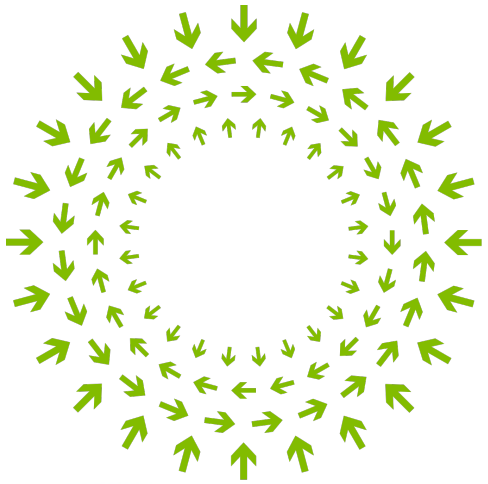

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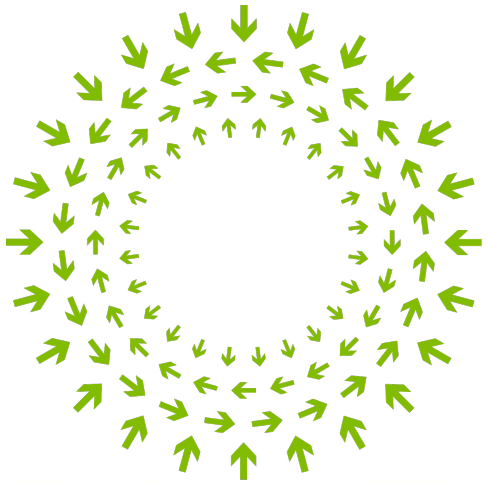
OCP Engineering Workshop – September 2017 – Dallas TX

Rack and Power Project

Steve Mills
Project Co-Lead - Facebook

Agenda for Rack and Power Project

5 min	Welcome	Steve Mills - OCP Rack and Power Project Co-lead - Facebook
45 min	Open Rack Standard V2 specification proposal: 'Independent Busbar'	Derek Winsor- Senior Design Engineer- Rittal Michael Wingard- FAE Manager- Amphenol Interconnect Products Justin Knott - Field Applications Engineer – Amphenol Interconnect Products
10 min	BarKlip 48V IT Gear Connector	Skip Fry - Engineering Manager - Amphenol Power Solutions
20 min	Review Proposed Changes to Open Rack Specification 2.0: - Reduce tolerance on rack busbar thickness to +/-0.15mm - Change busbar depth for 48V deep rack - Adjust power interconnect location between rack and power shelf to enable 1 OpenU power shelf	Steve Mills - OCP Rack and Power Project Co-lead - Facebook Antony Ren - Mechanical Engineer - Delta Electronics, INC.
10 min	Break	
45 min	Review Specification Proposal: True 3-phase 380 – 480 Vac to 48Vdc Power Shelf	Paul Smith - Sr. Applications Engineer - GE Industrial Solutions
45 min	Overview of Flatpack-: Adapting 12V IT gear to 48V Open Rack	Nate Klein - Hardware Engineer - Google Scott McCauley- Hardware Engineer - Google
30 min	Community Driven Discussion of the Power Shelf Specification Roadmap	Steve Mills - OCP Rack and Power Project Co-lead - Facebook



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Engineered Power Solutions

Open Compute +48V Busbar Discussion

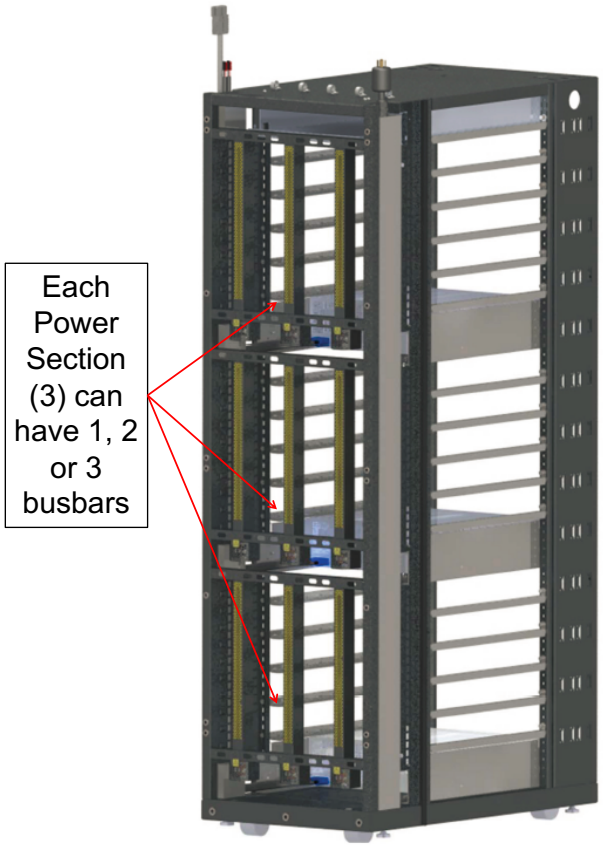
❑ Opportunities with Open Rack

• There are a few areas within the Open Rack 2.0 standard that remain undefined. In terms of the mechanical requirement of the busbar assembly, there is a gap where rack mount details are missing. This means that ever rack mounts to every busbar differently.

•It is difficult to design a busbar that will work in many applications for OCP. This is compounded when working towards an “OCP Accepted” certification. The reason is that to be “Accepted” the certification is granted per part number and not general application

•This is very difficult to achieve at a busbar level due to many variables that tend to be customer specific:

- •Power Requirements
- •Height (OU, OUI, etc.)
- •Location of Power Supplies
- •Mechanism/Locations for attaching the Power Supplies
- •Mounting Criteria for Busbar



OCP Specification

- To expand upon Rittal's Options: Amphernol is developing higher power busbars
  - 50 kW
  - 60 kW
  - 100 kW

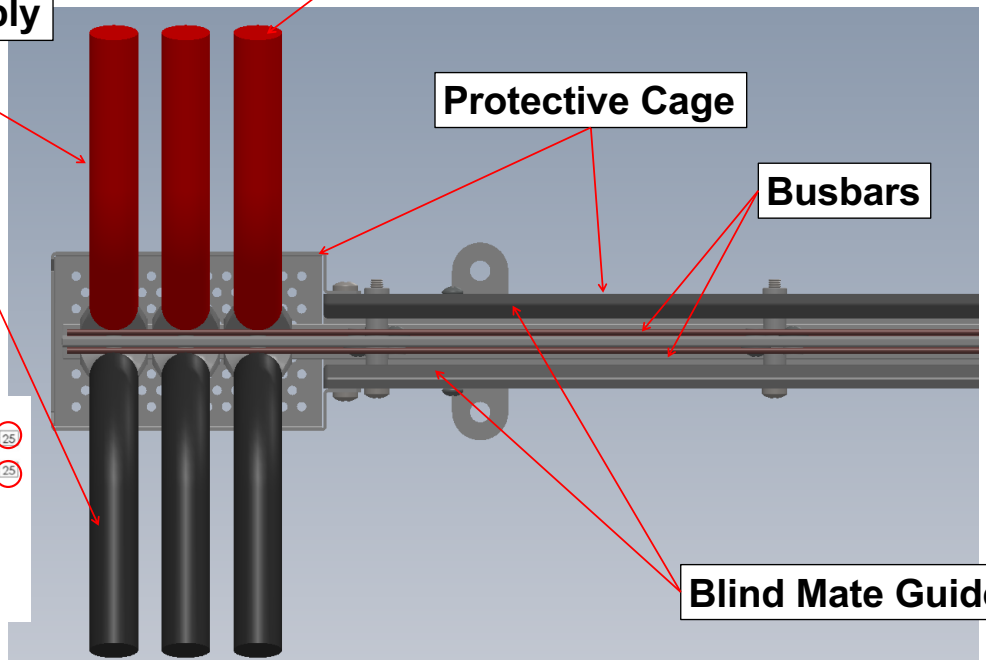
- Each of these will add additional SKU Levels:

48VDC										
Depth	Shallow (30")					Deep (44")				
Power Rating	15kW	36kW	50kW	60kW	100kW	15kW	36kW	50kW	60kW	100kW
Busbar Format	1X Busbar Solution	1X Busbar Solution	1X Busbar Solution	1X Busbar Solution	1X Busbar Solution (2 halves)	1X Busbar Solution	1X Busbar Solution	1X Busbar Solution	1X Busbar Solution	1X Busbar Solution (2 halves)

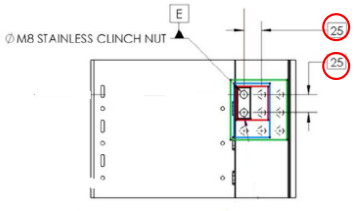
Management of Power Supply Connections

PowerLug or Busbars from The Power Supply

36 kW Busbar would require (3) 4/0 wires for each potential



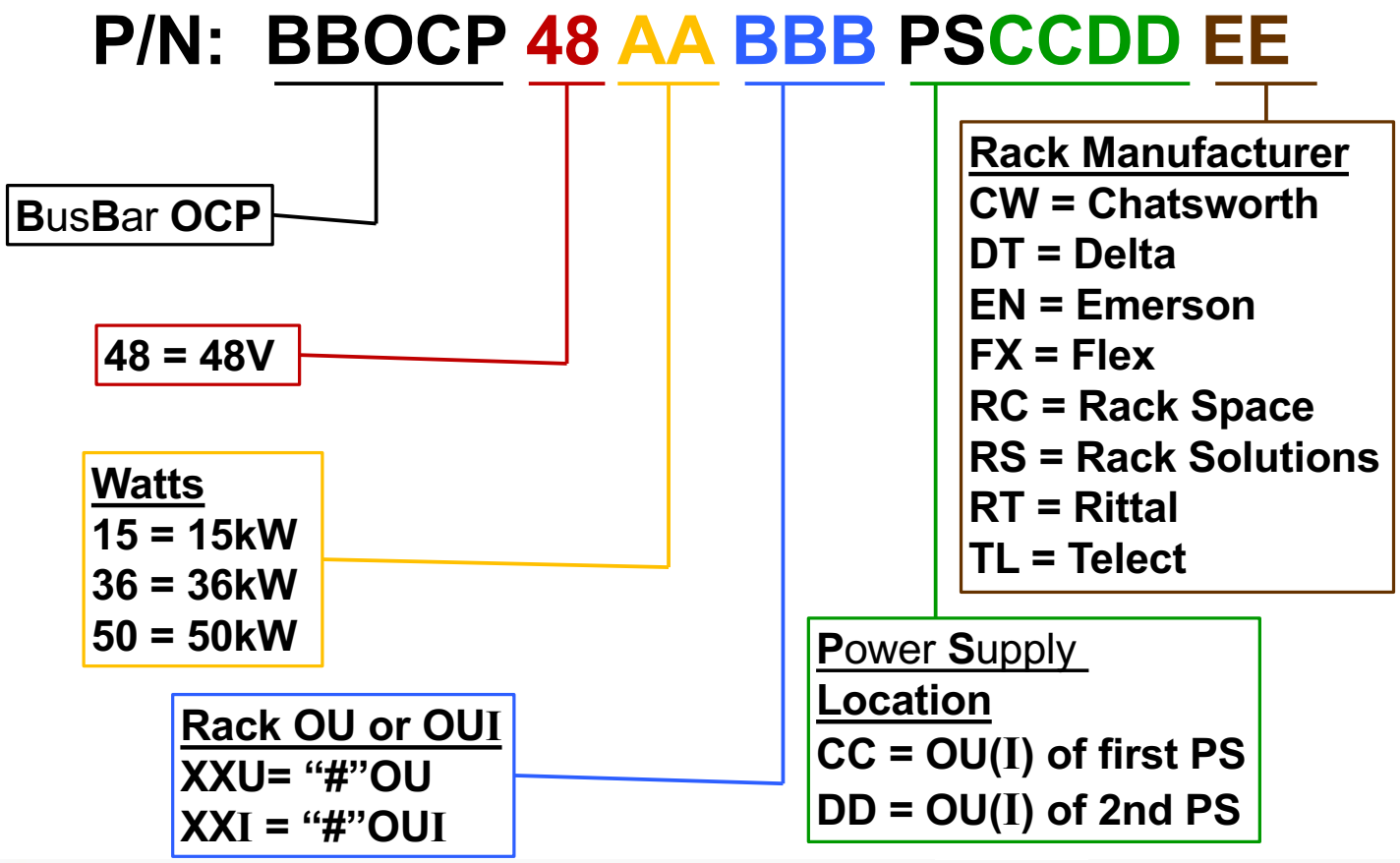
May need to change these dimensions and/or add studs?



Future question is with higher kW requirements, will 3 posts be sufficient? Will the spacing need to change to accommodate larger wire gage?

Amphenol

Example of OCP 48V Busbar SKU Matrix

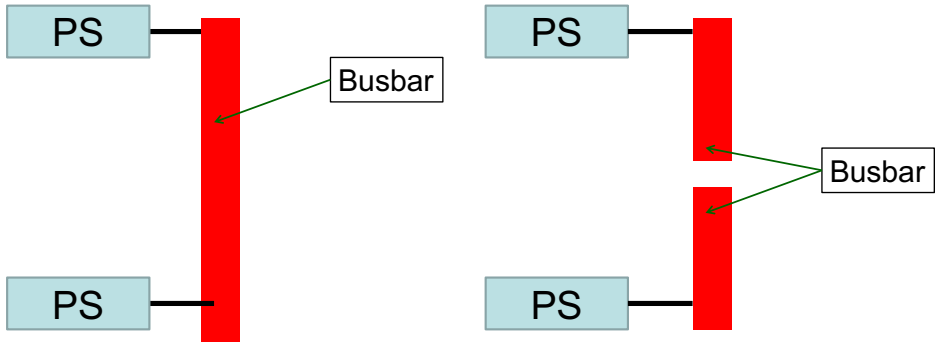


Power Zones

Not all Power Ratings are the Same!

Regarding the Topic of Power rating for an entire rack. A 36kW rack for example can be configured with a Single Power Zone, a Split Single (Dual), or (3) 12kW Power Zones.

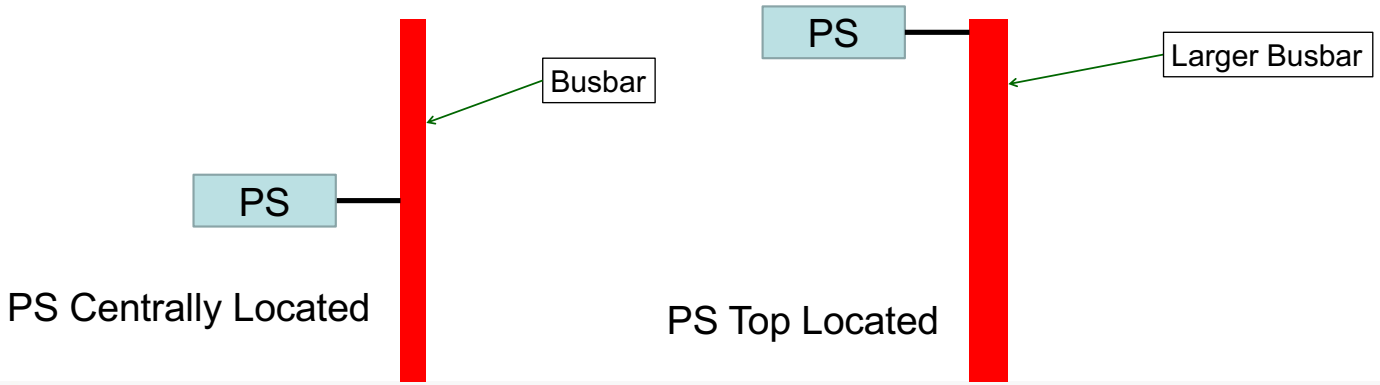
It is our suggestion that the number of Power Zone(s) should be considered when rating the busbar in context to the rack. A single 36kW power zone bubar will have more copper mass than a Split Single Zone 18kW busbar.



Single Power Zone Dual Power Zone

Power Supply Location

• Another challenge is the location of the Power Supply(ies). This becomes a particular challenge with the full length busbars (~42 OU).
•As a power solutions provider, the preference would be a central location to minimize the copper usage or increase the power availability
    •For example, the design of a 36 kW busbar with the power supplies centrally located will minimize the copper needed to support this power level (half the power for each busbar leg) vs. locating the Power Supplies either top or bottom which will require the support the full power (~950A at minimum voltage)



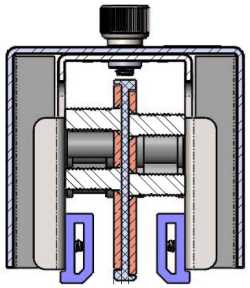
Copper Sizing Calculation

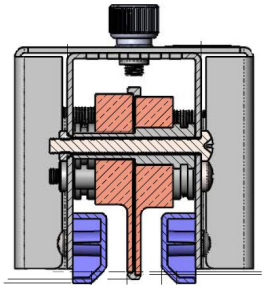
Busbar current ratings can vary from vendor to vendor. Should we reference in section 3.2 for the 48V OCP spec a variable for determining power rating based on cross section area of copper. A 30 degree C T Rise.

In the development of Busbars we use a very easy to remember formula of:

$5A / mm^2$

This has been supported by Simulation and Load testing by groups within Amphenol (AIPC and AFCI).



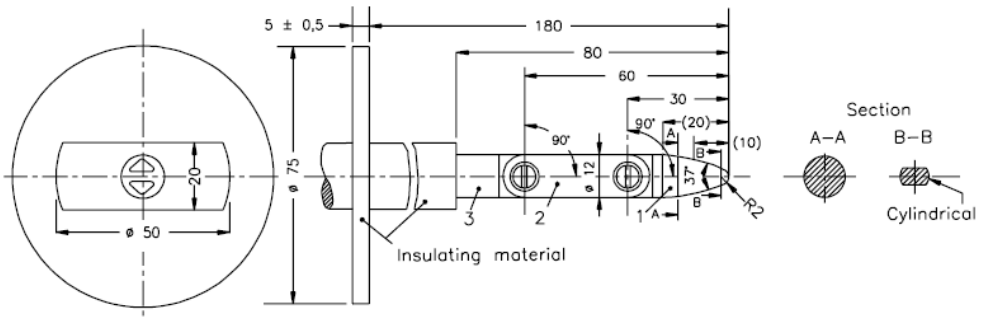


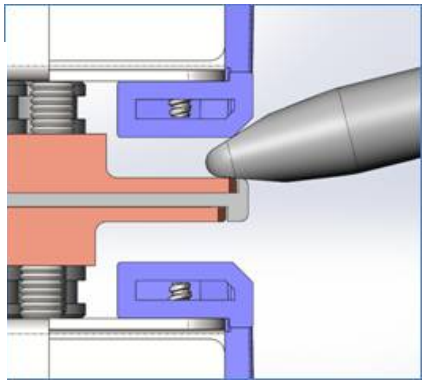
Touch Proof Requirement – Open Rack 2.0 Section 2.5

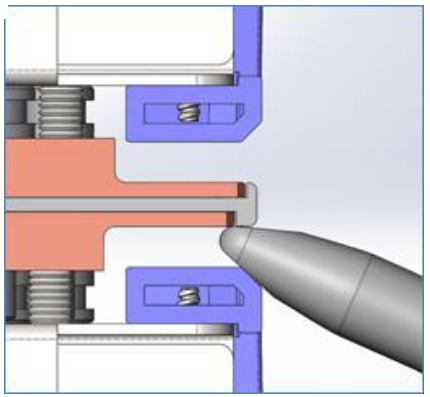
IEC60950 requires a finger probe test as shown in the below images.

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 7 and comply with Figure 8
- Be silver plated at interface points.
- Have user access limited by a method that conforms to UL 60950
- 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 8





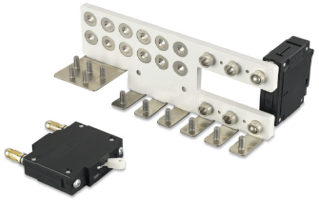


Amphenol

AIPC

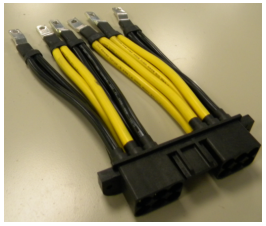
Amphenol Interconnect Products Corp.

Total Power Solutions

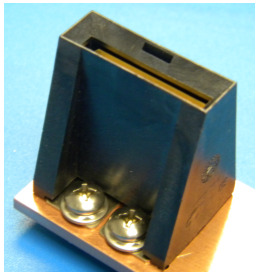


Busbars

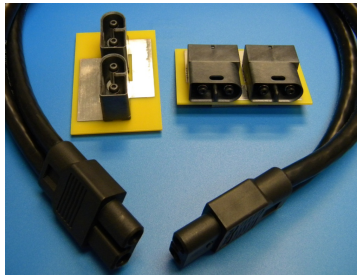
THANK YOU!



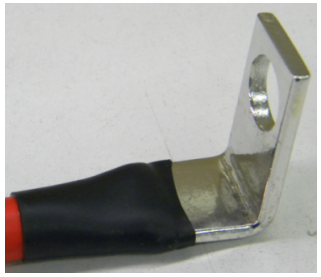
Power Assemblies



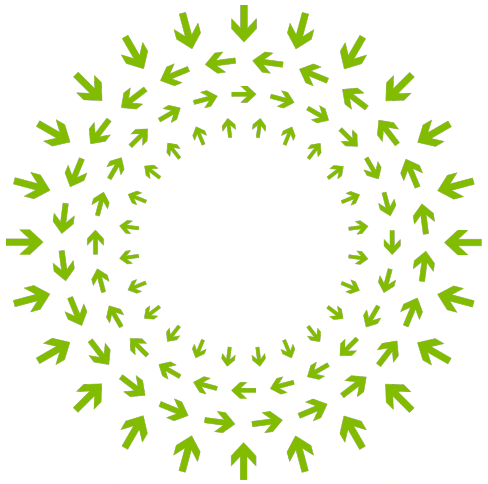
Connectors



Cable Assemblies



PowerLugs



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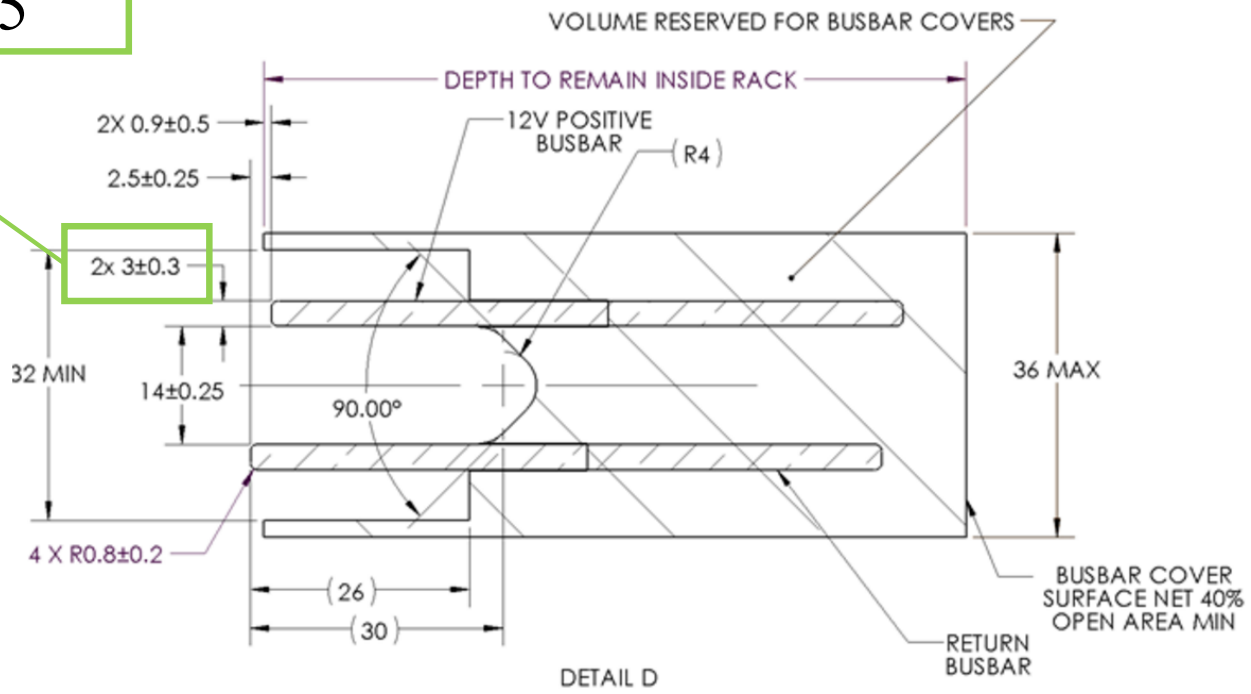
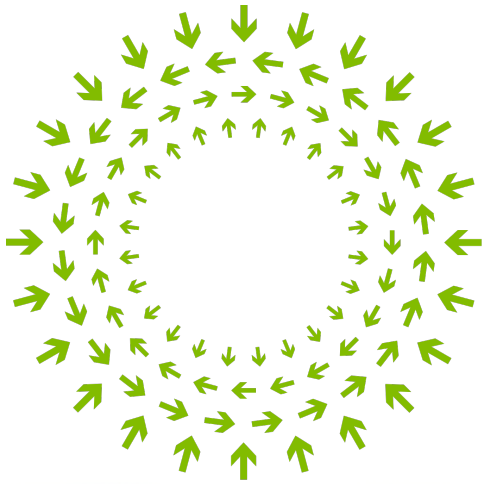
12V Busbar Thickness Tolerance Change:

Change to: 2x 3+/- 0.15





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True Three Phase 380 – 480 Vac to 48Vdc Power Shelf

Author: Ed Fontana

Author: Paul Smith

GE Industrial Systems

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Scope

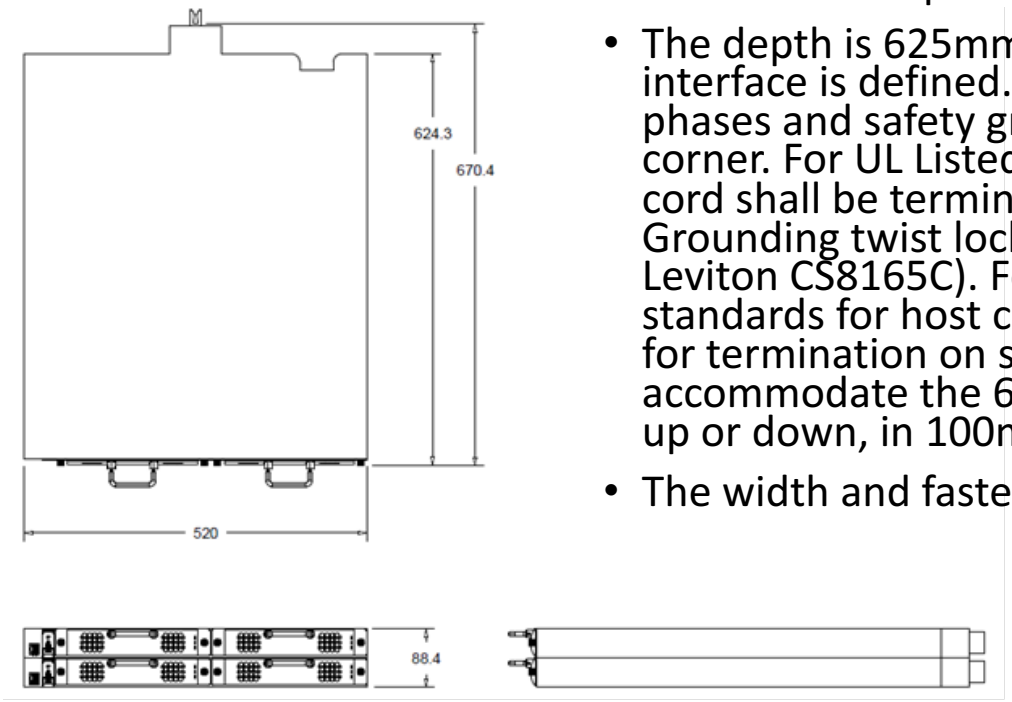
This document defines the technical specifications for:

- A true 3 phase 380 – 480 Vac to 48Vdc Power Shelf used in Open Compute Project Open Rack Standard V2.0
- The shelf is 2 open rack units high
- Is fed with a single 50A AC cord whip
- Delivers power using bus bar clips onto the 48V bus located in the shallow depth (660mm) cabinet as defined in Open Rack Standard 2.0

Benefits

1. Simple AC wiring in the data center. AC distribution wiring includes three phase conductors and one safety ground. No neutral is required.
2. AC phases are intrinsically balanced. Each 3-phase power converter processes all 3 phases, so provisioning to match need, and unit failures do not change the phase balance on the AC power feed into the facility. There should be no billing anomalies.
3. Simple powering of an Open Rack or cabinet. A single 50A whip can power an entire cabinet – depending on data center rack thermal capability.
4. Power can be flexibly located vertically in the rack. A dedicated position for power, driven by the need for bus bar studs, where power is introduced, is not required. The 2-rack unit shelf can be placed as needed in the rack to support logical partitioning of the data processing equipment.
5. Easy integration into Enterprise/Building management systems using Ethernet protocols (SNMP and MODBUS).

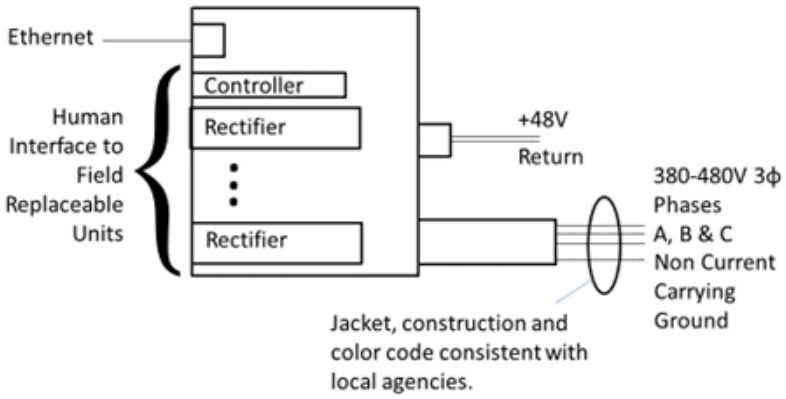
Compatiblity



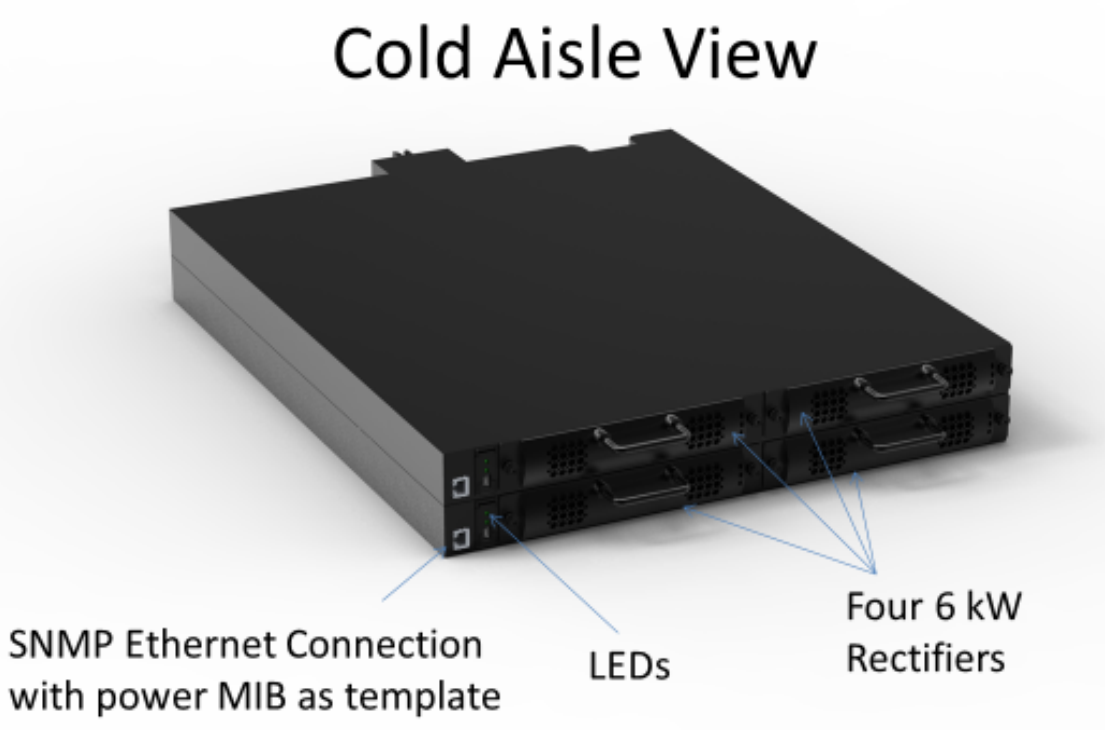
- The true three phase power shelf is 2 OpenU tall (96mm).
- The depth is 625mm, except where the floating (+/-2mm) busbar interface is defined. A 2 meter long four conductor power cord (3 phases and safety ground) pigtail is provided in the right rear corner. For UL Listed North American applications at 480Vac, the cord shall be terminated with a UL/CSA listed 3-Pole, 4-Wire Grounding twist lock connector (such as Hubble CS8165C or Leviton CS8165C). For 380V applications the cord will match standards for host country and be provided blunt cut at 2 meters for termination on site. The strain relief for this pigtail shall accommodate the 616mm depth and allow for a 90-degree bend, up or down, in 100mm.
- The width and fastenings are to fit in the Open Rack V2.0.

Compatiblity

Block Diagram



Cold Aisle View



AC Input – Line Voltage

	Parameter	Qualifier	Sbl	Min	Nom (Typ)	Max	Unit	Applicable Standards & Notes
1	Input Voltage 3Ø	Operating	V_{IN}	320	380/400/480	530	V_{ac}	Voltage is supplied via 3 wire with a frame ground for safety.
2		No damage continuous	V_{IN}	0		600	V_{ac}	Telcordia GR-947-CORE, section 3.1. Input voltages below 320V_{ac} shall not cause damage to the rectifier. Non-latching rectifier shut-down OK.
3		Low Voltage: Turn-OFF		(300)		320	V_{ac}	At least 5.0 V of hysteresis shall exist (V_{on} > V_{off} +5.0) between turn-on and shutdown on any particular unit.
4		Turn-ON		(315)		330	V_{ac}	
5		High Voltage: Turn-OFF		530		(550)	V_{ac}	Rectifier may turn off at input voltage above minimum value.
6		Turn-ON		520		(540)	V_{ac}	
7	Input Current Drain (3Ø)		I_{IN}			15.0	Amps	At input low voltage shut-down.
8	Inrush Current Limiting		A_{PK}			30.0	Amps peak per Ø	Measured at 480V_{ac}. Inrush current caused by EMI capacitors plus the circuit inrush shall not cause the input breaker to trip.
9	Over-current Protection					30	Amps	Telcordia GR-947-CORE, section 3.5. External Breaker requirement.

AC Input – Parameters

	Parameter	Qualifier	Sbl	Min	Nom (Typ)	Max	Unit	Applicable Standards & Notes
1	Input Frequency	Operating	F_{IN}	47	50/60	63	Hz	Telcordia GR-947-CORE, section 3.1.
2		Slew Rate		3			Hz/. 5C	Half cycle is between zero crossings.
3	Input Voltage Unbalance		V_{IN}	-15	1	+10	%	Telcordia GR-947-CORE, section 3.1. Line to line voltage unbalance.
4	Input Current Imbalance	Over all loads				1.5	%	Steady State. Unit should actively balance input current from each phase as a percent of full scale at 480V. Typically less than 1.5% phase imbalance.
5	Source Impedance			0.20	0.25	0.30	Ohms	NEC allows 2.5% of source voltage drop inside a building
6	ac Ground							NEC. The rectifier shall be grounded to ac service.
7	Hold-Up time	High Line Unit at 320 Vac	T	10	12		ms	Output allowed to drop from float voltage, 2.25 Volts per cell (VPC) to 1.75 VPC [54.5 Vdc to 42 Vdc with 6kW] constant power load. 60Hz, 25°C..
8	Ride through	at Nominal Vin, 25°C)	T	1/2	1		cycle	@ Nominal, 25C and Full load.

AC Input – Parameters

	Parameter	Qualifier	Sbl	Min	Nom (Typ)	Max	Unit	Applicable Standards & Notes
	Power Line Disturbance ANSI C62.41.2-2002 Category A, B, & C Low (most severe condition chosen for each of the following tests)							All Tests Applied Both line-to-line and line-to-ground. Transient disturbances shall be applied to one phase at a time. Transients shall be applied at the peak and at the zero crossing of the ac waveform - 90º and 0º phase angle. Voltage regulation limits may be exceeded during these conditions. The rectifier shall sustain no damage. It is permissible for the rectifier to shutdown. If shutdown occurs the rectifier shall automatically restart when the input voltage returns to within operating range. ANSI/IEEE C62.41
					10			Repetitions for each transient disturbance
				1			min	Interval between transient application
9		100kHz Ring Wave			6 0.5		kV kA	Category B Table 2
10		1.2/50µs – 8/20µs Combination Wave			6 3		kV kA	Category B Table 3
11		5/50ns EFT Burst			2		kV	Additional: Table 7 Severity II

AC Input – Parameters

	Parameter	Qualifier	Sbl	Min	Nom (Typ)	Max	Unit	Applicable Standards & Notes
12	IEC Surge	1.2/50µs (8/20µs)			2		kV	IEC/EN 61000-4-5 Level 4 Line to line.
13		1.2/50µs (8/20µs)			4		kV	IEC/EN 61000-4-5 Level 4 Line to earth.
	Surge & Sag							From nominal input voltage apply surges and sags returning to nominal input voltage. No damage. Voltage regulation limits may be exceeded during these conditions. Surges and Sags shall be applied to one phase at a time, and all three phases simultaneously. Surges and Sags shall be initiated at phase angles of 0 and 90, and 270 degrees. If shutdown occurs the rectifier shall automatically restart when input voltage returns.
					5			Repetitions for each Surge & Sag
				60			s	Interval between transient application
14	0.35 x Sag				0.35		x Nominal Input Voltage	Worst Case: at minimum nominal input voltage
					30		cycles	

AC Input – Parameters

	Parameter	Qualifier	Sbl	Min	Nom (Typ)	Max	Unit	Applicable Standards & Notes
15		0V Sag			0		V_{ac}	Worst Case: at minimum nominal input voltage
				0.5		200	cycles	
16	Total Harmonic Distortion – Current THD (3Ø)	At current limit [110 A] Load				5	%	All measurements at nominal line 25°C and 60Hz
17		At nominal current [100 A] Load				5	%	
18		At 75% of nominal current [75 A] Load				6	%	5% Desired
19		At 50% of nominal current [50 A] Load				9	%	5% Desired
20		At 25% of nominal current [25 A] Load				12	%	5% Desired

AC Input – Parameters

	Parameter	Qualifier	Sbl	Min	Nom (Typ)	Max	Unit	Applicable Standards & Notes
21	IEC Harmonics				Pass			EN 61000-3-2 (Harmonics) at 50 Hz 380V, 60Hz 480V, 50Hz and 60Hz 240V
22	Power Factor		PF	0.98	0.995			From 50 to 100% load at each listed nominal voltage.
23	Phase Failure							Loss of phase of ac line voltage shall not result in damage to the rectifier. Non-latched shutdown OK, but derated operation with phase failure desired.
24	Line Failure							Interruption and restoration of the AC power shall not nullify the proper operation of the controls, alarm signals, or visual indicators, when installed in battery plants.
25	Leakage Current		I_{IN}			5	%	Of nominal input current per phase. Marking per IEC/EN 60950. The rectifier will only be used in permanently connected / stationary applications and may be connected to IT power systems, i.e. systems without earth connected neutral conductors.
26	Isolation	Input - Chassis / Signals	V	2087			V_{ac}	Per EN60950. Consult factory for testing to this requirement.
27		Input - Output	V	3000			V_{ac}	

DC Output Parameters

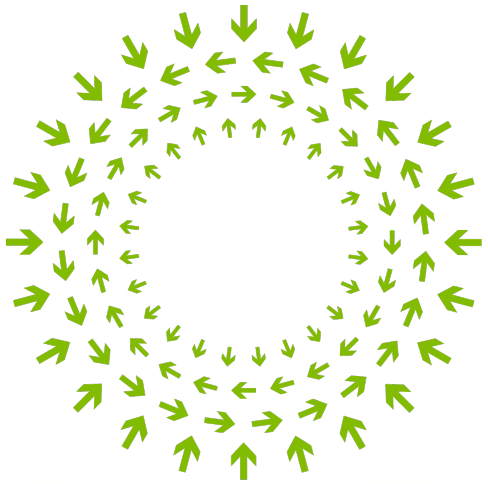
- Consistent with Open Rack Standard V2.0

Thermal Design Requirements

- Consistent with Open Rack Standard V2.0

I/O System

- Ethernet, see proposed data structure in appendix.



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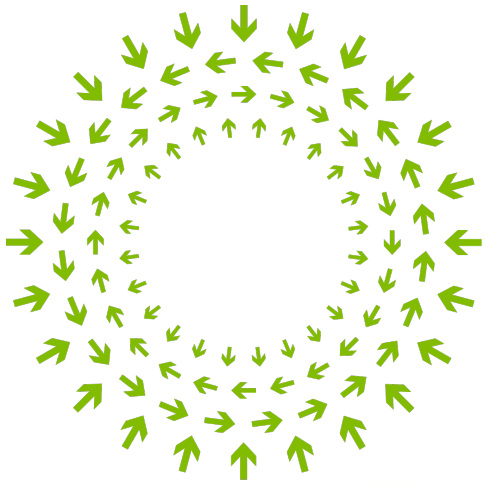
Community Driven Discussion of the Power Shelf Specification Roadmap

Steve Mills
Project Co-Lead - Facebook



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