACE CL

2±0.3

DETAIL I
SCALE 1.000

41.4±0.5 PMM BAY HEIGHT

SEE DETAIL A

SEE DETAIL B

15.8±0.4 PMM BAY WIDTH

6X 84.2±0.5

44.8±0.5

1.4±0.2 EMBOSS DEPTH

SEE DETAIL C

6X 41.2±0.5 PSU BAY HEIGHT

342.17±0.4 PMM CONNECTOR TO LATCH

30 MAX SHELF REAR TO DC INPUT EXTENSION

531±0.5

668.2±0.55 PSU CONNECTOR TO PSU LATCH

666.34±0.55 PSU STOP TO PSU LATCH

787.5±0.8 SHELF LATCH TO SHELF REAR

5 AIRFLOW →

C

D

E

15

THIRD ANGLE PROJECTION		WASS APPROVAL	1.13 kg
TOLERANCE UNLESS OTHERWISE STATED AND UNLESS OTHERWISE SPECIFIED: 0.50 ± 0.05 0.000 ± 0.025 ANGLES ± 0.1°		SCALE 0.08 @ A3 MATERIAL [1] TH DESCRIPTION DWG No HVDC_POWER_SHELF_100KW	

1 2 3 4 5 6 7

A

B

C

D

E

DETAIL E
SCALE 1.200

32±0.5

34.5±0.6 OUTPUT BUSBAR CUTOFF TO
DC INPUT EXTENSION SIDE

DETAIL F
SCALE 1.200

12±0.15

15±0.31

SILKSCREEN GROUND LOGO

DETAIL D
SCALE 2.000

12

SEE DETAIL D

SEE DETAIL E

SILKSCREEN INPUT PINOUT

2X 150.6 SHELF SIDE TO
DC INPUT CONNECTOR SIDE

SILKSCREEN ISHARE PORTS

101.88±0.8
SHELF SIDE TO RJ45 ⌀

SEE DETAIL F

SEE DETAIL G

8.5X11.5MM SLOT HOLES

18 REF

38 REF

99.63 REF
SHELF REAR TO BUSBAR EDGE

64.63 REF
SHELF REAR TO SLOT HOLE ⌀

13.25±0.75 SHELF BOTTOM TO LOWER SLOT HOLE ⌀

19.5 REF
LOWER SLOT HOLE ⌀ TO UPPER SLOT HOLE ⌀

DETAIL G
SCALE 0.750

THIRD ANGLE
PROJECTION

WALL
APPROX [] kg

TOLERANCE UNLESS OTHERWISE
STATED ANSI STANDARD:
0.10 - 0.5
0.005 - 0.25
ANGLES - 0.1°

ALL DIM'S
ARE IN MM

(EXCEPT TOLERANCES)

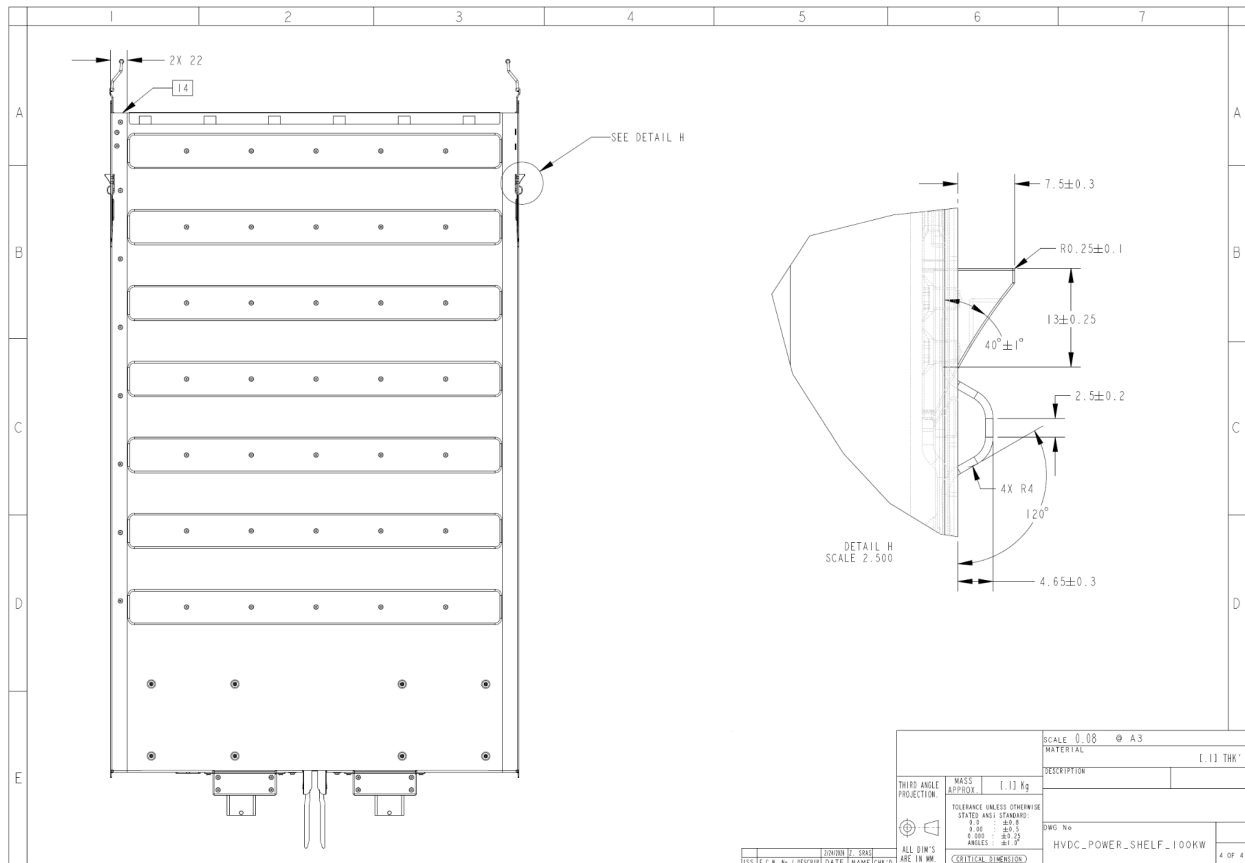
SCALE 0.05 A3

MATERIAL

DESCRIPTION

DWG No

HYDRO_POWER_SHELF_100MM



5.10 Power Shelf Allowable Sag

The power shelf shall have a maximum of 1mm sag in fully loaded condition. The sag shall be measured using a test setup that simulates the expected working condition where it's supported by the rails interface of the rack as specified in the mechanical drawings "Rack Rail KOZ".

Power shelf sag is of particular importance in the rack level integration as it's required to facilitate the functional clearances needed for intended operation of the shelf.

6. Thermal Requirements

6.1 Operational

- For operating environmental conditions, please refer to section 7.
- Airflow direction: Front-to-back
- Exhaust temperature from upstream components/assemblies: Should not exceed 75°C and should be driven by operation of upstream components (PSU and PMM).
- Thermal margin: Reserving adequate margins on components is critical. These margins should be defined with respect to de-rated values, as appropriate. Following are the requirements.
- Component thermal margin of $\geq 7\%$ or $\geq 5^\circ\text{C}$ up to 30°C inlet/ambient and 3050m (10,000ft) above sea-level. Target whichever value is larger.

- Margin to de-rated temperatures should account for associated differences in reading and measurement location. Impact to reliability should also be considered when determining required margin.

6.2 Thermal design requirements

- Sensor accuracy: For discrete and critical sensors (such as ambient temperature), an accuracy of $\pm 2^{\circ}\text{C}$ is required ($\pm 1^{\circ}\text{C}$ is preferred). If a component does not have an integrated temperature sensor, and uses a proxy, it needs to target an accuracy $\pm 5^{\circ}\text{C}$ ($\pm 2^{\circ}\text{C}$ is preferred). If this component is temperature sensitive, thermal margin requirements defined above should account for sensor inaccuracy.
- Back-pressure: Shelf design should accommodate compliance requirements while ensuring reasonable impact to upstream components. Rear panel design, shelf component sizing and layout can significantly influence the amount of back-pressure upstream components have to overcome (such as the PSUs). In general, the fans in the PSU modules should be adequately sized to account for the expected shelf-level back pressure as well as added back pressure from the rack/system and data center, while supporting long-term operation at the rated power or capacity. Back pressure from the rack/system and data center can be of the order of 0.2 inches of water.
- Bus-bar power or DC output connection assembly: If relevant, termination of cables within the shelf as well as the clip/connector (to the rack bus-bar) mounting at the rear panel should be designed to ensure adequate cooling for compliance requirements (temperature difference as a function of current draw).
- Surface temperature: To make the shelf safe for handling in-operation, accessible surfaces should not exceed a temperature of 75°C .

6.3 Shelf output busbar clip temperature monitoring and protection- if busbar clip is selected

- There are two thermistors attached to the busbar clip. One thermistor is in contact with the positive (+) metal contact, and the other thermistor is in contact with the negative (-) metal contact. The thermistor should meet sensor accuracy in all operational conditions.
- The PSU shall report the temperatures through Modbus registers.
- The PSU shall set an alarm bit within a Modbus register if the temperature exceeds the warning threshold. This alarm bit serves as an indication that the temperature has reached a level that requires attention. Additionally, if the temperature exceeds the safety threshold, the PSU will initiate a shutdown process to ensure the safety of the system.

7. Environment/test requirements

- Ambient operating temperature range: -5°C to $+45^{\circ}\text{C}$
- Operating and Storage relative humidity: 10% to 90% (non-condensing)
- Storage temperature range: -40°C to $+70^{\circ}\text{C}$
- Transportation temperature range: -55°C to $+85^{\circ}\text{C}$ (short-term storage)
- Operating altitude with no de-ratings: 3050m (10,000 feet)
- Acoustic noise: Target sound pressure should not exceed 85dBA when fan modules are running at full speed and operating within the defined environmental envelope

7.1 Vibration and Shock (non-packaged)

The “power shelf with PSUs and PMM module inside” shall meet vibration and shock tests per EN 60068-2-6 and 60068-2-27, respectively, for both non-operating and operating conditions, with the specifications listed below. During operating vibration and shock tests, the PSU shall exhibit full compliance to the specification without any electrical discontinuities.

During the non-operating tests, no damages of any kind (including physical damages) should occur and they should not corrupt the functionalities of the PSU per the specifications.

Shock and Vibration tests are to be performed on soft tooled and hard tooled parts.

7.2 Package Vibration, Drop and Compression

The power shelves (without PSUs) in their shipping package shall meet the following requirements:

Table 3: Package Vibration, Drop and Compression Requirements

Package Vibration	1.146 G _{rms} , 2-200-2 Hz, all three axes, Random Vibe	ISTA 3E 06-06
Package Drop	8-inch drop	ISTA 3E 06-06
Package Compression	Maximum compression loading on a bulk pack	ASTM D 642-94

8. Reliability and Quality

8.1 Derating Design

- The component stress analysis must include electrical and thermal stress measurements operating under worst case steady state and worst case dynamic load conditions. The components in the PSU design shall be properly derated to meet the derating guideline as specified in IPC-9592B “Requirements for Power Conversion Devices for the Computer and Telecommunication Industries”, Appendix A.
- For the components that are not included in the IPC-9592B document must be highlighted to the design team, together decide on the best approach: define/develop derating specification, waive for analysis, leverage result from simulations.
- E-cap Life analysis must be performed under the worst case operational conditions, which include operating under worst case steady state and worst case dynamic load conditions to demonstrate that the components can survive at least up to 6 years of operation.
- Worst Case Component Stress Analysis and E-cap Life **must be completed at each phase of development, starting from pre-EVT, with both Primary and Mixed Source (if applicable) components**. All violations must be reported to the design team within 24hours upon discovery. Full results and any violation must be shared and resolved before the design freeze of the next stage of development.

8.2 Reliability Prediction

- Power shelves are to be used for the DMTBF test for the PSU using PSUs and power shelves from mix-source build.

8.3 Design Failure Mode and Effect Analysis (DFMEA)

- The risk assessment must be performed with a focus on the long term exposure to environmental, electrical, mechanical stresses for the lifetime of the product, as well as based on the design and worst case product operational requirements that are outlined in this document.
- The assessment must start as soon as a design of any of the critical elements is available for assessment.
- The risk assessment must include failure modes, impact to the functional/appearance of the system, failure occurrence that must be based on historical data or simulation results.
- Risk levels that are classified as High and Medium risks must have mitigation plans in place before design freeze of the next stage of development, or at least by Phase Exit.
- Whenever there is a change in the design and/or operational requirements that affect the reliability of the product, reassessment must be completed.

8.4 Reliability Tests

- A comprehensive reliability qualification plan must include environmental, electrical, and mechanical test items, and the plan must be created and **each item must be prioritized** based on the outcome of the DFMEA. IPC9582B Section 5 can serve as a reference for test planning purposes.
- Reliability testing must be completed in each phase of the NPI development starting from pre-EVT. The reliability test plan must be reviewed and approved by the reliability team before execution.
- Additionally, the test plan must include test conditions, sample quantity/type/version, pass/fail criteria, reliability test location, Firmware version, as well as start and completion dates for each of the test items.
- Test items may include, but are not limited to **Power Temperature Cycling, High Temperature Humidity, Non-operational Thermal Cycling, High Temperature Storage, Mechanical Shock and Vibration (both operational and non-operational), Mechanical Drop test (both packaged and unpackaged)**, etc. Most importantly, test items should cover the worst case operational conditions in Data Center environment.
- If failures were found in any of the reliability tests, they must be reported to the design team within 24hrs upon discovery. Root cause analysis and corrective action must be identified before Next Phase Design Freeze with exception that is agreed upon by the design team.
- Vendors must allocate a sufficient number of samples to satisfy the design team approved reliability test plan.

8.5 Sheet Metal Material and Zinc Whisker Implications

- Sheet Metal Chassis Material is hot-dip Zinc coated, JIS G3302
- SGCC (Z18 to Z22), with 1.0mm - 1.2mm of thickness. The 'Z' parameter defines the metal coating thickness: Z20 is for 40µm of thickness, and Z22 is for 43µm.
- The Japanese standard is 'JIS G3302', while the US standard is 'ASTM A653'.
- Mechanical design shall prevent sharp edges and possible metal oxidation in the critical points of the sheet metal (e.g. in the cut & bends portions, etc.).
- Both chassis design and metal base material will not promote the growth and propagation of zinc and tin whiskers.
- Metal base materials with electro-zinc plating, or poor conductivity plating, are not allowed.
- Alloy materials are a possible option, while stainless steel is another possibility provided that it makes cost sense (both options are subject to approval)
- Aluminum material is not allowed for the enclosures.
- The chassis enclosure, as well as the whole electronics, shall meet certain contamination requirements (see ANSI spec at § 14)

9. Manufacturing Quality Control and Testing

The Vendor's manufacturing plan shall be designed to meet the quality process requirements as specified in IPC-9592B, Section 6 ("Quality Process"), which includes PFMEA, statistical process control (SPC), corrective action process, yield control, materials traceability, product change notice (PCN), qualification of change, etc.

The PVT samples shall be manufactured in the mass production line. Samples shall be shipped using the approved for production shipping boxes, are certified and with safety labels applied ("Pending Certification" sticker may be allowed until the certification process is complete).

During PVT and before production release, the following shall be submitted to the customer for review.

- a. Manufacturing Quality Plan
- b. Manufacturing Test Plan
- c. PVT Build Report with yield of >98% and issues analyzed with validated corrective actions in place
- d. First Article Inspection (FAI) CPK report for electrical parameters and mechanical dimensions - >1.33 on at least 32 samples
- e. Design for Test, Design for Manufacturability and PFMEA reports
- f. System Component Traceability
- g. Full spec compliance matrix with corresponding test reports
- h. RMA process including flowchart and turnaround time

During mass production, the vendor shall submit a production yield report and RMA summary on a biweekly basis. This shall include yield per station, Pareto of failures and assignable causes, root cause analysis with related risk assessment, corrective and/or screening actions as applicable. The RMA report shall include both overall and year to date historical data with identification of RMAs from the integrators and the field. It is the vendor's responsibility to inform the customer when failure excursions occur in the manufacturing, integrator and/or the field upon discovery.

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Standard failure analysis turnaround time on RMA units shall be 7 days upon receipt at the Vendor's facility. For urgent units, FA may be requested to be provided within 24hrs upon receipt. An 8D report may be required on trending issues and/or those causing thermal events.

The Vendor shall warrant the product for defects and workmanship for a period of three (3) years from the date of shipment when it is operated within specifications. The warranty is fully transferable to any end user. A standard "VOID" warranty sticker may be applied. The customer may request from the Vendor to support failure analysis and further actions as needed even if the product is outside the warranty period. These are on special cases including, but not limited to a thermal or safety event and early wearout.

A PCN shall be submitted for any change that affects form, fit, function, compliance, revision, version, process, material (including deletion), testing (i.e. BI reduction) and other modifications. If uncertain, please contact the customer. The PCN shall be issued with an assigned unique number for traceability and formally submitted via email. The supplier shall give a minimum of one month's notice before target implementation of the proposed changes unless urgent (i.e. resolve design, quality, process or supply issue, customer request). PCN approval is required before implementation of any changes.

The PCN document shall include the following:

- a. Vendor PN and revision/version (from and to, retain if not changed)
- b. Vendor PN HW and FW (if applicable) (from and to, retain if not changed)
- c. Date of Issuance
- d. Reason of change
- e. Description of changes
- f. Form, fit, function changes (if any)
- g. Before and after drawing with mark-up of changes if applicable
- h. Traceability (i.e. cut-in SN, date code)

In addition, a PCN shall be issued upon initial release to production and includes (or the links to) the required documents. It shall include the formal and controlled releases of specifications, drawings, manufacturing plans and others.

10. Compliance requirements

The power supply shelf shall be designed for compliance to allow worldwide deployment. Additionally, the manufacturer is fully responsible for:

- ensuring the complete compliance of the power supply shelf in the environment it is intended to function (as described by the Rack Spec)
- maintaining and updating the power supply shelf safety reports to current requirements and all new released requirements.
- all design and recertification costs required to update the power supply to meet the new requirements.
- Meeting EMC requirements
- Meeting Safety requirements

The manufacturer is responsible for obtaining the safety certifications specified below.

10.1 Safety Standards

The product is to be designed to comply with the latest edition, revision, and amendment of the following standards. The product shall be designed such that the end user could obtain the safety

certifications: UL 62368-1, IEC 62368-1 and EN 62368-1; hazard-based performance standard for Audio video, IT & Communication Technology Equipment

The manufacturer shall obtain the following safety certifications for the power supply shelf as applicable. Only requirements that absolutely rely on or are affected by the system may be left to the system level evaluation, but no Conditions of Acceptability is acceptable if it requires the rack level fire enclosure. Below are common requirements for North America and Europe. For other countries, different certifications may be required:

- UL or an equivalent NRTL for the US with follow-up service (e.g. UL or CSA).
- CB Certificate and test report issued by CSA or UL
- CE Marking for EU

10.1.1 Safety requirements

- Following (but not limited) safety requirements are also applicable. Only safety certified fans shall be used
- All current limiting devices shall have appropriate safety certifications and shall be suitable rated for the application where the device in its application complies with IEC/UL 62368-1.
- All printed wiring boards shall be rated UL94V-0 and be sourced from a UL approved printed wiring board manufacturer.
- All connectors shall be UL recognized and have a UL flame rating of UL94V-0.
- HVDC input and output connectors shall be designed to ensure that current-carrying parts are not accessible under any circumstance, preventing electrical shock or hazard.
- HVDC input and output cable assembly shall be UL recognized or listed w/o any condition of acceptability such as fire enclosure
- All internal wiring harnesses shall be sourced from a UL approved wiring harness manufacturer.
- The product must be marked with the correct regulatory markings to support the certifications that are specified in this document.
- Any single fault condition applied on the safety critical component shall not cause any electrical or mechanical unsafe conditions (such as electric shock to the user, arcing to ignite fire).
- Empty slots must be covered with the sheetmetal blank filler or any other equivalent method to form the safety fire enclosure.
- PCBA for +/-400V input shall meet the following clearance and creepage requirements

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Bare PCB		Uncoated clearance (ref: IPC-2221) (Meta recommendation)		Coated (Conformal) PCB clearance, (Meta recommendation)	
		Up to 3000m altitude	Over 3000m altitude	Up to 3000m altitude	Over 3000m altitude
External layers	400Vdc to ground	2.5mm	12.5mm	1.5mm	1.5mm
	400Vdc to -400Vdc	4mm	20mm	2.44mm	2.44mm
	400Vdc to signal	2.5mm	12.5mm	1.5mm	1.5mm
Internal layer	400Vdc to ground	0.25mm	0.25mm	0.25mm	0.25mm
	400Vdc to -400Vdc	2mm	2mm	2mm	2mm
	400Vdc to signal	0.25mm	0.25mm	0.25mm	0.25mm
Z-axis (PCB stackup)	400Vdc plane to Gnd	3 ply prepreg			
	400Vdc plane to -400Vdc plane	3 ply prepreg			

Figure 17: Clearance Requirements

Component lead		Uncoated creepage (Meta recommendation)	Coated (Conformal) (Meta recommendation)
External layers	400Vdc to ground	8.0mm	1.5mm
	400Vdc to -400Vdc	16mm	3.6mm
	400Vdc to signal	8.0mm	1.5mm

Figure 18: Creepage Requirements

10.2 EMC Requirements

The power shelf shall meet the following requirements in the latest edition of standards when operating under typical load conditions and with all ports fully loaded;

The power shelf shall not contribute any noncompliant conditions to the end-use product when integrated into the L11 rack. If at any time it is found that the power shelf causes the end-use product to fail emissions and/or immunity testing, the supplier is responsible for investigating and resolving the problem.

The power shelf shall have a minimum 6dB margin from the Class A limit for the radiated and conducted emissions. Depending on the system manufacturer's design goals and business needs, more margin may be required when it is integrated into the final end system. The following EMC Standards (the latest version) are applicable to the product.

- FCC /ICES-003
- CISPR 32/EN55032
- CISPR 35/EN55035 - Immunity

Each individual basic standard for immunity test has the following minimum passing requirement. Higher level of passing criteria may be applied depending on the system manufacturer's design goals and business needs.

- EN61000-4-2 Electrostatic Discharge Immunity
 - Contact discharge: >5.6kV

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- Air discharge: >11.2kV
- EN61000-4-3 Radiated Immunity
 - > 3V/m
- EN61000-4-4 Electrical Fast Transient Immunity
 - Signal Line (such as PMM) and DC power lines >1.0kV
- EN61000-4-5 Surge
 - DC Power Line: >0.5kV (Line-to Ground)
- EN61000-4-6 Immunity to Conducted Disturbances
 - DC Power Line: > 3Vrms
- EN61000-4-8 Power Frequency Magnetic Field Immunity, when applicable
 - > 1A/m

10.3 Environmental Compliance

The power shelf (including power supplies) shall comply with the following minimum environmental requirement and manufacturer shall provide full material disclosure, Declaration of Conformity and technical documentations to demonstrate compliance. The system manufacturer may have additional requirements depending on its design goals and business needs.

- RoHS Directive (2011/65/EU and 2015/863/EU); aims to reduce the environmental impact of EEE by restricting the use of certain substances during manufacture
- REACH Regulation (EC) No 1907/2006 including the restriction of PFAS substances; registration with the European Chemicals Agency (ECHA), evaluation, authorization and restriction of chemicals.
- Halogen Free: IEC 61249-2-21, Definition of Halogen Free, 900ppm for Br or Cl, or 1500ppm combined
- US SEC conflict mineral regulation to source mineral materials from socially responsible countries, if applicable
- Waste Electrical and Electronic Equipment (“WEEE”) Directive (2012/19/EU) if applicable; aims to reduce the environmental impact of EEE by restricting the use of certain substances during manufacture
- The vendor shall provide the declaration of compliance document stating that a product doesn't contain any substances regulated by EPA 40 CFR751

10.4 Acoustic pressure

The power shelf manufacturer shall demonstrate the compliance with acoustic pressure requirements defined by the design team.

10.5 Documentation

The manufacturer shall provide reproducible copies of all pertinent documentation relating to the following:

- Product Information
- Bill of Materials
- Schematics
- functional test report
- Final Compliance Approval
- NRTL certificate and report, Conditions of Acceptability and test report plus User documentation that explains safe installation and operating procedures.
- CB Certificate and report, including schematics
- Manufacturer's Declaration of Conformity to EN 62368-1, EN55032, EN55035 and ROHS
- FCC Part 15 Class A and CISPR32 Class A test data
- Other applicable certificates required by the system manufacturer.