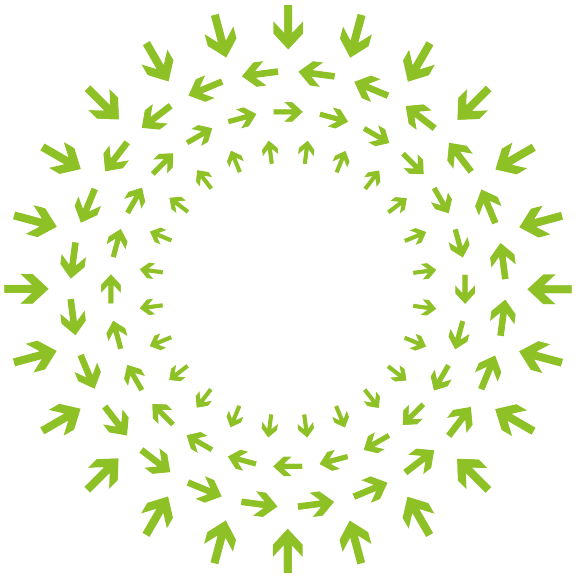

OPEN
Compute Project

Open Rack Hardware v0.5

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1 Scope

This document describes the technical specifications for the custom rack that houses Open Compute Project server technologies.

2 Contents

3 Overview

When data center design and hardware design move in concert, they can improve efficiency and reduce power consumption. To this end, the Open Compute Project is a set of technologies that reduces energy consumption and cost, increases reliability and choice in the marketplace, and simplifies operations and maintenance. One key objective is openness—the project is starting with the opening of the specifications and mechanical designs for the major components of a data center, and the efficiency results achieved at facilities using Open Compute technologies.

The main components of this project are the Open Rack and equipment chassis that can be configured as a server rack, storage box, and more. The Open Rack uses an all-encompassing design to accommodate compatible Open Compute Project chassis components, and include the power solution as well as input and output voltage distribution.

3.1 License

4 Open Rack Overview

The Open Rack has a very flexible configuration. The rack comes in two form factors:

- Singlet, a single column rack
- Triplet, a three column rack in a single cabinet

Each column in the rack is divided into one or more *power zones*. A power zone comprises an *equipment bay* for the compute, storage, or other components and a *power shelf*, which powers the compute components in the equipment bay. The power shelf includes backup power capability using an external Open Compute Project Battery Cabinet, or it comprises a power shelf and Battery Backup Unit that embeds batteries. If there are multiple power zones, they are stacked one above another. The power shelf is described in Power Shelf Specifications.

Each column has space for up to three Ethernet switches. In the current version, the switches are installed in one of two locations:

- All three switches are at the top of the rack, above the topmost power zone.
- Each power zone has its own switch located within its equipment bay, typically above the power shelf, so the switch may be powered at 12V from its own power zone.

Users may arrange the switches and equipment in other configurations as needed.

Each equipment bay in a power zone can be set up in various configurations and can accommodate different numbers and height of equipment chassis (such as individual server or storage chassis). Motherboards and other Open Compute hardware are hot-swappable within the individual equipment bay.

Variable configurations are achieved because the rack enclosure is designed to accommodate various equipment mounting configurations. The rack has no side walls; rather, shelves in the equipment bay are locked in place to the vertical support posts. As long as the design follows Open Compute Project standards, the chassis (whether server chassis, storage chassis, or other) will fit.

4.1 Open Rack Images and Drawings

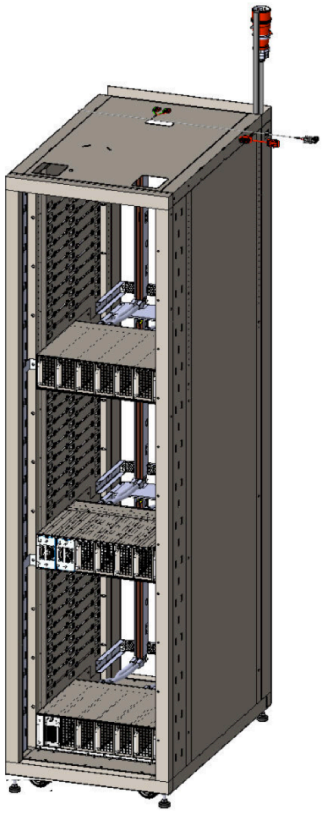

Figure 1 Open Rack Singlet

Figure 2 Open Rack Triplet

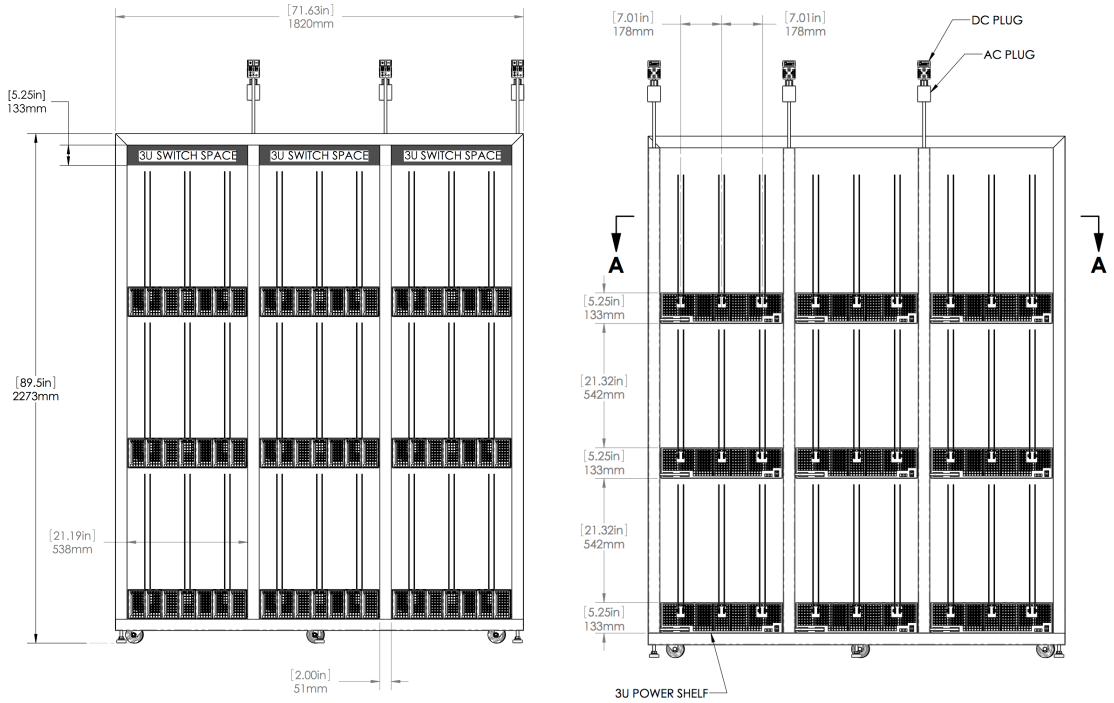

Figure 3 Open Rack Structural Drawing with Vertical PDUs

4.2 Mechanical

The Open Rack has these dimensions:

- The singlet rack is nominally 600mm ±1mm (23.6") wide, which includes a 538mm +1/-0mm (21" nominal) wide equipment bay
- The triplet rack is nominally 1820mm ±2mm (71.6") wide, which includes three 538mm +1/-0mm (21" nominal) wide equipment bays
- Depth can be no shorter than 914mm/36" and no longer than 1220mm/48" with a maximum depth for IT equipment of 914mm/36"
- Maximum total height is 2413mm (95")

The power shelf must comply with OCP standards. The power shelf has these characteristics:

- Up to 3 bus bar pairs, depth is the same as the actual rack depth (36—48")
- 538mm/21" wide
- 460mm/18" deep (maximum); depth can vary depending upon the power shelf design
- Can be up to 3U height (maximum); if 2U height is the total height of the power shelf and BBU, then the remaining 1U in each power zone may be removed to reduce the total height of the rack. Otherwise, the empty space must be blocked off so air doesn't flow through (see Power Shelf Specifications for details).

Refer to the CAD model for exact dimensions and details of the Open Rack.

The singlet has 4 casters capable of supporting the specified net weight of the chassis while rolling, while the triplet rack has a minimum of 6 casters. They are mounted in such a manner so they withstand tipping under normal deployment or relocation

activity. Four leveling feet are threaded into nuts welded into the bottom of the singlet, while the triplet has six leveling feet.

4.3 Rack Height Options

Open Rack IT chassis height is measured in OU. Unlike a rack unit (RU), an OU is 48mm high, which includes the space between each unit. Chassis unit height is measured in 0.5 OU increments for flexibility in form factor. A single chassis height can be between 0.5 OU and 12 OU, as long as all the chassis add up to 12 OU (maximum) per power zone.

For example, in a three power zone configuration, the top power zone can have six 2U chassis, the middle power zone can have one 4U chassis, three 2U chassis and two 1U chassis, and the bottom power zone can have four 1.5U chassis and two 3U chassis. Each bay can be partially stuffed as well.

Suggested heights include:

- The rack maximum height for power and server equipment is 48 OU, where each power zone is 12 OU high with a 3 OU power shelf.
- The rack can be made 45 OU high, where each power zone is 11 OU high with a 3 OU power shelf, or each power zone is 12 OU high with a 2 OU power shelf.
- The rack can be made 42 OU high, where each power zone is 10 OU high with a 3 OU power shelf, or each power zone is 11 OU high with a 2 OU power shelf.

Each rack also includes 3 OU for up to three top of rack switches.

4.4 Prescribed Materials

The equipment chassis is zinc-plated sheet metal. The chassis allows for the easy installation of hardware components without requiring any tools.

Primary materials used in construction of the rack include the following:

- Cold-rolled steel in sheet form
- Zinc pre-plated cold-rolled steel in sheet form
- Toolless sheet metal without any threaded holes
- Plastic cabling ducts

All joining in the rack is done by welding. The raw steel tubing is welded together to form the frame. After welding, black powder coat paint is applied to the weldments.

Next, zinc plated steel panels are screwed onto the rack using threaded fasteners. The panels are installed on both outer sides and in between each column.

One panel is installed at the top of each column; one rivet in each corner secures the panel to the top of the rack. A zinc-plated panel is installed at the bottom of the rack and is held in place by rivets or screws. The top and bottom panels are baffles that close off air holes for airflow impedance.

The cabling duct is mounted to the vertical columns as needed. It allows cables to enter and exit the rack.

The rack is shipped to an assembly facility where the electrical components are installed and network switches put into place. Server chassis (or other equipment such as storage chassis) are installed at this time.

4.5 Thermal Specifications

The following table indicates the thermal specifications for the rack.

Thermal Specification	Value
Loading	Idle to 100%
Inlet temperature	65°F to 85°F (18°C to 29°C)
Humidity*	Approximately 30 - 90%
Altitude	1000m (~ 3300ft)
Dew point*	41.9°F minimum (5.5°C)

Figure 4 Thermal Specifications at Rack Level

* Based on regional climate conditions where the data center operates; supply air temperature 64.4°F to 80.6°F (18°C to 27°C), relative humidity 65% maximum, dew point 41.9°F to 59°F). For more information, including a psychrometric chart, see the *Open Compute Project Data Center v1.0* specification.

5 Power Shelf Specifications

The Open Rack can be powered either by three-phase (3 or 4 wires) or single-phase AC voltage, or high voltage DC (HVDC), depending upon the power solution adopted. Typical three-phase voltage is 320Vac—530Vac. Typical single-phase voltage is 180Vac—305Vac. Output voltage is 12Vdc nominal (but can be slightly higher to compensate for distribution voltage losses) and connected to the bus bars.

The power solution must support redundancy, no matter which input voltage configuration is used and regardless of how much space it occupies in the power zone.

Dimensions:

- Height is in 0.5RU increments (**Note:** RU, not OU)
- Maximum width 536mm (21"), same as IT chassis
- Maximum depth is defined by room constraints and on rack depth chosen

The IT chassis are hot swappable from the front of the rack directly to the bus bar using bus bar connector clips. Each chassis is powered by the nominal 12V available at the bus bars installed at the rear of each power zone (although the suggested voltage is 12.5V). Each chassis includes two clips installed to the rear with positive and negative cables. A ferrite toroid clamps the cables for high frequency CM noise reduction.

The 12V output of each power zone is independent and floating with respect to the other power zones. This helps reduce potential DC currents from looping through the rack, and against onset noise. Each bus bar pair can support up to 500A, which can be increased by adding more copper.

Each bus bar pair can support up to 6KW, while power can be increased by using more copper. The bus bars can be adjusted for higher current, depending on the desired power per column, as they are interchangeable. Normally the Open Rack has three bus bar pairs installed, but it is also configurable with two or one bus bar pairs in the power zone:

- Three pairs (+/-) of bus bars, on the left, right and middle of the column
- Two pairs (+/-) of bus bars, on the left and right sides of the column
- One pair (+/-) of bus bars, down the center of the column

5.1 Power Shelf and Battery Backup Options

Backup power can be provided by one of two power shelf configurations:

- **V1 power shelf:** This (6 + 1) redundant shelf is 3RU high and requires the Open Compute Project battery cabinet to engage backup functions. The power modules deployed in this shelf are a variation of the Open Compute Project power supply with increased power, repackaged as a hot swappable module with handle, and adding more features like a power module failure signal and OR-ing devices. The opto-isolated failure signals are daisy-chained between all three power shelves in each column to allow for reporting of a power module failure, identifying the shelf where the failure occurred. The failure is reported to the management switch through a custom digital box sitting on top of the rack, with one Ethernet RJ45 output and several inputs.

  The PDUs distribute both AC and DC.

  One Open Compute Project battery cabinet sits in between a pair of triplets in the data center aisle, providing 48V DC backup voltage used in the event of an AC power outage. The cabinet is normally offline and exceeds 99.75% of equivalent UPS efficiency. For more information, see the *Open Compute Project Battery Cabinet Hardware v1.0* specification.

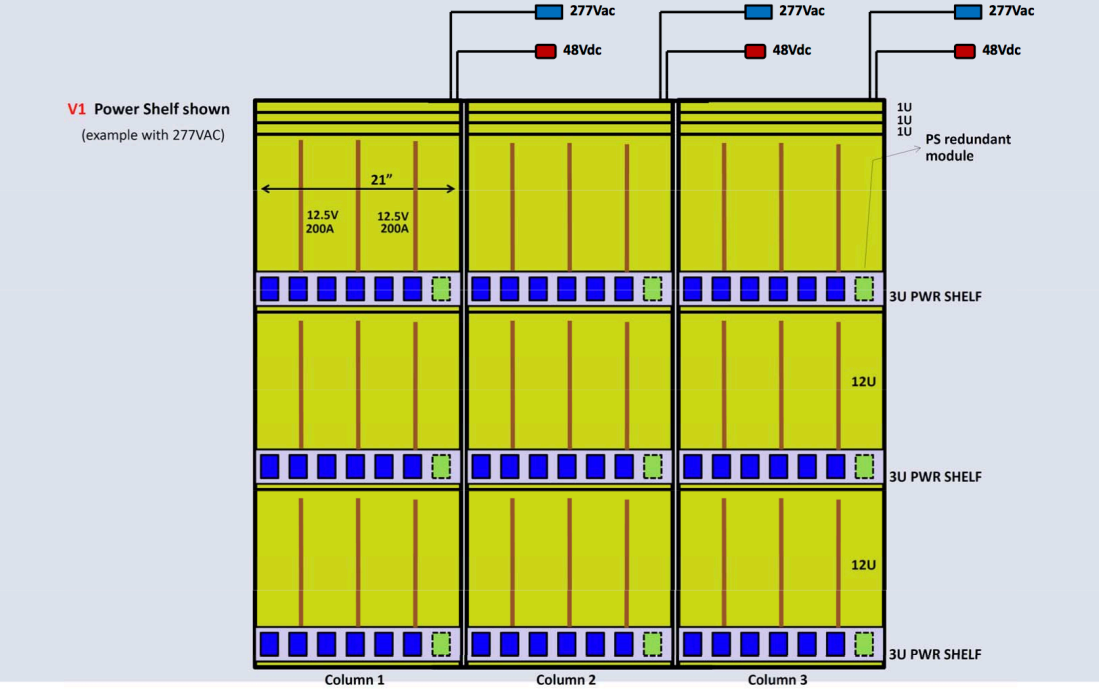

Figure 5 Open Rack Triplet with 9 V1 Power Shelves (3 OU) (OCP Battery Cabinet Not Shown)

- **V2 power shelf:** This (N + 1) redundant shelf is 2U (or 1U) high with a 1U battery backup unit (BBU) module normally installed underneath. The Open Compute Project battery cabinet is not needed as the BBU normally includes its own high-density lithium-ion battery pack. Each BBU module may also be placed above the 2U/1U power shelf to directly power the bus bar behind it (depending on topology). The PDUs distribute only AC because BBUs are included in the power zones.

  To account for power module failure signals and more functionality, a digital bus with a more complete reporting on the power shelf functionality and health may be defined as needed for the V2 power solution.

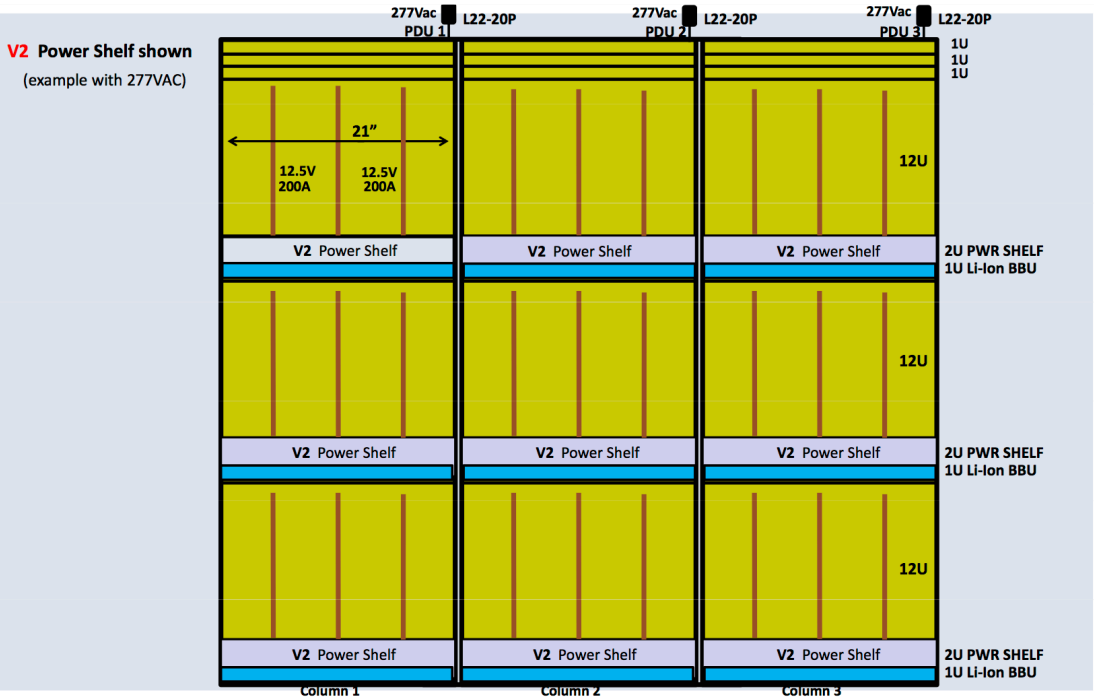

Figure 6 Open Rack Triplet with 2 OU Power Shelf and 1 OU BBU (Optional 12.5V Bus Bar Shown)

5.2 DC Input Voltage Options

The Open Rack may be powered by High Voltage DC input (HVDC) instead.

An AC power shelf solution, after some customizations (such as input connector, circuitry adjustment, safety and regulatory compliance, and so forth), may support HVDC input directly. Otherwise a custom power shelf can be designed for DC input only. Typical voltage levels are in the range of 360Vdc ~ 400Vdc. This option gives the ability to power the rack in a data center environment with HVDC distribution or when the DC power is generated on site (for example, by fuel cell or other renewable energy source). An HVDC source is normally already backed up by batteries. Otherwise a BBU unit may still be included in the power zone.

6 PDU

An AC PDU may be required when there is more than one power zone in each column. Alternately, the power shelf may be reached directly with a power cord (either a single-phase or a three-phase plug).

A DC PDU is required when the Open Compute battery backup cabinet is used as a backup power unit.

6.1 Suggested PDU Dimensions and Configurations

The PDU for a triplet rack is 2" wide, to match the square tubing of the rack, and up to 4" deep (AC and DC distribution in the same PDU) or 2" deep (AC distribution only).

PDU height correlates to the rack height.

The AC voltage distribution is as follows:

- Power zone 1 is powered by 277V Line 1 to Neutral
- Power zone 2 is powered by 277V Line 2 to Neutral
- Power zone 3 is powered by 277V Line 3 to Neutral

The 277V value always refers to the usage in the US, with three-phase power at 480Vac.

For a power shelf solution using true three-phase power with or without Neutral, the AC PDU would distribute the same identical three-phase voltage to every power zone (4 or 5 wires, including GND conductor). Therefore a three-phase solution at the power shelf level is another option. This approach makes more sense when a high power density solution is needed, and in this way a three-phase balance is easily achieved without regard to the configuration of the load in the power zones. It also avoids usage of the Neutral conductor. However, a three-phase solution at the power shelf level that includes the Neutral conductor may still be considered, and while the three-phase balance may be less accurate, it has other advantages.

In general, all the PDUs are installed at the rear of the rack and are flush with the rear of the rack.

AC and/or DC outputs from the PDUs are normally dongle cables terminated with connectors (that must use strain relief or molding), and with the corresponding counterparts installed in the rear panel of the power shelf.

7 Example Implementation

This section describes one possible implantation of the Open Rack. It is a triplet rack using three V1 power shelves in each column (three power zones). AC and DC PDUs are also used because the power shelf is single-phase and the battery cabinet is used as a backup unit.

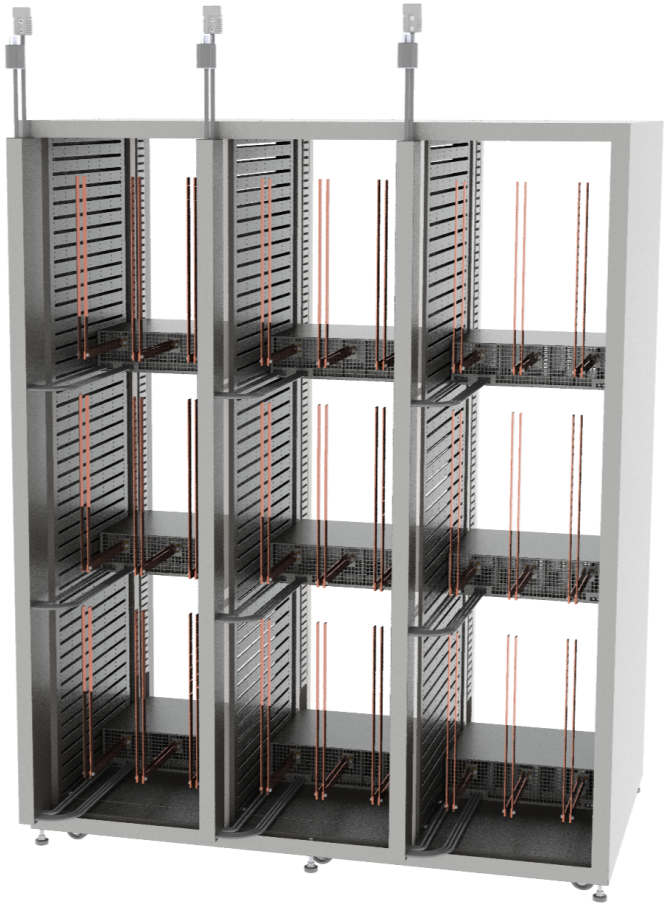

Figure 7 Triplet Rack with PDUs

The power shelves are powered with single-phase (nominal three-phase voltage range 340Vac—480Vac RMS) using a single-phase Line-to-Neutral distribution with a PDU. In the US, the Open Rack uses 480Vac three-phase with a single-phase 277Vac distribution to each power zone. The power shelf is a single-phase power converter rated 200–277Vac nominal, and supports a voltage range from 180Vac to 290Vac for worldwide compatibility.

Each power shelf supports up to 4.2KW at 12.5Vdc output, for a maximum of 13.3KVA of AC power (277Vac x 16A x 3 phases) in a single column when using a US standard NEMA L22-20P plug. The AC plugs are normally derated 20%; the L22-20P becomes a 16A plug. These ratings factor in an efficiency of ~ 0.94 for an OCP power supply module (for example, 4.2KW = 277Vac x 16A x 0.94 efficiency) and nearly unity power factor (PF) at full load. Higher power per column may be achieved by hard wiring the AC power cord to the grid or by using a higher power plugs (like NEMA L22-30P or industrial plugs).

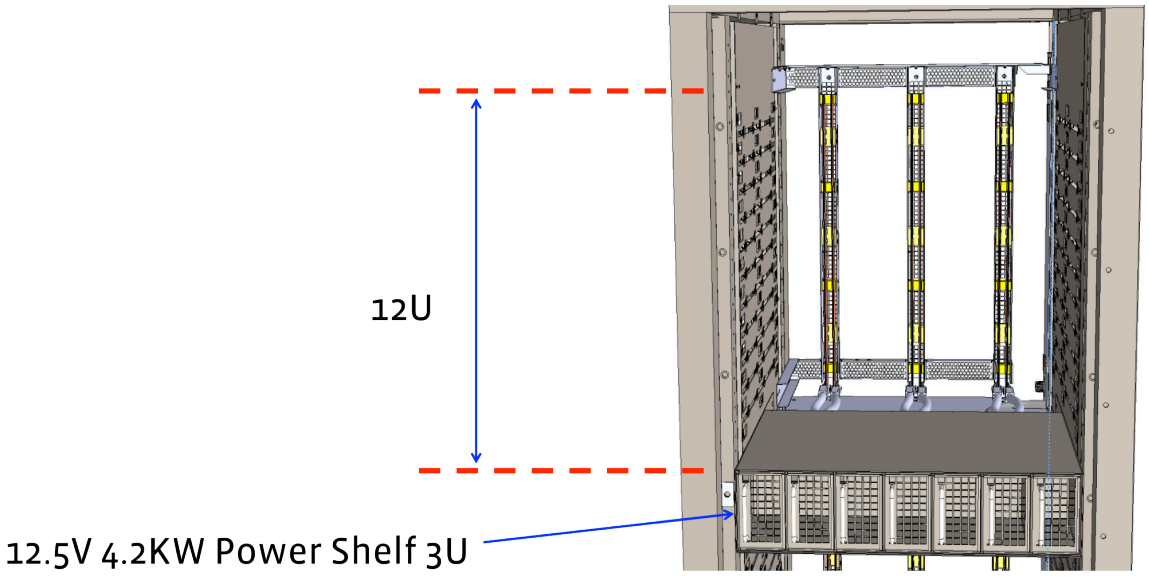

Figure 8 Power Zone (3U Power Shelf, 12.5V, 4.2KW Power, L22-20P Plug Shown)

The example rack uses three-phase voltage distributed into single phases for flexibility and cost effectiveness. Each column in a triplet gets one phase for each power zone. To achieve three-phase load balance, each of the three power zone loads are configured identically to the other two.

The rack supports backup power functionality, with no interruption of service in case of an AC outage. Since the OCP battery cabinet is used, the 48Vdc backup voltage is connected to the V1 power shelf by means of high-current blade connectors APP SB175 (one connector supports three power zones) within the same PDU.

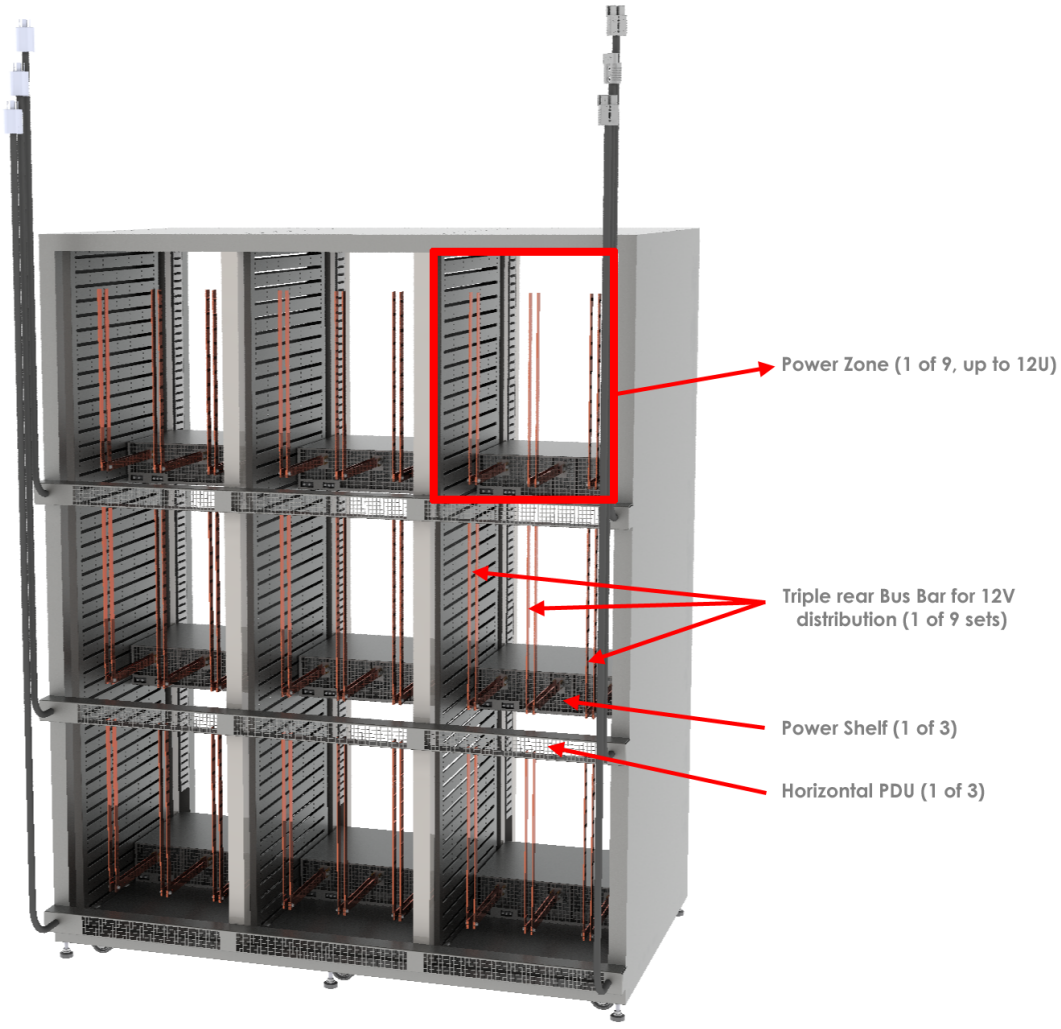

Figure 9 Open Rack Triplet Rear View

A triplet has 9 power zones (three in each column), and three PDUs (distributing AC and DC in the same enclosure).

8 Conclusion

This specification is a work in progress. To offer feedback or contribute, join the mailing list at http://lists.opencompute.com/mailman/listinfo/opencompute-openrack.