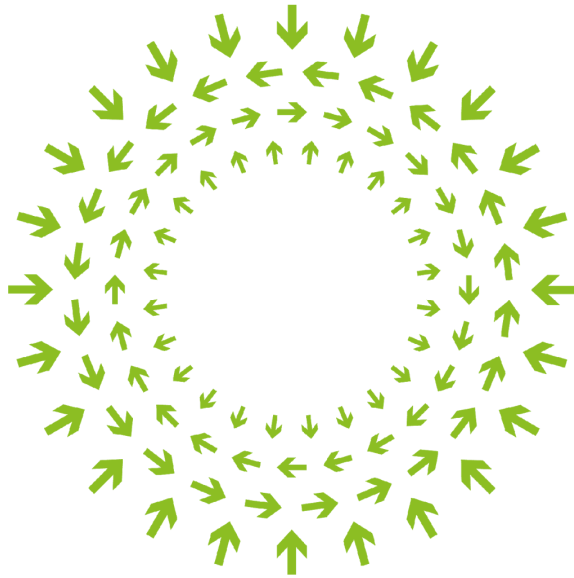




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Compute Project

Open Rack V3 HPR V2 72kW Power Shelf

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1. License	3
1.1. Open Web Foundation (OWF) CLA	3
2. Scope	7
3. Overview	7
4. Power shelf options	7
4.1. Power shelf option 1 – 6x 12kW PSU with dual cords (2x 60A NEC breaker upstream)	7
4.2. Power Shelf Option 2 – 6x 12kW PSU with dual cords (2x 63A IEC breaker upstream)	8
5. Electrical requirements	8
5.1. AC Electrical requirements	8
5.1.1. Facility Protection	9
5.2. DC Electrical requirements	9
5.3. PSU physical addressing	9
5.4. Monitoring & Control Interface	9
5.4.1. Shelf Manufacturer EEPROM with I2C	9
5.4.2. PSKILL	10
5.4.3. Present_L	10
5.5. AC_Loss and Pulse_Mgmt Signal Connector	10
5.5.1. AC_Loss Signal	10
5.5.2. Pulse_Mgmt_L Signal	10
5.6. Peak Load requirements	11
5.7. Parallel Operation Mode with Multiple Shelves	11
5.8. Grounding	11
5.9. Y-cap	12
5.10. Shelf Output Busbar Temperature Sensing Circuit	12
5.11. Busbar Temperature Monitoring	12
6. Mechanical Requirements	13
6.1. Power Shelf Assembly Dimensions	13
6.2. Rack Mounting Features	14
6.2.1. Front Latch & Bumper	14
6.2.2. Rear Stop	15
6.3. Connectors	16
6.3.1. AC Input connector	16
6.3.2. DC Output	17
6.3.3. Power Supply Connector	18
6.3.4. PMM Connector	18
6.3.5. AC_Loss and Pulse_Mgmt Signal Connector	19
6.3.6. ISHARE Port connectors	21
6.3.7. Busbar Temperature Monitoring Connector	22
6.4. Front Access	24
6.5. Construction	24
6.6. Materials and Fasteners	24
6.6.1. PCR Targets & Implementation	24
6.6.2. Supplier Qualification & Material Testing	25

6.6.3. Documentation & Certification	25
6.7. Labeling & Markings	26
6.8. PSU Slot Blanks	26
6.9. Mechanical Drawings	27
7. Thermal Requirements	30
7.1. Operational	30
7.2. Thermal design requirements	31
7.3. Shelf output connector temperature monitoring and protection	31
7.4. External horizontal busbar Temperature monitoring and protection	31
8. Environment/test requirements	31
8.1. Vibration and Shock (non-packaged)	32
8.2. Package Vibration, Drop and Compression	34
9. Reliability and Quality	35
9.1. Worst Case Component Stress Analysis (WCSA)	35
9.2. Reliability Prediction	35
9.3. Design Failure Mode and Effect Analysis (DFMEA)	35
9.4. Reliability Tests	35
9.5. Sheet Metal Material and Zinc Whisker Implications	36
10. Manufacturing Quality Control and Testing	36
10.1. Manufacturing Testing	37
10.1.1. Incoming Quality Inspection	37
10.1.2. In-Circuit and Parametric Test	37
10.1.3. Hipot and Ground Continuity Test	37
10.1.4. Ongoing Quality Assurance	37
10.2. Automation and Continuous Improvement	37
10.2.1. Conformal Coating and Insulation	37
10.3. Quality Control Process	38
10.4. Warranty and Failure Analysis	38
10.5. Product Change Notification	38
11. Compliance requirements	39
11.1. Safety Standards	39
11.1.1. Safety requirements	39
11.2. EMC Requirements	40
11.3. Environmental Compliance	41
11.4. Acoustic pressure	41
11.5. Documentation	41
12. Compliance with OCP Tenets	42
12.1. Openness	42
12.2. Efficiency	42
12.3. Impact	42
12.4. Scale	42
12.5. Sustainability	42
13. References	43

Revision History

Date	Version	Change By	Comments
06/12/2026	1.0.0	Jingjing Sun David Sun Mohammed Alisa Wenying Zhang Ben Kim Baby Neil Escudro Siu Lam	Initial OCP release

2. Scope

This document defines the technical specifications for Open Rack V3 72kW Power Shelf used in the Open Compute Project.

3. Overview

The Open Rack power architecture consists of centralized scalable power shelves that distribute power over a common bus bar to the payload devices (IT Gear). This spec will define the power shelves that fit into the Open Rack. The power shelves shall house several PSUs with minimum of N+1 redundancy to provide DC power to all payload inside the rack. Single or multiple power shelves may be used in a rack depending on the power rating of the rack and power shelf.



Figure 1: Power Shelf Isometric View

4. Power shelf options

The following power shelves are introduced on this Spec according to the application:

4.1. Power shelf option 1 – 6x 12kW PSU with dual cords (2x 60A NEC breaker upstream)

1 OU shelf with two AC power inputs.

6x 12kW PSU slots.

Output power: 60kW with N+1 and dual cords.

Direct connection to tap-boxes/facility – no intermediate PDU.

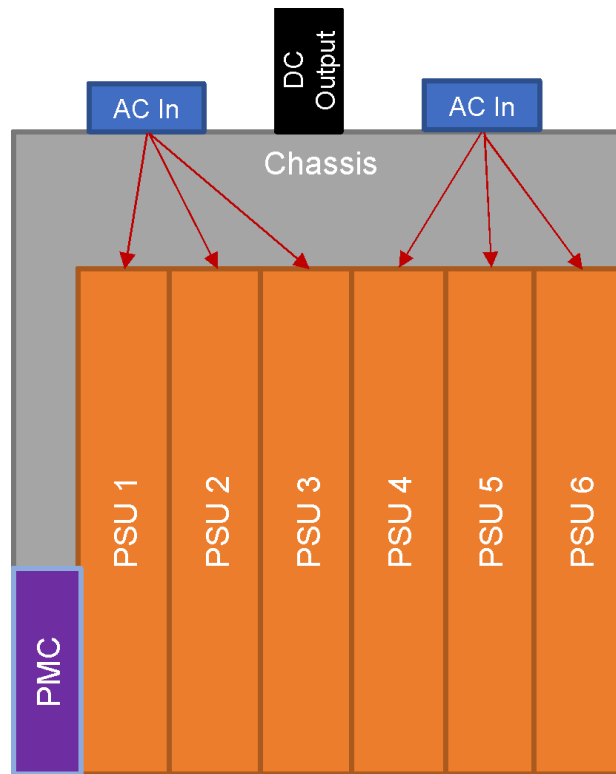


Figure 2: HPRv2 72kW Power Shelf Block Diagram (Top View)

4.2. Power Shelf Option 2 – 6x 12kW PSU with dual cords (2x 63A IEC breaker upstream)

10U shelf with dual AC power input.
 6x 12kW PSU slots.
 Output power: 60kW with N+1 and dual cords.
 Direct connection to tap-box/facility – no intermediate PDU.
 Same drawing as option 1.

5. Electrical requirements

5.1. AC Electrical requirements

Power shelf AC input(s) are universal 5 pin connectors configurable as:

- Star connection
- Single phase

For details, see the AC input connector section.

- The input voltage to each phase-to-return shall be 230-277V nominal.
- Frequency: 50/60 Hz
- The power module must withstand continuous exposure to 305Vac RMS input with no damage.

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

5.1.1. Facility Protection

Datacenter facility protection rating is 2x 60A NEC circuit breaker for 2-feed 1U shelf and 2x 60A IEC for 2-feed 1U shelf. The short circuit current available is 40kA.

5.2. DC Electrical requirements

The PSU operates based on “Narrow Range 48V Architecture.” Based on this concept, PSU output voltage is 50V with an adjustable range. Benefits of this architecture compared to Orv2 with 40~60V dc voltage range are:

- Voltage range as low as possible to eliminate oversized voltage/current design.
- Widely enable 4:1 fixed ratio converters and downstream conventional 12V PoL converters.
- Power to flow naturally, not with Software control and dependency.
- Enable simple fixed-voltage PSU design.

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.

5.3. PSU physical addressing

Four PSU signal pins are used for physical addressing. There are digital signals that should 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.

5.4. Monitoring & Control Interface

Each Power shelf shall include a monitoring module (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 PMM and will be set according to the shelf position when installed into the rack.

If the monitoring module fails, the power system shall continue to operate normally. Refer to *Open Rack V3 HPR V2 Power Monitoring Interface Module (PMM)* [1] specification for details of communication requirements.

5.4.1. Shelf Manufacturer EEPROM with I2C

Each power shelf shall include an EEPROM so that the 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 PMM itself.

Shelf EEPROM write protection signal shelf_EEPROM_WP (x1) is connected to PMM. (Please refer to *Open Rack V3 HPR V2 Power Monitoring Interface Module (PMM)* [1] specification for the detailed pinout of the PMM edge connector).

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

Each address pin (E2,E1 and E0) 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.

5.4.2. PSKILL

This is an LMFB short pin for hot swap arcing mitigation on the PMI/PMM interface connector. The PSKILL is grounded on shelf board through a 10Ohm resistor to provide quick turn on/off PMI/PMM auxiliary power supply.

5.4.3. Present_L

There is an individual PSU/BBU module present signal PRESENT_L from each PSU/BBU to PMM/PMI. (Please refer to PMM specs for the detailed pin out of the PMM edge connector).

5.5. AC_Loss and Pulse_Mgmt Signal Connector

5.5.1. AC_Loss Signal

AC_Loss signals have been added to the PSU (Power Supply Unit) and BBU (Battery Backup Unit) and shelves to enable control during AC loss events. Each PSU now has an output AC_Loss signal, while each BBU has two input AC_Loss signals. Upon detection of AC loss, the PSUs will assert the AC_Loss signal after a validation delay of 4-5ms.

When a BBU receives either one of the active AC_Loss signals, it will pull the Sync_Start_L signal low, allowing the BBU shelf to initiate immediate discharge. The output voltage of the BBU shelf shall ramp up to the normal setting range within 5ms.

5.5.2. Pulse_Mgmt_L Signal

Upon detection of the pulse load and PSU has depleted the available bulk capacitor's energy, PSU shall assert a Pulse_Mgmt_L signal to request load sharing from BBU.

Pulse_Mgmt_L Signals have been added to the PSUs and BBUs, and are connected between PSU shelf and BBU shelf to extend the capability of peak power shaving. Each PSU now has an output Pulse_Mgmt_L signal and all the Pulse_Mgmt_L signals are connected together on the shelf board. Pulse_Mgmt signal is connected to each BBU on the BBU shelf.

When BBUs receive the Pulse_Mgmt_L signal, each BBU will check the battery capacity level and decide whether to share the load with PSU or refuse to do so. If BBU is available for the load sharing, the BBU would initiate discharge to share the load. BBU may terminate load sharing anytime based on the battery capacity level and the depth of discharge, without any signaling to PSU.

The following is the diagram of AC_loss_L and Pulse_Mgmt_L signal connection.

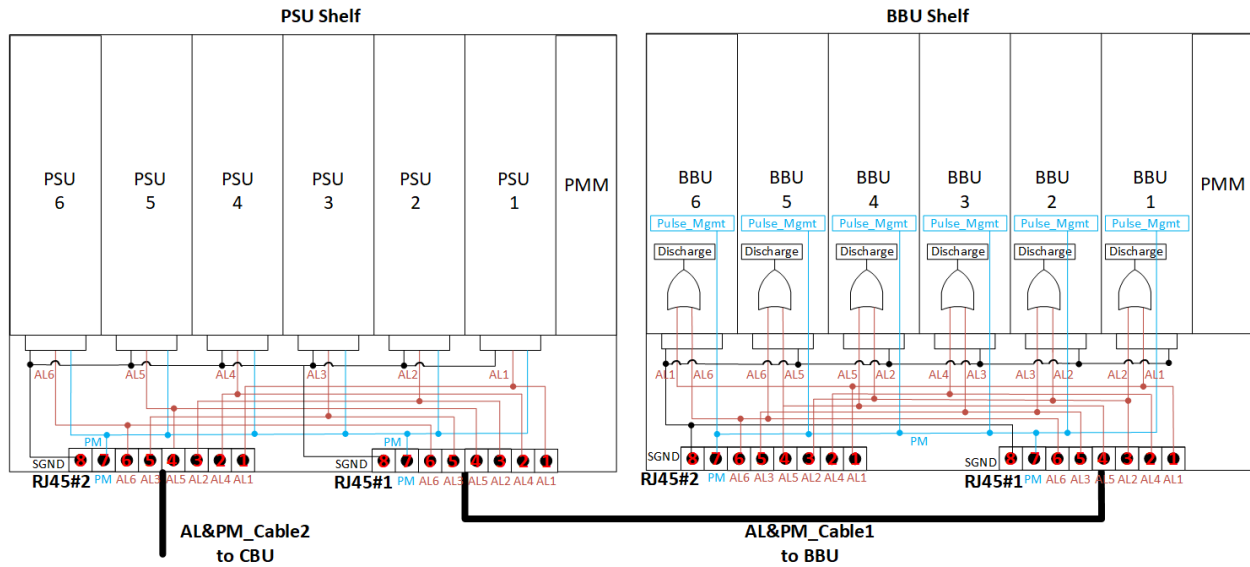


Figure 3: HPR V2 PSU/BBU AC_LOSS & PULSE_MGMT Signals for AC to BBU Transition

See Section 6.3 for connector details

5.6. 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. BBU backup should not be triggered during the pulse loading operation.

- ≤140%, ≤50ms moving average,
- ≤160%, ≤400us moving average,
- ≤100%, ≥1s moving average.

5.7. Parallel Operation Mode with Multiple Shelves

The PSU and shelf design shall support at least 10x power shelves in parallel operation.

5.8. 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 PMM signal ground through a 10 ohm resistor. Please check the *Open Rack V3 HPR V2 Power Monitoring Interface Module (PMM)* [1] specification for more detailed ground connection with the shelf.

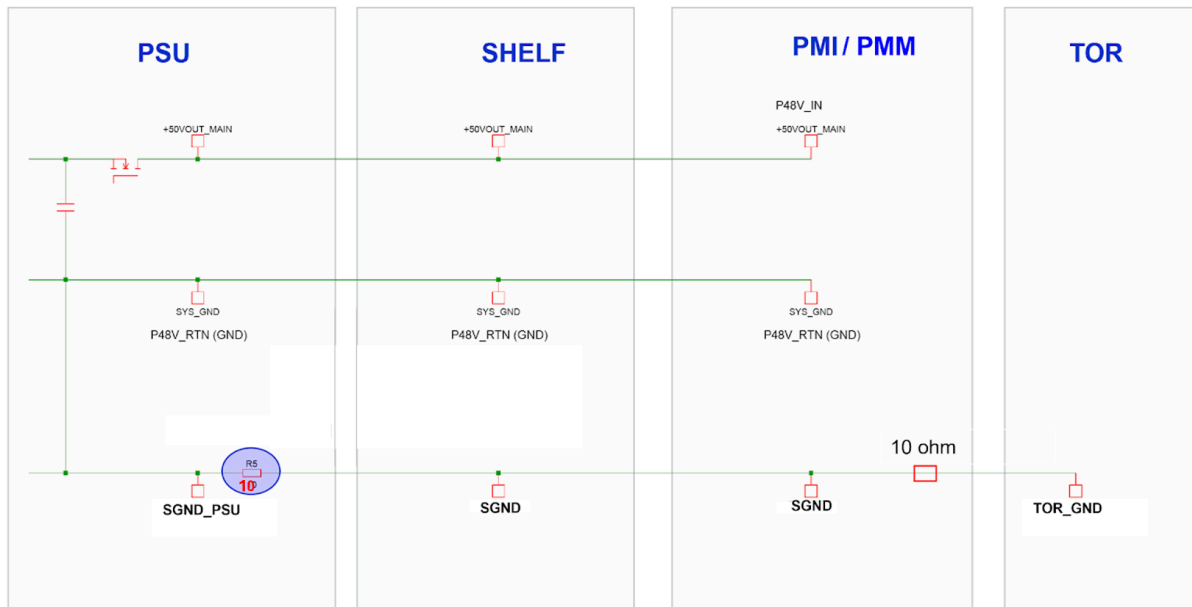


Figure 4: HPRv2 Grounding Scheme

5.9. 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.

5.10. 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.

Acceptable thermistors include, but are not limited to, the following:

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

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 +/-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 (+/-0.5%) LDO regulator.

5.11. Busbar Temperature Monitoring

The power shelf shall be able to monitor the rack busbar temperatures by accepting the sensed temperature signals from 3x external horizontal busbars.

- Two 3x USB-C connectors (BB_Temp) as defined in section 6.3.7 are required to accept 12x sensed temperature signals from 3x busbars.
- Voltage divider circuits are implemented on the shelf backplane board for the busbar sensing. Each thermistor is grounded and connected in series with a pull-up resistor 2K +/-0.1% to a regulated power supply (3.3V). The bias power supply shall be converted from the 48V bus voltage through a high-accuracy (+/-0.5%) LDO regulator.
- The sensed voltage signals are sent to ADC ICs with I2C interface and connected to shelf EEPROM.
- PMM will monitor the sensed busbar temperature signals by reading shelf EEPROM.

6. Mechanical Requirements

6.1. Power Shelf Assembly Dimensions

Power shelf options 1 and 2 are 10U tall. The overall dimensions of the 10U power shelf are 537mm x 46.2mm x 867.5mm [Width x Height x Depth]

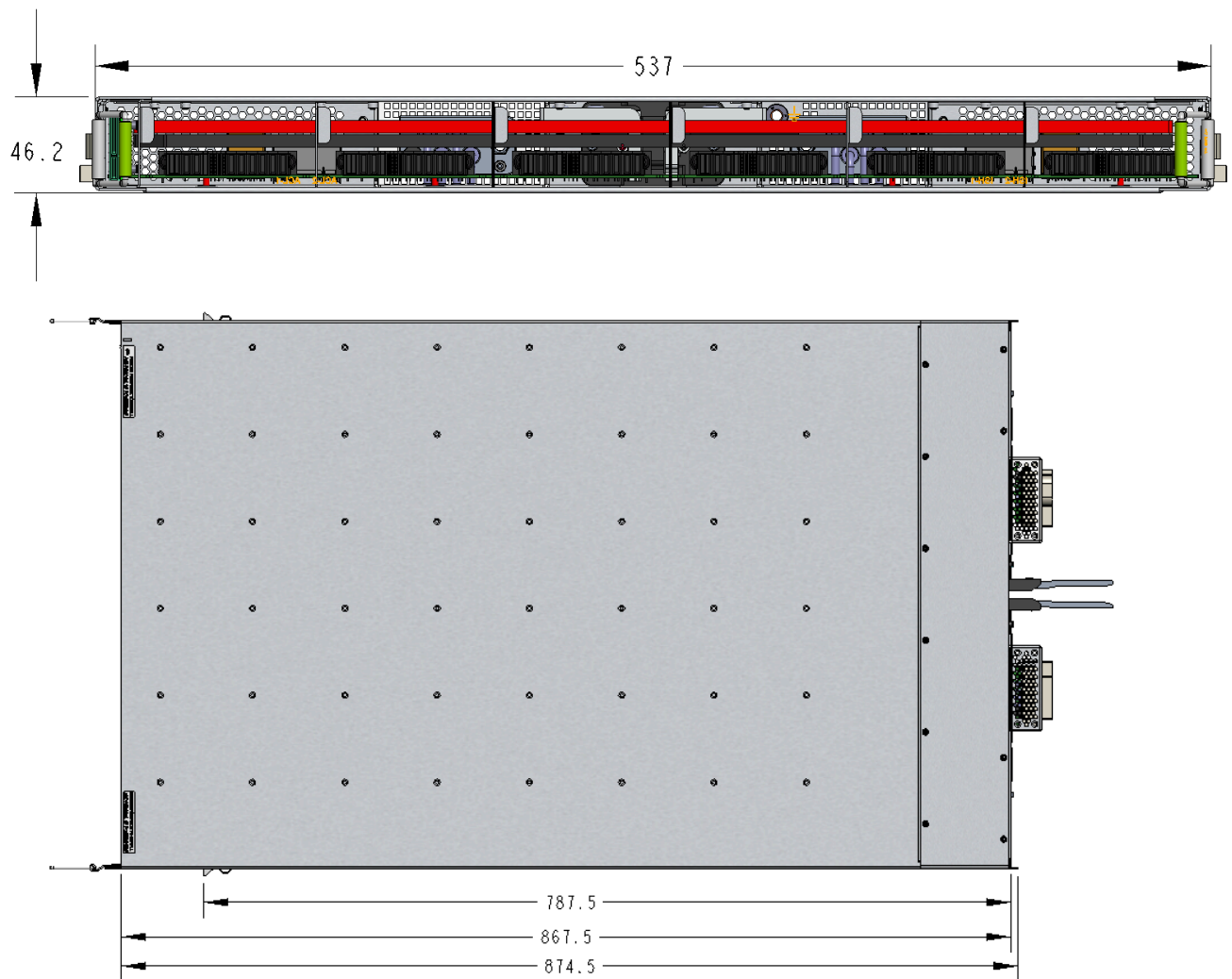


Figure 5: Power Shelf Critical Dimensions

6.2. Rack Mounting Features

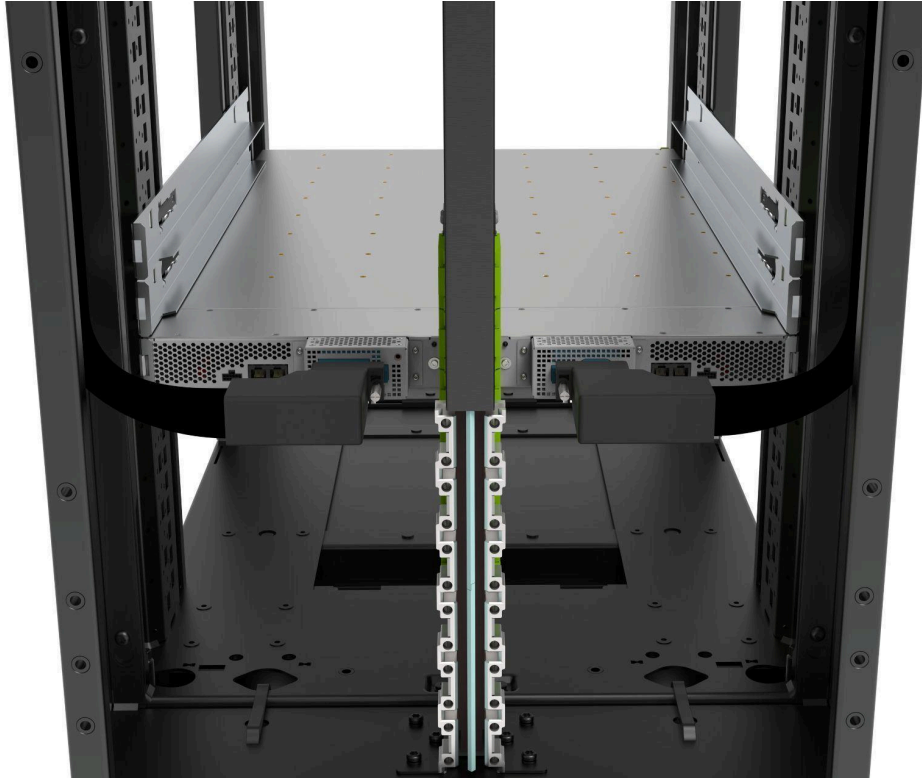


Figure 6: Power Shelf Rack Install

The power shelf shall be front mounted in predetermined OU positions within the HPRv3 power rack. These specific OU locations are OU3-8 & 37-42 - featuring modified busbar geometry and threaded hardware to allow for 72kW power shelf DC output connector mounting.

6.2.1. 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. It is suggested to use SUS304 for the latch ring material.

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, retracting the latch inward.



Figure 7: Shelf Latch & Bumper

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 8: Shelf Pull Latch Mechanical Actuation

6.2.2. Rear Stop

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



Figure 9: Shelf Rear Stop

6.3. Connectors

6.3.1. AC Input connector

The shelf input connections provide AC input power to the PSUs. This is a pluggable 5-pin connector that allows various input power configurations (star, single phase). Please refer to the “*Open Rack V3 High Power (60A) AC WHIP Power Cable*” [2] specification for further details on the connection.

Acceptable connectors include, but are not limited to, the following:

- Left Side (viewing from the front), PCB Mounted: Amphenol 10182665-1RF001LF
- Right Side (viewing from the front), PCB Mounted: Amphenol 10182665-1LF002LF

Shown below is a drawing of the left-side PCB mounted connector:

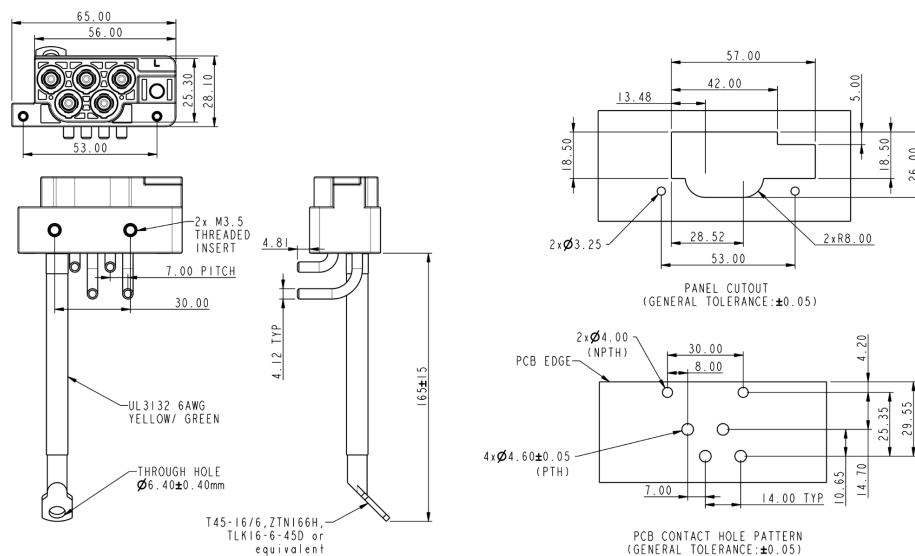


Figure 10: AC Input Connector Drawing

The female mating connector supplies AC power into the shelf. It is rated for 60A and is angled 90° outward to enable cable routing along the sides of the rack.

6.3.2. DC Output

Due to the high current output of the 72kW power shelf, it is recommended to use a bolted DC output connector. This bolted output connection will interface with the HPRv3 rack vertical busbar.

The HPRv3 rack vertical busbar includes modified mounting geometry & M5 threaded hardware at OU3-8 & 37-42. Chamfers on the power shelf output busbars 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 +/- 0.25Nm) shall be used to secure the connection. See *OCP ORv3 HPR 2000A DC Power Output Connector* [3] specification for more details.

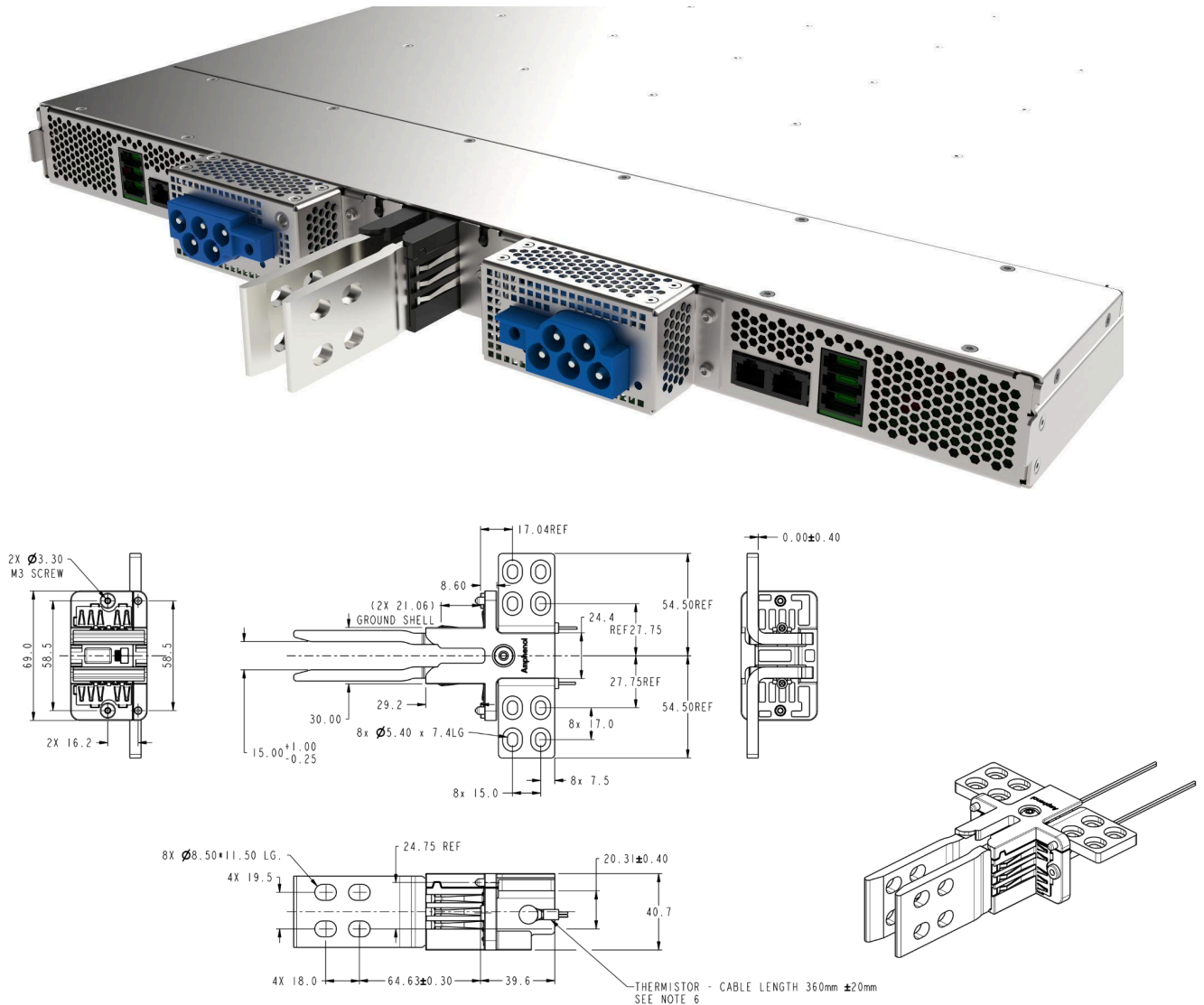


Figure 11: DC Output Connector Drawing & Power Shelf Rear View

6.3.3. Power Supply Connector

The chassis side of the rear PSU blind mate connector shall be Amphenol 10169892-643003SLF or equivalent. This is a R/A connector with 3 low power pins, 24 signal pins, and 6 high power pins. Please refer to the drawing for more details. The connector positions (in all 6 or 12 locations) within the power shelf are fixed in x, y, and z directions 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 HPR V2 12kW PSU*” for pinout signals.

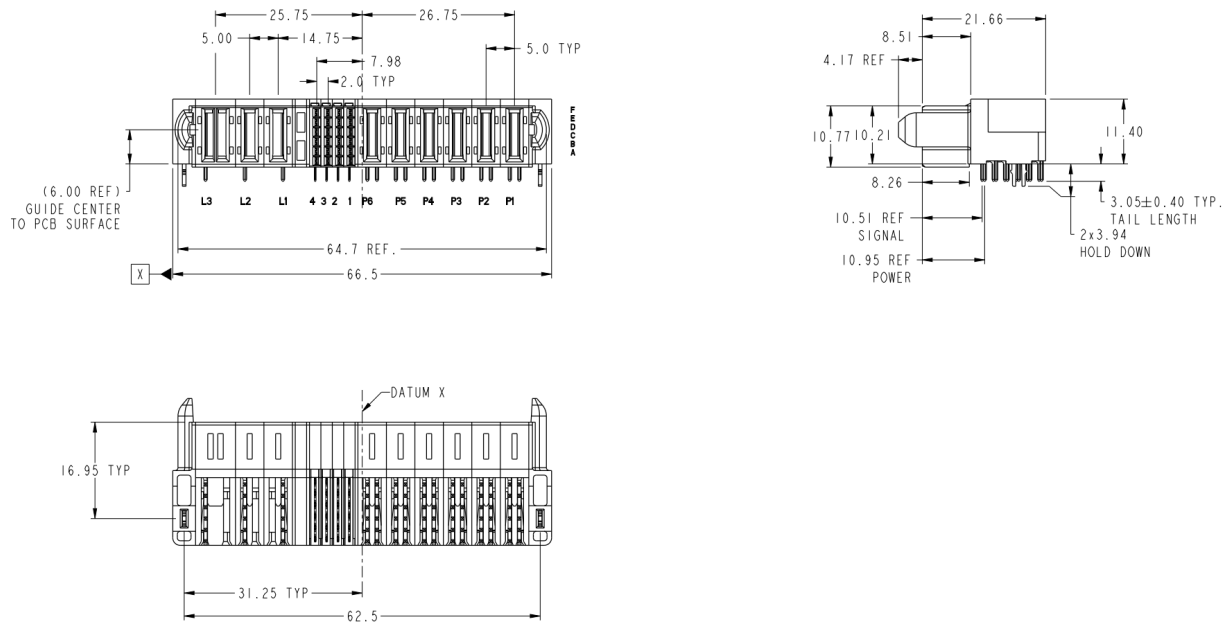


Figure 12: PSU Mating Connector

6.3.4. 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)* [1] specification for connector pinout signals.

Acceptable connectors include, but are not limited to, the following:

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

Drawing of Amphenol Mini Cool Edge 1008410201071 is shown below.



6.3.5. AC Loss and Pulse Mgmt Signal Connector

There shall be a 2 port high speed RJ-45 8p8c shielded connector on the rear of the power shelf to allow for AC_Loss Signal and Pulse_Mgmt Signal cable to be plugged in between the PSU shelf and BBU shelf.

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 is to be 30 μ " thick minimum. Please refer to the 3D drawing for the suggested position.

Acceptable connectors include, but are not limited to, the following:

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

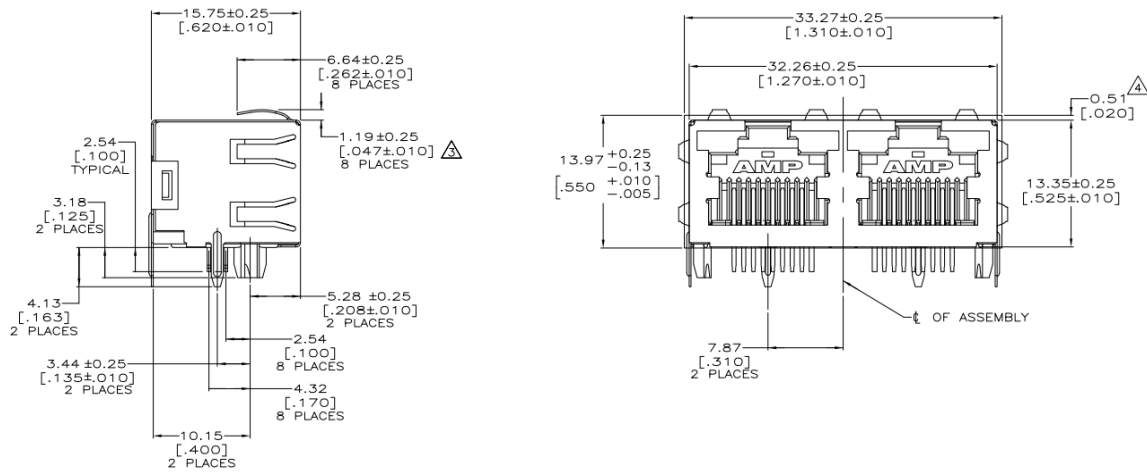


Figure 14: AC_Loss RJ45 Connector Drawing

Pinout of the two RJ45 connectors are defined as below.

For RJ45 port 1 (ACL-1):

Pin#	Wire Color	Signal Name	Function
1	White/Orange	AL1	AC_LOSS signal from PSU 1
2	Orange	AL4	AC_LOSS signal from PSU 4
3	White/Green	AL2	AC_LOSS signal from PSU 2
4	Blue	AL5	AC_LOSS signal from PSU 5
5	White/Blue	AL3	AC_LOSS signal from PSU 3
6	Green	AL6	AC_LOSS signal from PSU 6
7	White/Brown	PM	Pulse_Mgmt signal from 6 PSUs
8	Brown	SGND	signal ground

For RJ45 port 2 (ACL-2):

Pin#	Wire Color	Signal Name	Function
1	White/Orange	AL1	AC_LOSS signal from PSU 1
2	Orange	AL4	AC_LOSS signal from PSU 4
3	White/Green	AL2	AC_LOSS signal from PSU 2
4	Blue	AL5	AC_LOSS signal from PSU 5
5	White/Blue	AL3	AC_LOSS signal from PSU 3
6	Green	AL6	AC_LOSS signal from PSU 6
7	White/Brown	PM	Pulse_Mgmt signal from 6 PSUs
8	Brown	SGND	signal ground

Table 1: AC_Loss RJ45 Connector Pinouts

6.3.6. 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 different types of shelves are NOT allowed.

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

Acceptable connectors include, but are not limited to, the following:

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

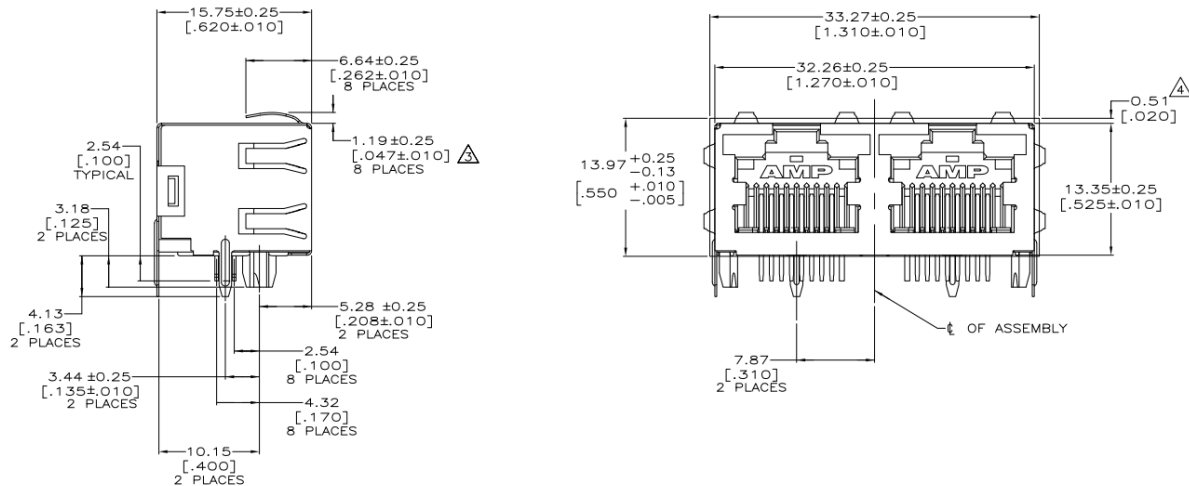


Figure 14: ISHARE RJ45 Connector Drawing

ISHARE RJ45 port 1 (ISH-1):

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

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	
6	Green	AC_Fault_CLR	clear latch off flag after ac 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 if it is the last PSU shelf on the rack.

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

Table 2: ISHARE RJ45 Connector Pinouts

6.3.7. Busbar Temperature Monitoring Connector

There shall be 3 USB-C connectors at both sides of the rear of the power shelf. Recommendation is to have a singular board-mounted connector with 3 USB-C ports. These connectors are to be used for horizontal busbar (HBB) temperature monitoring.

The connector shall be Amphenol 12402592P912A or equivalent.

Drawing of Amphenol 12402592P912A is shown below.

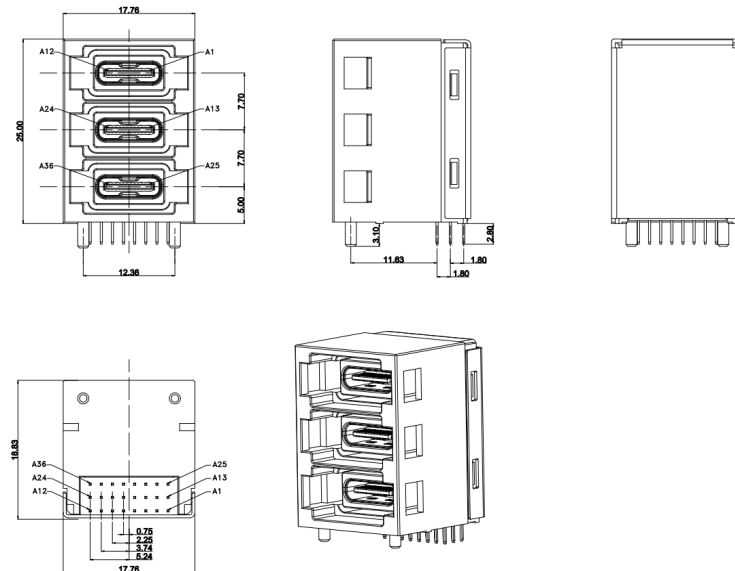


Figure 15: Stacked USB-C Connector Drawing

Pinout of the 3x USB-C connectors (BB_Temp) for busbar temperature sensing are defined as below.

Connector 1:

A1			A4	A5	A6	A7	A8	A9			A12
Right Neg +			Right Neg -	Right Pos +	Right Pos -	Left Pos -	Left Pos +	Left Neg -			Left Neg +

Connector 2:

A13			A16	A17	A18	A19	A20	A21			A24
Right Neg +			Right Neg -	Right Pos +	Right Pos -	Left Pos -	Left Pos +	Left Neg -			Left Neg +

Connector 3:

A25			A28	A29	A30	A31	A32	A33			A36
Right Neg +			Right Neg -	Right Pos +	Right Pos -	Left Pos -	Left Pos +	Left Neg -			Left Neg +

Pin#	Signal Name	Function
A1	BB1_Neg_TEMP1	Negative busbar temperature 1 from Busbar 1
A4	SGND	signal ground
A5	BB1_Pos_TEMP1	Positive busbar temperature 1 from Busbar 1
A6	SGND	signal ground
A7	SGND	signal ground
A8	BB1_Pos_TEMP2	Positive busbar temperature 2 from Busbar 1
A9	SGND	signal ground
A12	BB1_Neg_TEMP2	Negative busbar temperature 2 from Busbar 1
A13	BB2_Neg_TEMP1	Negative busbar temperature 1 from Busbar 2
A16	SGND	signal ground
A17	BB2_Pos_TEMP1	Positive busbar temperature 1 from Busbar 2
A18	SGND	signal ground
A19	SGND	signal ground
A20	BB2_Pos_TEMP2	Positive busbar temperature 2 from Busbar 2
A21	SGND	signal ground
A24	BB2_Neg_TEMP2	Negative busbar temperature 2 from Busbar 2
A25	BB3_Neg_TEMP1	Negative busbar temperature 1 from Busbar 3
A28	SGND	signal ground
A29	BB3_Pos_TEMP1	Positive busbar temperature 1 from Busbar 3

A30	SGND	signal ground
A31	SGND	signal ground
A32	BB3_Pos_TEMP2	Positive busbar temperature 2 from Busbar 3
A33	SGND	signal ground
A36	BB3_Neg_TEMP2	Negative busbar temperature 2 from Busbar 3

Table 3: USB-C Connector Pinout

6.4. Front Access

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

6.5. 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 sharp corners or edges. When assembled into a rack, with PSUs installed, maximum deflection of the PSU shelf shall be less than 1.3 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

6.6. 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-200GMR01
- Kingfa JH960-6950 C2B-S0759
- Kingfa JH960-6950 C7G-S0023
- Wistron WAM NCT50T#

6.6.1. PCR Targets & Implementation

- PCR content must be met in aggregate for polymers and steel.
- Functionality and reliability take priority; waivers may be considered for components where recycled content impacts performance.
- PCR requirements are mandatory at MP; strongly recommended to pilot in DVT for risk mitigation.

6.6.2. Supplier Qualification & Material Testing

- All new material suppliers or materials not previously validated must complete full qualification testing to confirm performance and compliance with recycled content requirements.
- Suppliers already validated for the specified recycled content do not require requalification.
- Required testing (as applicable):
 - Mechanical: Tensile, hardness, standoff mounting strength.
 - Corrosion/finish: Salt spray, silkscreen print adhesion.
 - Sheet metal feature limits: Max emboss height, min L-flange bend height, min closed hem length, min inner hole radius of closed hem, and other relevant features.
 - Key mechanical properties must be tested to relevant JIS standards (or equivalent), or any other applicable standards.

6.6.3. Documentation & Certification

- Required
 - Recycled Content Certificate from supplier.

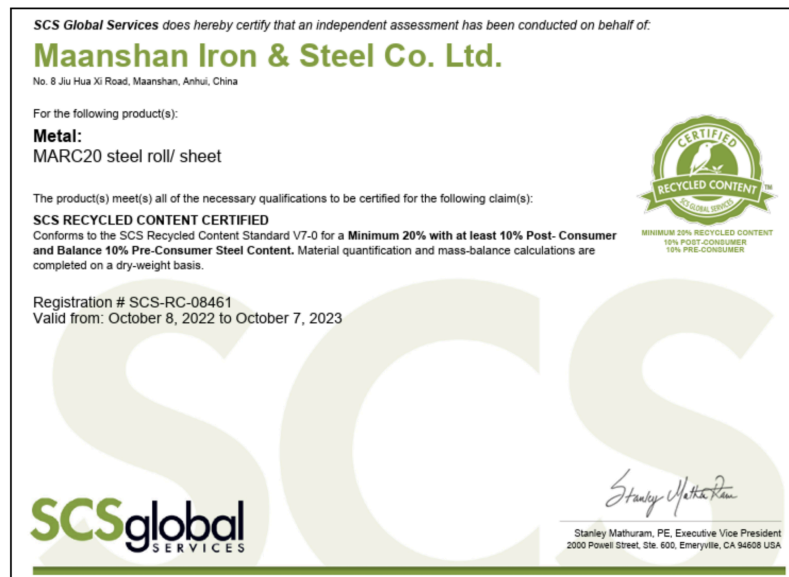


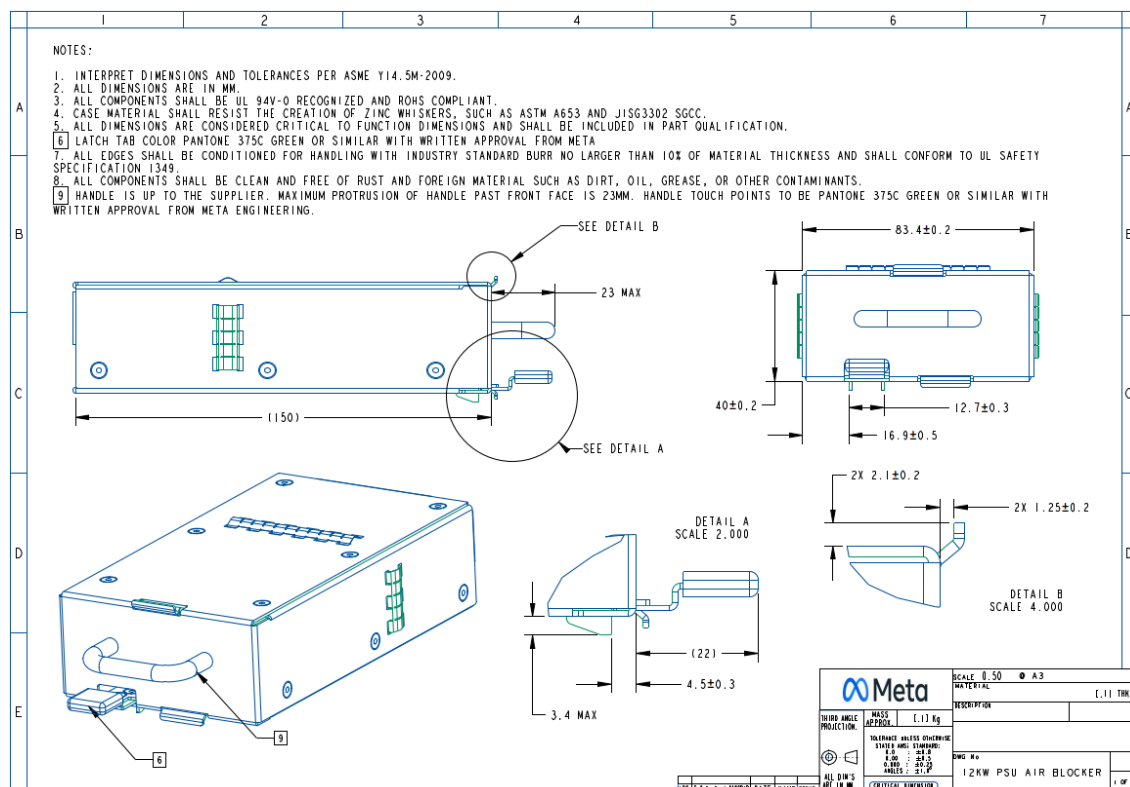
Figure 15: Example of RC Certificate

- Material Certificate showing compliance with relevant standards (e.g., JIS G 3302:2019).
- Metal coating certificate (e.g., Z18–Z22).
- RoHS compliance certificate.
- BOM with detailed breakdown: material, PCR %, aggregate PCR % by weight for polymers and steel.
- Optional but Preferred
 - ISO 17065/14021 accreditation.
 - Recognition from LEED, EPA, or BREEAM.

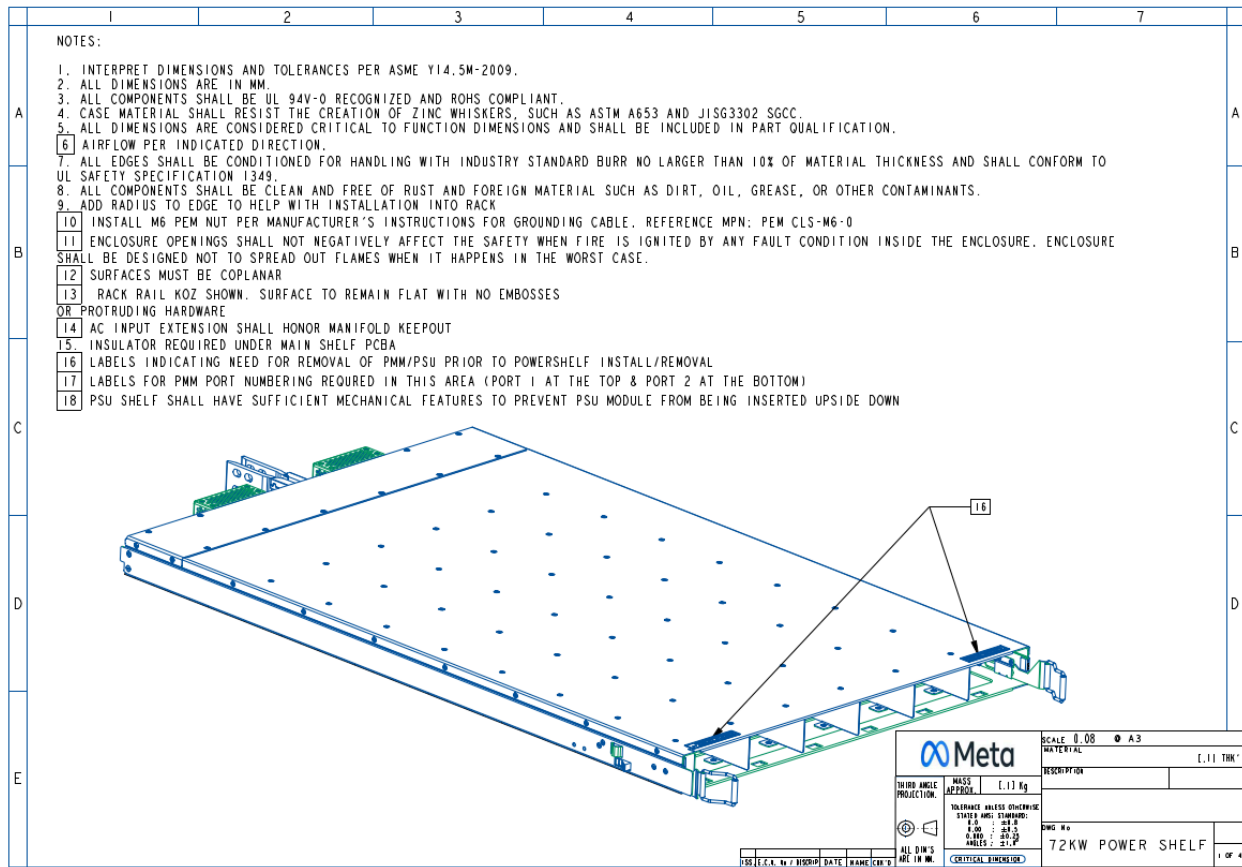
Shelf labeling to be placed on the top side or other approved location.

6.8. PSU Slot Blanks

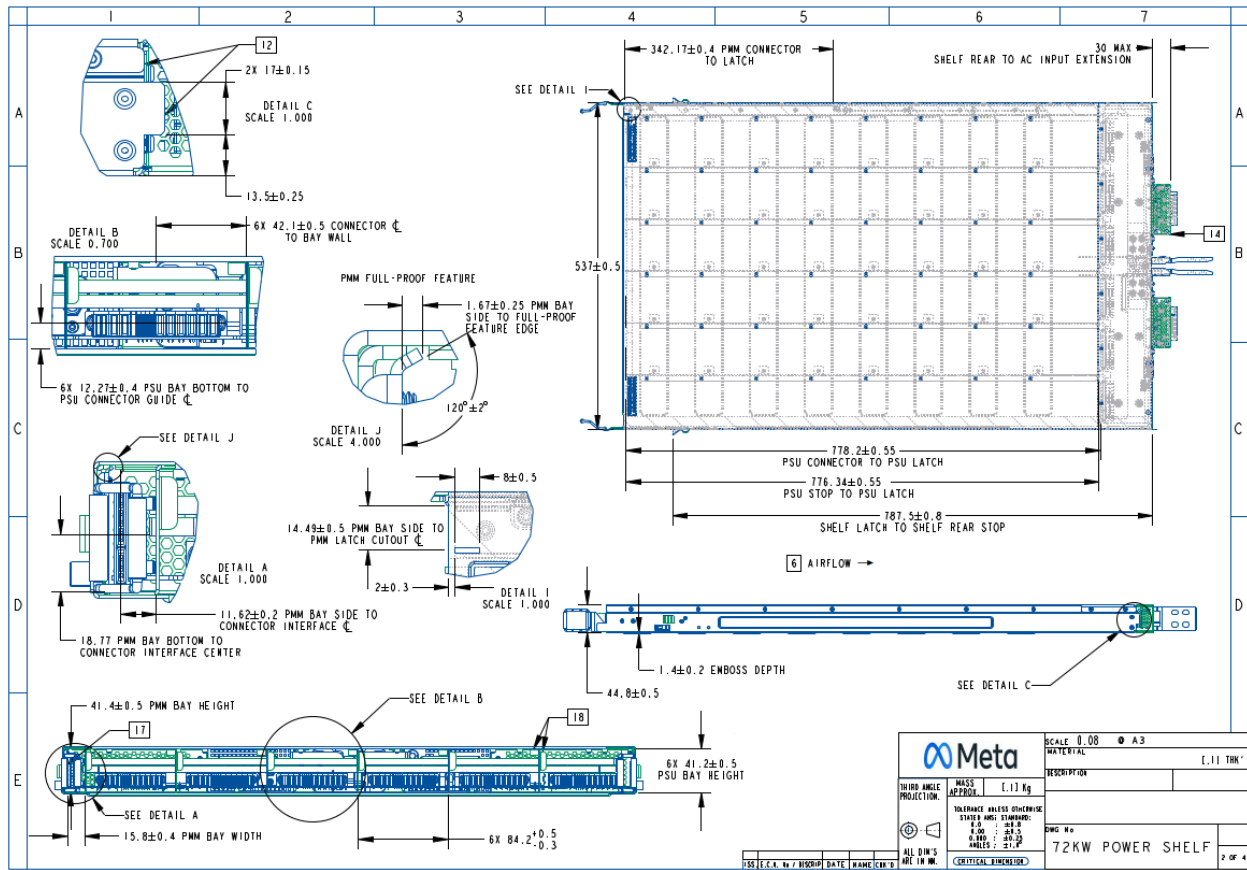
Any configuration that dictates the use of less than 6 PSUs in one shelf must include a PSU slot blank in order to properly channel airflow through the operating PSUs. The PSU slot blank features a latch identical to those used on the PSU module.



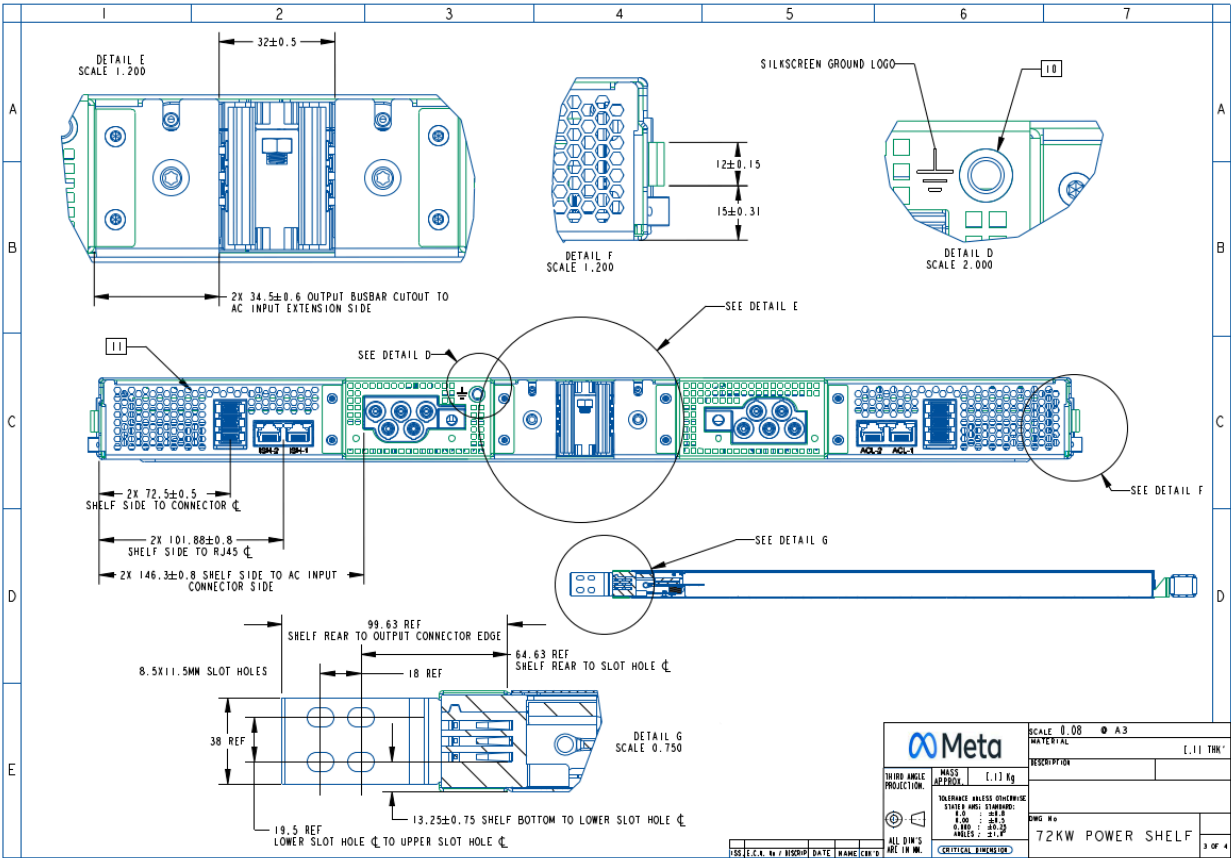
6.9. Mechanical Drawings



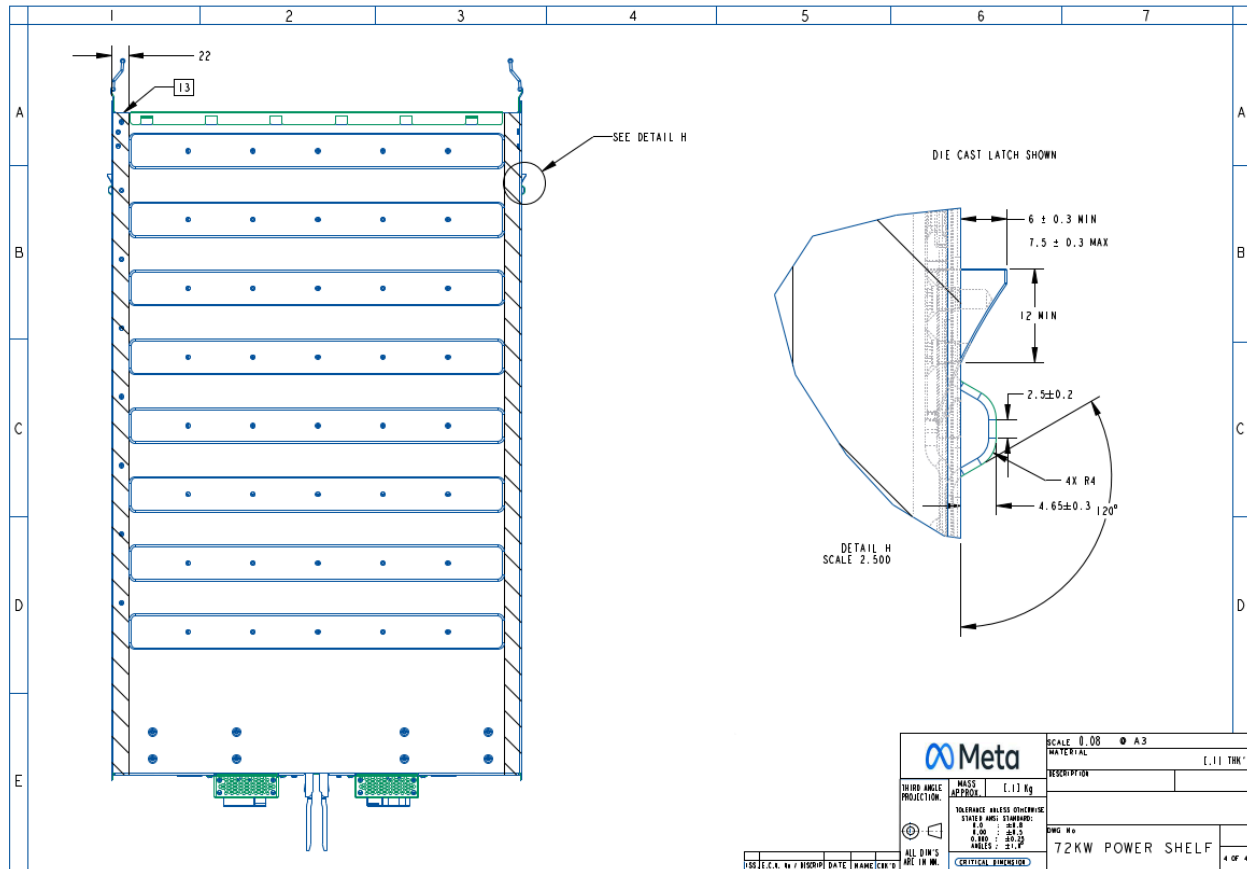
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7. Thermal Requirements

7.1. Operational

- For operating environmental conditions, please refer to section 8.
- 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 ≥7% or ≥5°C up to 30°C inlet/ambient and 3050m (10,000ft) above sea-level. Target whichever value is larger.
 - Component thermal margin of ≥4% or ≥3°C at greater than 35°C inlet/ambient and up to 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.

7.2. 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 can significantly influence the amount of back-pressure upstream components have to overcome (such as the PSUs). In general, targeting a back-pressure of ≤ 1.5 inches of water for a flow rate higher than 250 CFM is highly recommended (at sea-level and flow through PSU area only).
- Signal cables and connectors: Termination of cables within the shelf as well as the connectors at the rear panel should be designed to ensure adequate cooling for compliance requirements in the component spec.
- Surface temperature: To make the shelf safe for handling during operation, accessible surfaces should not exceed a temperature of 75°C .

7.3. Shelf output connector temperature monitoring and protection

- There are two thermistors attached to the DC output connector. 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.
- PSUs report the temperatures through Modbus registers.
- Shelf output connector over temperature alarm and OTP:
 - The PSU shall set an alarm bit within a Modbus register if the temperature exceeds the warning threshold. This alarm bit indicates 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.

7.4. External horizontal busbar Temperature monitoring and protection

- The power shelf is designed with three USB-C connectors on the rear side for external horizontal busbar temperature monitoring, where NTC thermistors are installed inside the horizontal busbars. The thermistor should meet sensor accuracy in all operational conditions.
- External busbar temperature signals are sensed by the conditioning circuit on the power shelf and sent to PMM for monitoring and reporting via Modbus registers.
- External busbar over temperature alarm and OTP:
 - The PMM 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 PMM will initiate a shutdown command to PSU/BBU modules to ensure the safety of the system.

8. Environment/test requirements

- Gaseous Contamination: Severity Level G1 per ANSI/ISA 71.04-1985
- 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

8.1. Vibration and Shock (non-packaged)

The “power shelf with PSUs and PMI module inside” shall meet vibration and shock test per EN 60068-2-6 and 60068-2-27, respectively, for both non-operating and operating condition, 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 non-operating tests, no damage of any kind (including physical damage) should occur and there should be no functional impact of the PSU per the specifications.

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

Vibration Non-Operating:

Endurance

Excitation Mode	Sinusoidal
Test Frequency	5Hz to 500Hz
Amplitude	(5.0-9.0Hz) 6mm peak to peak (9.0-500.0Hz) 1g
Frequency Change Rate	1 octave / min
Test Directions	3 directions in space (x,y,z)
Duration	10 sweep cycles for each direction (2hours 13 minutes)
Test Temperature	Room temperature
Electrical Work	None

Functional | per MIL-STD-810, Method 514 (random vibration):

Excitation Mode	Random
Test Frequency	5Hz to 500Hz
Overall Level	1grms
Test Directions	3 directions in space (x,y,z)
Duration	1 hour / axis (3 hours)
Test Temperature	Room temperature
Electrical Work	None

PSD Profile:

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Frequency (Hz)	PSD (g ² /Hz)
5	0.000238
20	0.00238
80-350	0.00238
500	0.000238

Shock Non-Operating:

Shock Pulse:	half sinus
Shock duration:	11ms
Shock Amplitude:	12g
Test Directions:	6 directions
Number of Shocks:	60 (10 per each direction)
Test Temperature:	Room temperature
Electrical Work:	None

Vibration Operating:

Endurance

Excitation Mode	Sinusoidal
Test Frequency	5Hz to 500Hz
Amplitude	(5.0-9.0Hz) 6mm peak to peak (9.0-500.0Hz) 1g
Frequency Change Rate	1 octave / min
Test Directions	3 directions in space (x,y,z)
Duration	10 sweep cycles for each direction (2hours 13 minutes)
Test Temperature	Room temperature
Electrical Work	Power supply in operation

Functional | per MIL-STD-810, Method 514 (random vibration):

Excitation Mode	Random
-----------------	--------

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Test Frequency	5Hz to 500Hz
Overall Level	0.5grms
Test Directions	3 directions in space (x,y,z)
Duration	15 minutes / axis (45 minutes)
Test Temperature	Room temperature
Electrical Work	Power supply in operation

PSD Profile:

Frequency (Hz)	PSD (g ² /Hz)
5	0.0000594
20	0.000594
80-350	0.000594
500	0.0000594

Shock Operating:

Shock Pulse:	half sinus
Shock duration:	11ms
Shock Amplitude:	6g
Test Directions:	6 directions
Number of Shocks:	30 (5 per each direction)
Test Temperature:	Room temperature
Electrical Work:	Power supply in operation

8.2. Package Vibration, Drop and Compression

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

9. Reliability and Quality

9.1. Worst Case Component Stress Analysis (WCSA)

- Component stress analyses must include Thermal and Electrical stress analyses, and the analyses must consider the worst case operating thermal and electrical conditions (defined in [Section 7 Thermal Requirements](#) and [Section 5 Electrical Requirements](#) of this document respectively) applied to all applicable components in the Power Shelf; Capacitor life must be included in the overall analysis as well when applicable.
- IPC-9592B may serve as a reference document for defining the derating specifications of various components, and all components must meet or exceed the specifications defined in IPC-9592B (Class II) as a minimum requirement.
- All Capacitors must meet/exceed > 6 years operational life requirement.
- This activity must be completed at each phase of development (both Primary and Mixed Source, if applicable) with the exception of no violation found and no change in design, operational requirements, component selection compared to previous phases of development.

9.2. Reliability Prediction

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

9.3. Design Failure Mode and Effect Analysis (DFMEA)

- A reliability focused risk assessment must be performed with emphasis on long term exposure to environmental, electrical, mechanical stresses that are based on the product specification defined in this document for the entire life of the Power Shelf and its associated components.
- Each of the failure modes must be quantified based on the Severity of the failure/impact to the system operation, Occurrence of the failure, and Detectability of the failure mode during development/production.
- Risk levels that are classified as High and Medium risks must have mitigation plans in place before design freeze of each stage of development.
- All high risk level failure modes must have mitigation in place before design freeze.
- Medium risk level failure modes must have mitigation in place before phase exit.
- Low risk level failure modes are recommended to have mitigation plan in place and implemented.

9.4. Reliability Tests

- The PSU/PSS must pass a set of reliability tests that comprises environmental stress (defined in [Section 7 Thermal Requirements](#) of this document), electrical stress (defined in [Section 5 Electrical Requirements](#) of this document), and mechanical stress. (operational/non-operational/transportation) conditions. IPC9592BL may serve as a baseline reference for the reliability test plan development, but the exact test item and the

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respective test conditions should be defined based on the product specifications and DFMEA results.

- Reliability tests must be performed at each phase of the NPI development starting from EVT, and continue in DVT and PVT.
- Test durations for some of the test items must meet or exceed > 6 years of PSU operation life. The acceleration factors that are based on thermal, electrical, etc may be employed to reduce the test duration for the purpose of demonstrating the robustness of the design under the most extreme operational requirements as defined in this document.
- Sample types include PSU module + PMM + Shelf.

9.5. 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 customer approval)
- Aluminum material is not allowed for the enclosures.
- The chassis enclosure, as well as all electronics, shall meet certain contamination requirements (see ANSI spec at § 14).

10. 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 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, as applicable, 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

10.1. Manufacturing Testing

10.1.1. Incoming Quality Inspection

- All assembly inspection dimensions and tolerances in the drawings provided must be met.
- Inspection shall include critical components and mechanical dimensions.

10.1.2. In-Circuit and Parametric Test

- For all the boards used in the design: the in-circuit test coverage and test point access shall be 95% or higher. The rest shall be covered by functional testing.
- Functional parametric testing, if applicable, shall be done on an automated tester. The tester shall be subjected to Gage Repeatability and Reproducibility (GR&R) and bench correlation testing before release to production.

10.1.3. Hipot and Ground Continuity Test

The power shelf shall be tested 100% in production for both Hi-Pot (with the applicable limits for the AC leakage current) and ground continuity (per the applicable standard). Stamps shall be applied accordingly to the chassis.

10.1.4. Ongoing Quality Assurance

Sampling testing shall be conducted on each batch of finished goods for shipment. It shall include, but not be limited to parametric testing, hipot, and final visual inspection.

10.2. Automation and Continuous Improvement

Certain areas of production shall be planned for automation before and after the product is released to production. Continuous improvement plans shall be submitted on a regular basis to ensure uniformity of process and quality control.

10.2.1. Conformal Coating and Insulation

Automated conformal coating shall be applied to critical areas of the boards to protect sensitive circuitries, using an atomized spray process (dipping is not permitted). The thickness of the coating shall be ~50µm to ~150µm. The Vendor (mainly the ultimate Manufacturing Facility) shall demonstrate proven capability and extensive experience in automated conformal coating application and process. The main PCBA shall be partially conformal coated (top & bottom); critical board areas shall be agreed upon, typically the ac high- voltage input section at shelf level, like the AC input, board-mount connector area.

An insulator may be required between chassis and solder side of the shelf main PCBA. This is to prevent shorting/arcing between the chassis (i.e. earth ground) to any of the line inputs due to conductive loose parts or foreign materials, etc.

10.3. Quality Control Process

The vendor shall submit a production yield report and RMA summary to the customer 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.

10.4. Warranty and Failure Analysis

- The Vendor is responsible for the power shelf to meet the specifications as stand-alone unit as well as at system level, and for assuring that the shipment from production will conform to the specifications with no deviations.
- 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 or as agreed upon. An 8D report may be required on trending issues and/or those causing thermal events.
- The Vendor shall warrant the power supply for defects and workmanship for a period of three (3) years from the date of shipment when the device is operated within specifications. The warranty is fully transferable to any end user. A standard "VOID" warranty sticker may be applied.
- The Vendor may be requested to support failure analysis and further actions as needed even if the power supplies are outside the warranty period. These are on special cases including, but not limited to a thermal or safety event and early wearout.

10.5. Product Change Notification

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. FBPN and revision (from and to, retain if not changed)
- b. Vendor PN and revision/version (from and to, retain if not changed)
- c. Vendor PN HW and FW (if applicable) (from and to, retain if not changed)
- d. Date of Issuance

- e. Reason of change
- f. Description of changes
- g. Form, fit, function changes (if any)
- h. Before and after drawing with mark-up of changes if applicable
- i. 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.

11. 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.

11.1. 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 are 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, UL, VDE, TUV or DEMKO
- CE Marking for EU

11.1.1. Safety requirements

- Following (but not limited) safety requirements are also applicable. All Fans shall have the minimum certifications: UL and TUV or VDE.
- All current limiting devices shall have UL and TUV or VDE 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.

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- All connectors shall be UL recognized and have a UL flame rating of UL94V-0.
- All wiring harnesses shall be sourced from a UL approved wiring harness manufacturer. SELV cable to be rated minimum 80V, 130C.
- Product safety label must be printed on UL approved label stock and printer ribbon. Alternatively, labels can be purchased from a UL approved label 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 to the safety critical component shall not cause any electrical or mechanical unsafe conditions (such as electric shock to user, arcing to ignite fire...PCBA shall meet the clearance and creepage requirements defined in FBPN: 18-000207 and UL62368-1 standard (whichever is greater).

11.2. 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
- EN61000-3-2 - Harmonics
- EN61000-3-3 - Voltage Flicker

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
 - Air discharge: >11.2kV
- EN61000-4-3 Radiated Immunity
 - > 3V/m
- EN61000-4-4 Electrical Fast Transient Immunity
 - AC Power Line: >1kV
 - Signal Line: >0.5kV
- EN61000-4-5 Surge
 - AC Power Line: >2kV (Line-to-line), >4kV (Line-to-earth)
 - Signal Port: >1kV
- EN61000-4-6 Immunity to Conducted Disturbances
 - DC Power Line: > 3Vrms
- EN61000-4-8 Power Frequency Magnetic Field Immunity, when applicable
 - > 1A/m
- EN61000-4-11 Voltage dip and sag

11.3. 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 documentation 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
- Refer to FBPN: 18-000142 for more detail environmental compliance requirements

11.4. Acoustic pressure

The power shelf manufacturer shall demonstrate the compliance with acoustic pressure requirements defined in FBPN: 18-000207

11.5. 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
- Declaration of Conformity to EN 61000-3-2 Class A and test report including waveforms and harmonic output levels.
- Other applicable certificates required by the system manufacturer.

12. Compliance with OCP Tenets

12.1. Openness

The entire design of the 72kW Power Shelf is openly specified -- mechanical envelope, electrical interfaces, connector definitions, and monitoring/control architecture. Acceptable components are defined with component drawings, allowing any third party to build, modify, or personalize the shelf. Developed collaboratively with suppliers and the OCP community, with lessons learned incorporated to enable successful implementation by others.

12.2. Efficiency

The 72kW power shelf delivers high power density, providing up to 72kW of capacity within a single 10U shelf and maximizing rack power per unit of floorspace. Centralized power distribution over a common busbar minimizes interconnect losses, and the N+1 PSU redundancy enables long term reliability.

12.3. Impact

The 72kW power shelf is a critical element of the ORV3 High Power Rack ecosystem, delivering centralized, scalable DC power over a common busbar to all payloads in the rack. Standardizing the shelf interface alongside the PSU, PMM, BBU, and AC WHIP contributions enables a global supply chain to deliver high-power rack infrastructure across many customers and regions.

12.4. Scale

The design of the 72kW power shelf supports parallel operation of at least ten power shelves, from single-rack to large hyperscale clusters. Architecture, connectors, and supply chain developed with OCP solution providers and validated for high-volume manufacturing, with multiple approved sources.

12.5. Sustainability

The specification defines post-consumer recycled (PCR) material targets and implementation requirements, together with supplier qualification, material testing, and the associated documentation and certification to verify them. The shelf conforms to applicable environmental regulations, including RoHS and REACH, and to defined acoustic pressure limits.

13. References

Refer to the latest available revision of the following specifications:

- [1] *Open Rack V3 HPR V2 Power Monitoring Interface Module (PMM)* (in progress as of May 2026)
- [2] *Open Rack V3 High Power (60A) AC WHIP Power Cable* (In progress as of May 2026)
- [3] *OCP ORv3 HPR 2000A DC Power Output Connector* (In progress as of May 2026)
- [4] *Open Rack V3 HPR V2 12kW PSU* (In progress as of May 2026)
- [5] [Open Rack V3 Base Specification](#)