

OPEN
Compute Project

Open Rack Standard V1.2

Author:

Steve Mills, Mechanical Engineer, Facebook

Pierluigi Sarti, Technical Lead, Facebook

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1 Introduction

1.1 Purpose

By adhering to the following principles, the Open Rack fulfills the Open Compute Project goal of maximizing operational efficiency of large-scale deployments:

- Installation and service operations are located in the cold aisle
- Data cables are located on the front of the rack
- Component faults are identifiable from the front of the rack
- Routine service procedures do not require tools
- Non-recyclable components are minimized
- Designs are vanity-free
- Racks are integrated directly into data center air containment solutions

This standard defines the required interfaces between the Open Rack and the equipment it supports. **NOTE:** The standard does not include all of the information necessary to completely define an entire rack.

1.2 License

As of FEB 25 2015, the following persons or entities have made this Specification available under the OCPHL-R, which is available [here](#).

Steve Mills Facebook, Inc.

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1.3 Reference Documents

A 3D CAD file of the standard cross-section is provided as a reference to help with the design of the rack on the [Open Compute Project](#) website.

There is also a [Chassis design guide](#) on the website as well.

1.4 Compliance

In order for any product to state compliance with this standard, the product must meet all of the requirements stated with the term SHALL and verified by an OCP certified lab. Any statements using the term SHOULD are recommendations for the design, but are NOT required features to show compliance.

1.5 Definitions

1.5.1 IT Gear

IT Gear is defined as IT equipment installed in an Open Rack standard Equipment Bay that plugs directly into the live 12V bus bars. 'IT Gear' may also be a shelf that plugs directly in to the bus bars, and hosts multiple 'IT Trays' within the shelf. The shelf receives 12V from the Equipment Bay bus bars with one connector clip pair, and distributes the 12V to the 'IT Trays' installed within the Shelf.

1.5.2 IT Tray

IT Tray is defined as sub-component of the 'IT Gear' that may consist of one or more motherboards on individually removable metal trays or sleds. The mechanical and fit functions of the Open Rack standard apply only to the 'IT Gear' that plugs directly to an Open Rack bus bar system. The electrical requirements, however, apply to both 'IT Gear' and 'IT Trays'

2 Overview of Open Rack

Open Rack is divided into three zones as shown in Figure 1:

- A Cable zone facing the cold-aisle side of the data center
- An Equipment Bay in the middle for all of the equipment
- A Power and Cooling zone on the hot-aisle side of the data center

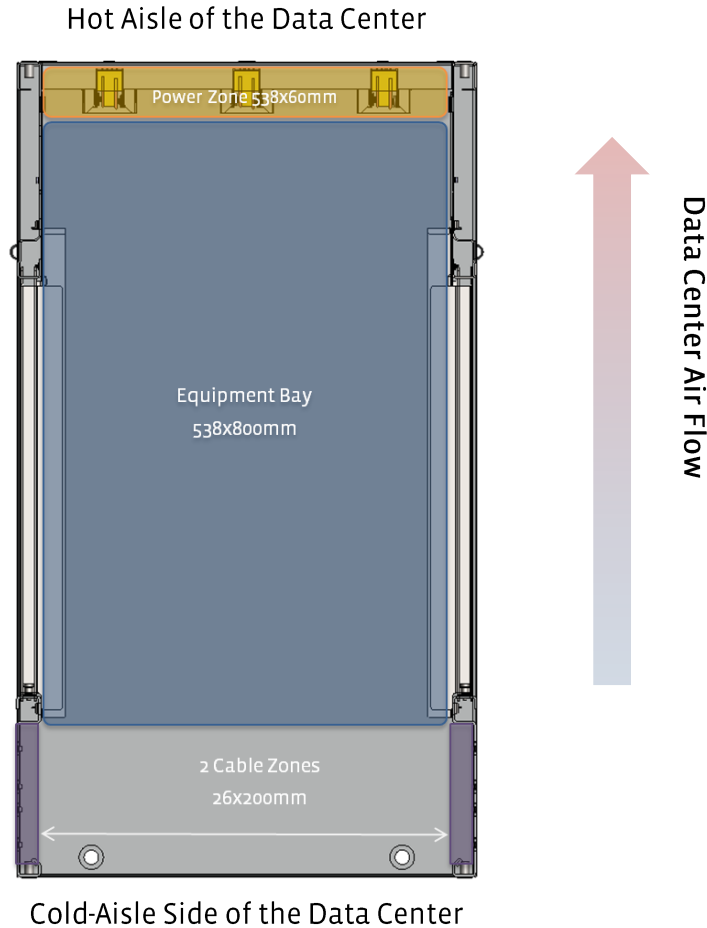


Figure 1: Top View of the Open Rack

The Cable zone, located at the front of the rack, manages and protects the data cables connected to the IT equipment. Technicians can add and remove equipment from the rack without standing in the hot-aisle to perform routine service.

The Equipment Bay is approximately 538mm wide by 800 mm deep. This is the area in which equipment sits (e.g., servers, storage, switches and rack level power shelves). During installation, the equipment slides past the cable zone and rests on a series of horizontal support shelves within the rack. Once on the support shelves, a DC connector in the equipment blind-mates into the 12V bus bars in the Power/Cooling zone.

The Power/Cooling zone in the rack consists of one or more pairs of 12V bus bars that transmit power from a rack level power shelf to the equipment. The vertical bus bars connect the equipment with the rack-level power sub-system located either above or below the Equipment Bay. The system is designed so that equipment in the Equipment Bay can attach to the bus bar continuously along its entire length to accommodate chassis of different sizes over multiple generations. Optionally, this zone could also include rack-level cooling fans, a rack level management system, data fabrics, and PDUs.



Integrated together, these components combine to create a self-contained eco-system optimized for hyper-scale computing.



Figure 2: Open Rack Assembly Example

3 Mechanical Requirements

3.1 Rack Columns

The vertical columns in the rack help retain equipment and also limit its horizontal movement. This enables the chassis to align the bus bar clip to the bus bars.

As the equipment is installed into the rack, it will stop against a series of lances in on the hot-aisle side of the rack frame. The lances keep the equipment from falling out the back of the rack when moving the rack or servicing equipment. The lances also provide several millimeters of air gap between the back of the equipment and the bus bars. This air gap prevents shock loads from damaging the bus bars.

Once the equipment is installed, the rack frame equipment has a series of rectangles along the front vertical frame that can be used to prevent the equipment from moving forward. Equipment designers can use these rectangles when designing retention schemes that help technicians quickly remove equipment. For example, equipment that does not weigh much could use simple metal spring latches to grab into the rectangle. Heavier equipment might use a thick cam lever with a positive latch for retention.

The rectangles and lances used to retain the equipment repeat every 48 mm. This 48mm pitch is defined as an OpenU.

In order to comply with this standard, the vertical columns of the rack SHALL contain the features defined below and displayed in Figure 3 and Figure 4 and Figure 5:

- A series of 14x18mm rectangles on the front column for the equipment in the Equipment Bay. The rectangles must appear at least 15mm deep into the frame.
- A series of lances in the rear column to act as hard stops for the equipment in the Equipment Bay.
- Rectangles and lances SHALL repeat every 48mm along the length of the vertical columns. They MAY repeat every 24mm (support for 1/2OpenU) if desired.

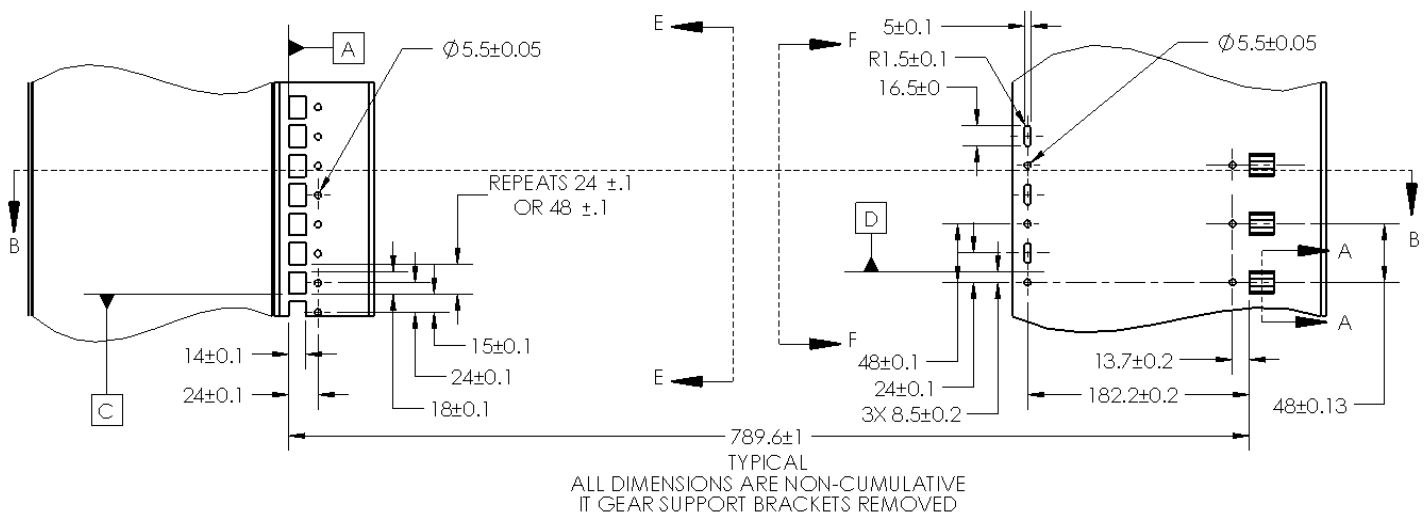


Figure 3: Open Rack Front Detail

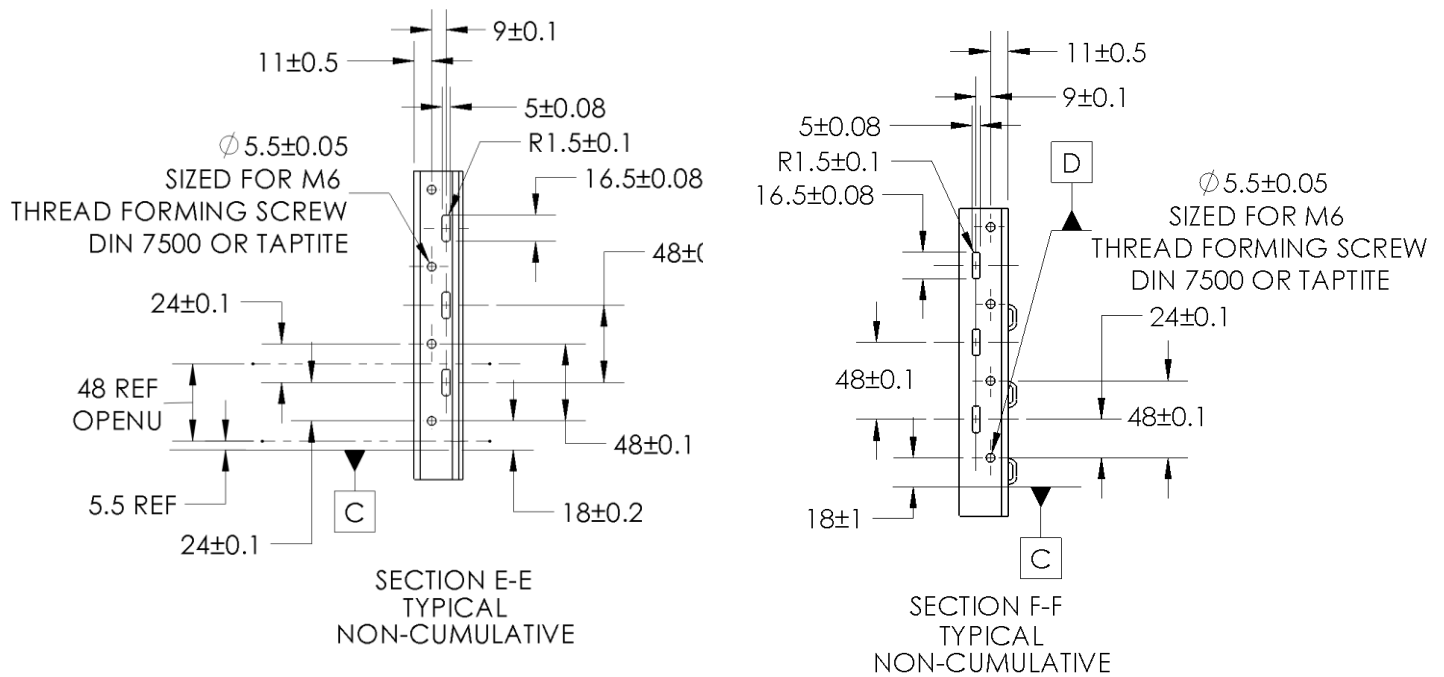


Figure 4. Front and rear Vertical Post Detail

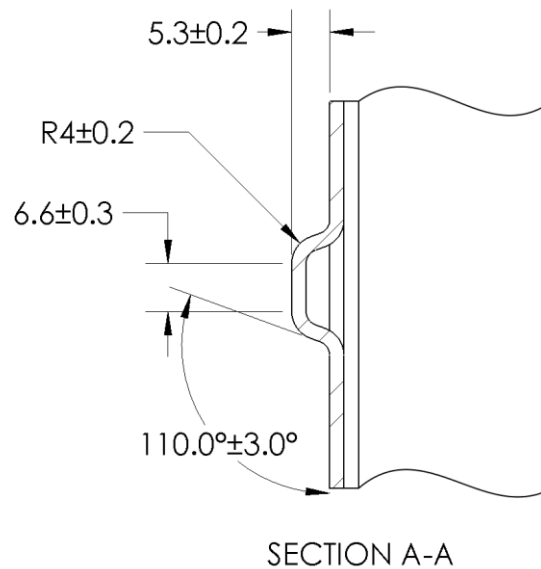


Figure 5: Open Rack Rear Stop Detail

The rack SHALL also provide the following features (see Figure 6):

- Vertical columns 538-540mm apart
- Support for three-bus bar pairs (though only center position SHALL be populated)
- Reserved volume for PDUs within the vertical columns
- Provide ability to pass a IEC 60309 connector from the PDU volume to the roof of the rack (110mm diameter)

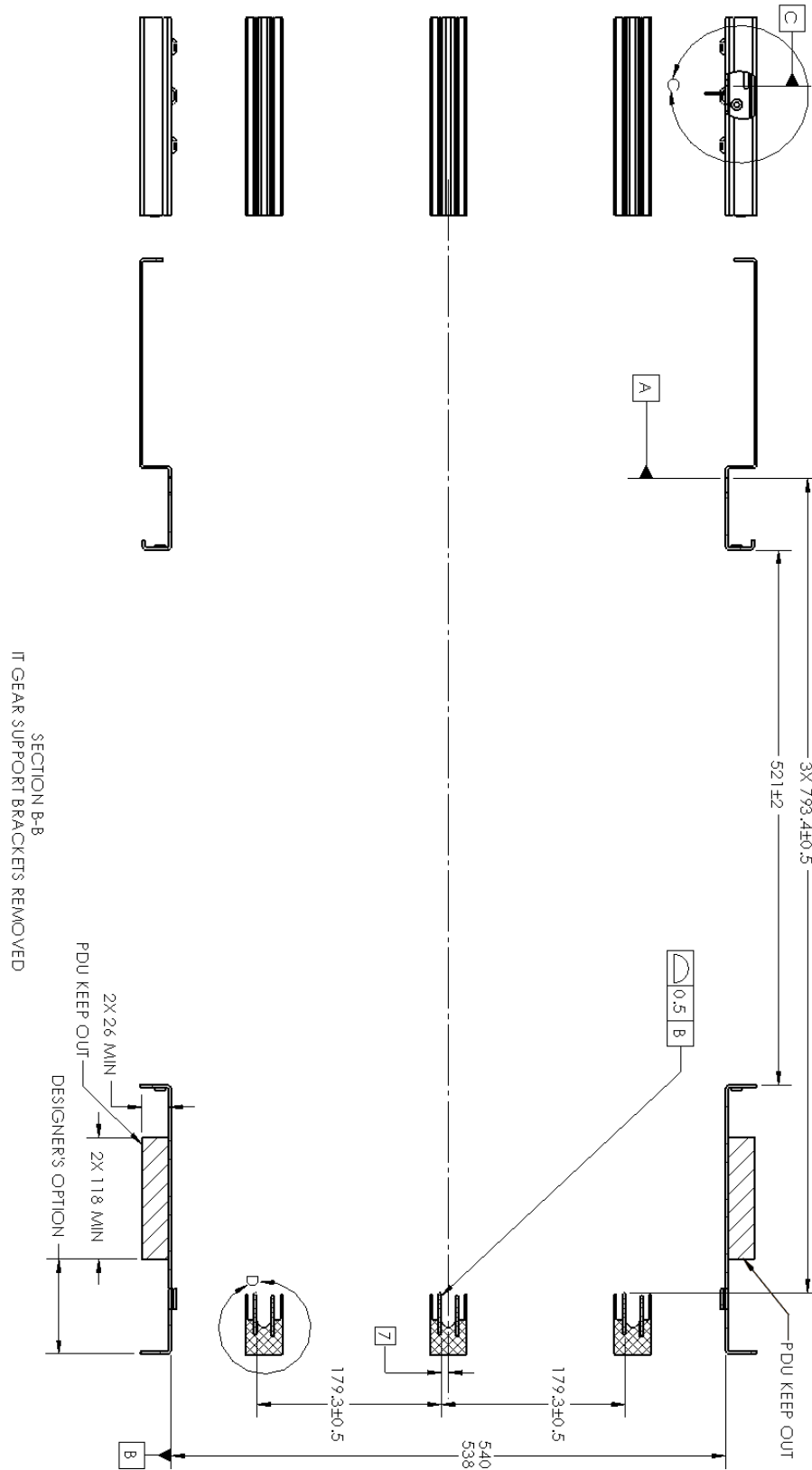


Figure 6: Open Rack Cross-Section

3.2 IT Support Shelves

The IT equipment sits on a series of horizontal support shelves. These shelves could be constructed as individual brackets that are assembled into the rack, or incorporated into the rack structure itself by creating them out of the sides of the rack. The quantity (which may be zero) and vertical locations of the shelves are left to the customer to specify.

The IT Support Shelves SHALL:

- Support equipment as small as 1 OpenU tall (48mm)
- Conform to the shape shown in Detail C (Figure 7). If the IT Support Bracket is continuous along the entire width of the rack instead of two Support Brackets, then the 20mm bracket length in Detail C may be ignored.
- Provide a continuous ground path from the equipment to the Open Rack frame
- Have a finish that does not encourage the growth of metal whiskers
- Be recessed between the vertical posts so that the 538mm equipment bay width is not reduced
- Support an evenly distributed load of at least 700kN load per pair without taking a permanent set.

The pair of IT Support brackets SHOULD:

- Have a pre-plated hot-dip zinc coating conforming to ASTM A653 or JIS 3302 SGOC or be post-plated

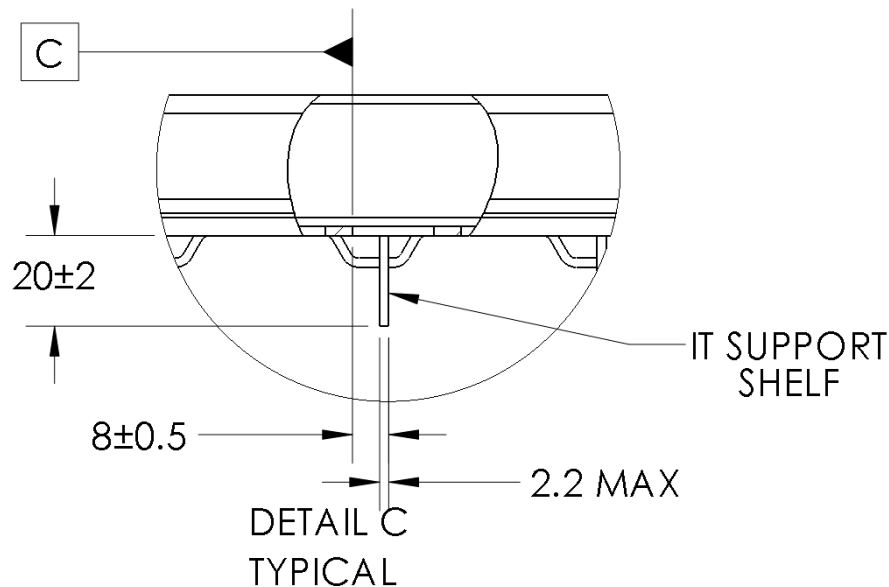


Figure 7: IT Support Bracket Detail

3.3 Bus bar

The bus bars are located in the back of the rack and transmit the 12V power from the rack-level power sub-system to the equipment in the rack. The bars allow the equipment to plug directly into the power so the technician does not need to go to the back of the rack to disconnect power cords prior to servicing equipment.

The bus bar cover protects people from the positive 12V bus bar when the rack is powered-up. Access to the front of the bus bar should be limited by the design of the equipment and/or a blank to fill any empty equipment location in the rack.

The Bus bars SHALL:

- Be populated with either one or three bus bars per power zone
- Be located in the center position in the rack if only a single bus bar pair is populated
- Be located in the rack per Figure 6 and comply with Detail D in Figure 8
- Be plated with nickel at minimum of 10 microns thick. The nickel plating may be over-plated with silver or gold.

The Bus bars SHOULD be designed so that they can be removed and re-installed by a trained service technician in the field.

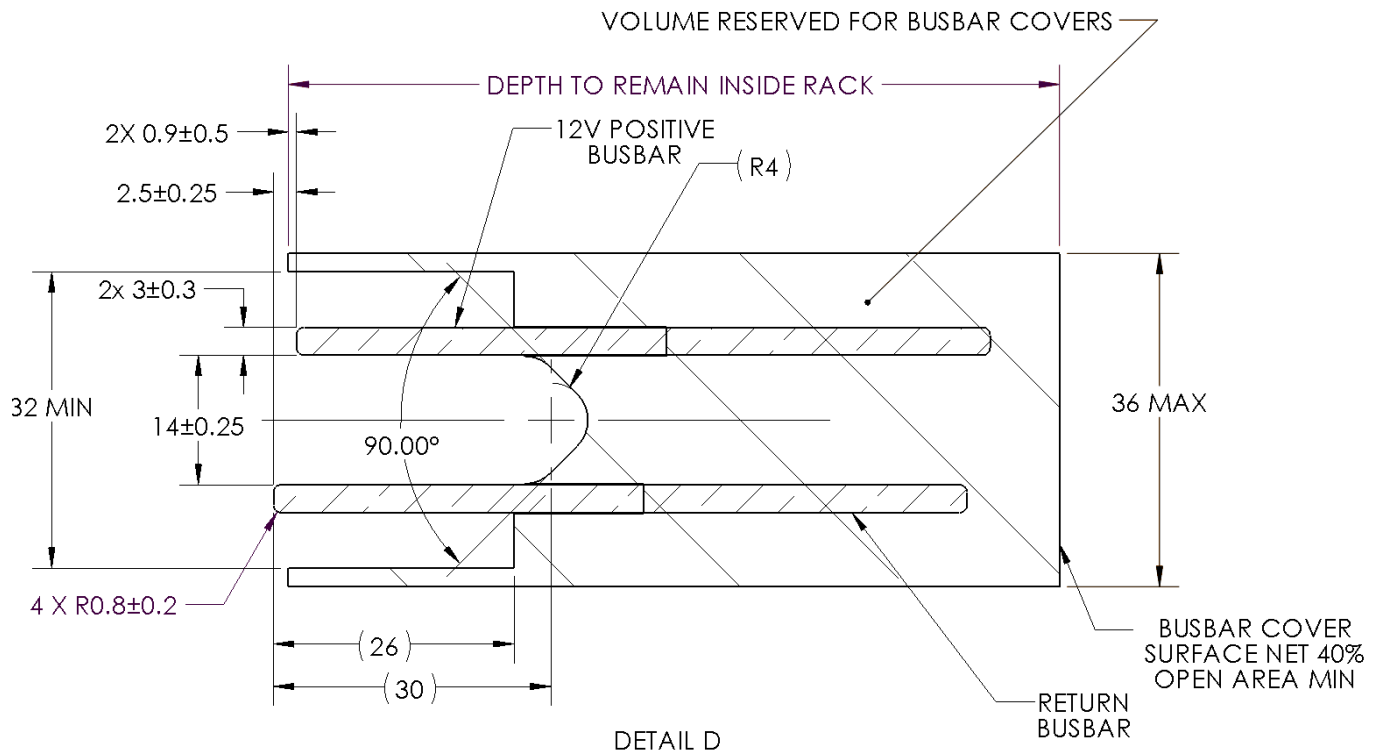


Figure 8: Bus bar Detail

A volume around each bus bar is reserved for an optional bus bar cover to protect people. While protecting people is not optional, the methodology is. For example, a single hinged panel could cover the entire back of the rack rather than using individual covers around each bus bar set.

The bus bars SHALL:

- Have user access limited by a method that conforms to UL60950
- Be made of copper with an IACS near 100%

If individual bus bar covers are used, the bus bar covers SHALL:

- Stay within the zone defined in Figure
- Have a perforated surface behind the bus bars that has a minimum of 40% opening after any support, insulators, or labels are included (Figure 8)
- Have perforations and limited access to service panels that conform to UL 60950

The quantity of bolted bus bar connections between the power subsystem and Open Rack is variable based on the power and efficiency expected of the rack. The number of possible connections increases in a 25mm grid pattern as defined in Figure 9.

Any bolted connections to the rack SHALL:

- Be located in the rack as shown in Figure 9.
- Consist of a minimum of two connections as shown by the black rectangle in Figure 9.

Additional locations can be added in the following order as shown in Figure 9:

- 4 holes in a square pattern shown in **red**
- 6 holes in a rectangular array as shown in **blue**
- 9 holes in a square pattern as shown in **green**.

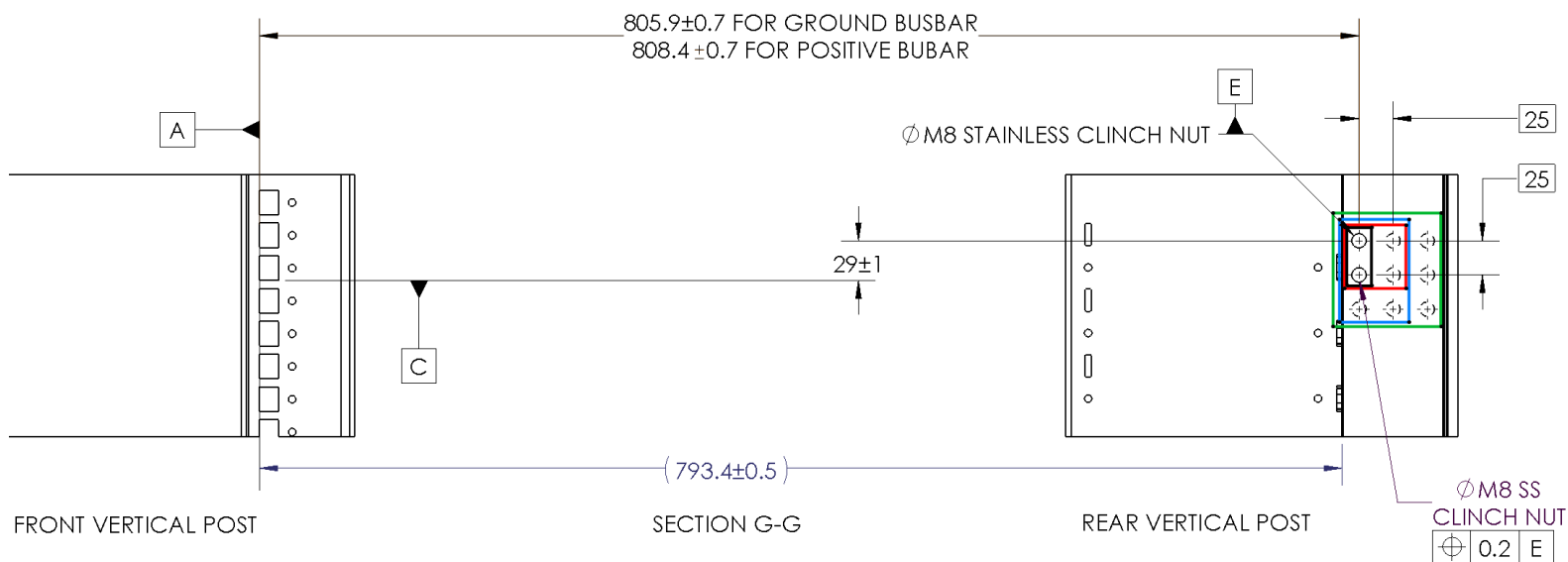


Figure 9: Power System to rack busbar interconnect location

3.4 OpenU Marking

Each OpenU on the rack:

- SHOULD be numbered so people can easily identify the exact location of the equipment.
- SHALL be sequentially numbered in a permanent and legible manner starting with the number one (1) in the bottom of the rack.
- SHOULD be numbered in a location where cable bundles and equipment will not hinder its visibility.

3.5 Marking for Re-Use

The lifecycle of the rack is normally significantly longer than the equipment inside it. Ideally the rack would be used for multiple generations of equipment. The maximum load rating of the rack frame and the IT Shelves, however, is not controlled by this standard. Thus, when it is time to re-purpose the rack for future equipment, it is necessary to know the limits of the rack.

The load rating SHOULD be located so it is visible from the cold-aisle of the rack.

The rack SHALL be marked:

- In a permanent and legible manner with the maximum load-mass (in kilograms) that the IT Support shelves and the rack frame are capable of supporting (whichever is less) under Telcordia GR63 Zone2.
- With the latest revision number of the standard for which the rack is compliant in either of the following formats:
 - OPEN RACK STANDARD REVXX.X
 - ORS REVXX.X

Where “XXX” is the alphanumeric version of the specification such as: V1.0 or V2.2

- In a location that is visible without removing equipment
- In a location that will not be damaged by equipment sliding in and out of the rack during routine service

For purposes of qualification testing, the total mass used for determining the frame load rating SHALL be evenly distributed within the entirety of the equipment bay.

4 Electrical Requirements

The following requirements pertain to a populated Open Rack system when the Rack contains IT Gear and Power Shelves.

4.1 Bus Bar Electrical Specifications

The busbar(s) in an Open Rack Compliant system:

- SHALL have a voltage of $12.2V \pm 0.4V$ average DC (Hz bandwidth) at any point along the entire length of the bars with any configuration of the loads and any physical distribution of the IT Gear along its length.
- SHOULD have an output voltage is $12.5V \pm 0.1V$ at the connections to the bus bar pair(s).
- SHOULD be sized for a current density at full load not higher than 5 Amps / mm². The recommended bus bar current density at full load is 3.5 Amps / mm² (or lower) which will limit the conduction losses and also guarantee optimum dynamic performances of the bus bar pair during heavy dynamic loads.

The bus bars of an Open Rack system SHALL NOT:

- Be electrically connected to the rack system metal frame (chassis ground)
- Have the positive bus bar connected to the chassis ground
- Have the negative bus bar connected to the chassis ground

4.2 Bus Bar Power Connection

The 12V DC power clip that connects the IT Gear to the Open Rack busbar SHALL:

- Provide a minimum of 3mm horizontal float in both directions to ensure that the connector mates to the busbars in the rack
- Provide a minimum of 1mm vertical float between the IT gear and the busbar to reduce the movement of the clip relative to the busbar during transportation. If there is no vertical float designed into the clip, then IT Gear that is shipped in the rack while connected to the busbar will cause the clip to wear on the busbar during transportation. More vertical float in the connector allows for greater displacement of the IT gear during transport without causing wear on the busbar.
- Ensure that the negative bus bar makes electrical contact prior to the positive bus bar. Since the negative busbar in Open Rack is already 2.5mm offset from the positive busbar in the depth axis, the clip SHOULD have both the negative and positive contact located on the same plane. They SHALL NOT be offset by 2.5mm so that both contacts mate at the same time.
- Be plated with either Nickel or Silver on top of a primary Tin plating layer, to protect the surface of the bus bar during repeated cycling and to avoid corrosion.

4.3 IT Gear

This section applies to all IT gear that plugs directly to the busbar on the Open Rack.

4.3.1 Hot Swap

All IT Gear that connects to the busbar SHALL:

- Include an input 12V hot swap controller and circuitry for soft start operations, inrush control, and protection.

- Limit the inrush current during hot swap to less than the 100% of the total load of the IT Gear.
- Maintain the maximum positive and negative voltage deviations (spikes) induced on the bus bars when a single IT Gear is hot swapped either in or out of the Open Rack to be within the allowed bus bar voltage range of $12.2V \pm 0.4V$ at all points along the busbar.

4.3.2 Noise Limits

All IT Gear that connects to the busbar SHALL:

- SHALL have enough overall input capacitance and filtering to virtually induce no differential-mode Ripple & Noise into the bus bar pair so that the common source of 12V power is not polluted.
- SHOULD have a 1-turn Common Mode high-permeability ferrite core (pass-thru choke) installed near to the 12V connector on the rear panel of the IT Gear for high frequency common mode reduction.
- Provide a method of preventing an electrical short within the sled from causing the voltage to drop along the busbar to drop below the specification limit.

4.3.3 Max Power Draw

All IT Gear that connects to the busbar SHALL have a maximum draw of 1500W DC per full width of OpenU. So, a unit of IT Gear that is two OpenU tall and a full 538 mm across should support a maximum of 3000W DC of power irrespective of how many sleds or trays are included within the 2OpenU unit.

4.4 Power Shelf

All components that provide the 12VDC power into the busbar:

- SHALL have an output voltage with ripple & noise less than 120mV 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 $0.1\mu F$ capacitor connected locally to the oscilloscope probe tips during this measurement.
- SHALL have a 1-turn Common Mode high-permeability ferrite core (pass-thru choke) through its 12V output(s) pairs, near to the rear panel of the shelf, for high frequency common mode reduction.
- SHALL NOT have the 12V Positive termination connected to the power solution chassis ground.
- SHALL NOT have the 12V Negative termination connected to the power solution chassis ground.
- SHOULD have the 12V negative termination of the power solution grounded to the Open Rack system chassis at the node or tray level.
- SHALL limit the amplitude of the positive and negative voltage spikes during transient-loads test between 50% to 100% of the load (10 Amps / μS) to within $\pm 3\%$ of the nominal output voltage ($\pm 360mV$), with a response time $< 1mS$

5 Revision History

	Release	Change Description
Steve Mills	0.1	Initial release
Steve Mills	0.9	Release for OCP review
Jay Hauser	0.9.1	Revised by
Steve Mills	0.92	Finalize EE portion and Add updates from OCP Summit
Steve Mills	1.0	Update per Aug OCP Summit; add Figure 4; 4.2 add predefined load (TBD)
<u>Steve Mills</u>	<u>1.1</u>	1.0 Minor updates; 1.3 added "...and verified by an OCP certified lab."; 3.1 added reserved volume for PDU 3.2 <u>ref change to Detail C</u> ; 3.5 changed "load" to "mass"; clarified <u>mass distribution for GR63 qual</u> ; Changed "SPECIFICATION" to "STANDARD" for labelling requirement; Rename Figure 4 to Figure 7; rename Figure 5 to Figure 8 and add dimension to busbar; Replaced EE section; added holes to Figure 3 and Figure 4.
Steve Mills Pier Sarti	1.2	Update link for chassis design guide; Add theoretical OpenU location to Figure 4; ADD 2x to 0.9mm dim in Figure8; Add bus bar location per Figure 9; Major revision to section 4; change "user" to "people"; clarified that single busbar must be in the middle in section 3.1