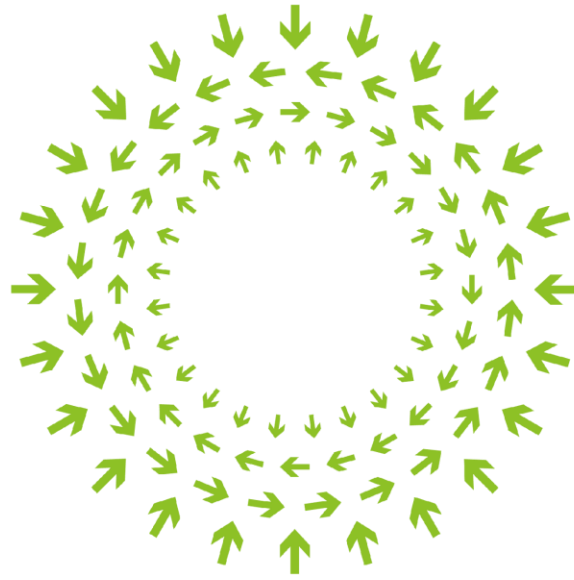




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Compute Project

Mt. Diablo Disaggregated Power Rack Specification

1.0.0

Base Specification

Effective October 8th, 2026

Authors: Microsoft, Meta, Google

Version history

Date	Version #	Authors	Description
5 May 2025	0.5.0	Microsoft: Laurentiu Olariu, Samir Kala, Joel Jaramillo, Kelsey Wildstone, Brandon DeVaul, Harsha Bojja, Andy Regimbal, Jason Adrian. Meta: David Sun, Dmitriy Shapiro, Ben Kim, John Fernandes, Drazena Brocilo, Mingchun Xu. Google: Jorge Rodriguez, Xiong Li, Christina Peabody, Vijay Boovaragavan, Matt Tamashiro, Bill Barry, Maziar Mobarrez, Adrian Shanov, Scott McCauley, Tamar Makharashvili, Vivek Khaire	Initial Release
May 2025	0.5.1		Updated Authors
May 2025	0.5.2	Same as above	Updated Interface Section and Compliance Section. Updated PSU power for 400Vac input. Released to OCP
February 2026	0.7	Microsoft: Laurentiu Olariu, Samir Kala, Joel Jaramillo, Brandon DeVaul, Andy Regimbal, Mingchun Xu, Jamie Chen Meta: David Sun, Dmitriy Shapiro, Ben Kim, John Fernandes, Zuhir Sras, Xianyong Feng Google: Jorge Rodriguez, Xiong Li, Christina Peabody, Vijay Boovaragavan, Matt Tamashiro, Bill Barry, Maziar Mobarrez, Adrian Shanov,	Renamed 0.53 to 0.7. Updated Telemetry section, updated doors section. Added Appendix C for DC output connector and appendix D for AC input connectors. Renamed version 0.5.3 to 0.7. Updated PSU ride through with energy storage option. Corrected tables, minor edits, added references.

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		Scott McCauley, Tamar Makharashvili, Jason Adrian, Tanya Liu	
March 2026	0.7.0	Laurentiu Olariu, David Sun	Corrected version number per OCP standard. Removed section heading from version history and TOC, correction on intentionally blank pages, License section, removed HVDC and rectifier term, included tolerance statement in section 6, added intro to Appendix sections, corrected references.
Oct 2026	1.0.0	Microsoft: Laurentiu Olariu Google: David Sun, Jorge Rodriguez Meta: Xiaoyun Hu	Updated section 8.1.4, updated dimensions on PSU section 8.2.1. Updated Table 10. Updated 800Vdc to “differential 800Vdc” everywhere. Updated whips qty in ACPDU section 8.1.1. Updated section 14.1 with PN and 15.1 with information. Updated title to reflect CLA and replaced Diablo 400 with Mt. Diablo. Added definition of TDP in section 7.3.2. Replaced HVDC with LVDC in section 5 diagrams. Included definitions of AC PDU, DC PDU and PSU in section 7.1. Moved AC and DC interconnect from Appendix to its own

Open Compute Project • Mt. Diablo Disaggregated Power Rack Specification

			section 9 and 10. Minor edits on formatting, etc. Final release
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Table of Contents

1	License	8
2	Open Web Foundation (OWF) CLA.....	8
3	Acknowledgements.....	9
4	Compliance with OCP Tenets.....	10
4.1	Openness.....	10
4.2	Efficiency.....	10
4.3	Impact.....	10
4.4	Scale.....	10
4.5	Sustainability.....	10
5	Scope.....	11
6	Rack Physical Dimensions.....	12
6.1	Mechanical Features	12
7	Voltage Distributions.....	13
7.1	Rack AC Power Requirements.....	13
7.1.1	AC Input Voltage	13
7.1.2	AC Input PF and THD.....	13
7.1.3	AC Loss (Holdup and ride-through).....	14
7.1.3.1	PSU ride-through without energy storage.....	14
7.1.3.2	PSU ride-through with energy storage.....	14
7.2	Energy Storage Solutions.....	14
7.2.1	BBU Option.....	14
7.2.1.1	Battery Backup Time	15
7.2.2	Capacitor Bank Option CBU.....	15
7.3	Rack DC Power Requirements	15
7.3.1	DC Output Voltage for Nominal $\pm 400\text{VDC}$	15
7.3.2	DC Output Power for Nominal $\pm 400\text{VDC}$	15
7.3.3	DC Output – Dynamic loading	16
7.3.4	End to End Output Power Conversion Efficiency	18
7.4	Multi Rack Parallel Option	18
8	Power Rack Building Blocks.....	18
8.1	AC & DC PDU	18
8.1.1	AC PDU Configuration.....	18

8.1.2	±400VDC Power Distribution.....	19
8.1.3	±400VDC PDU Output Protection and Control Module	19
8.1.4	PE Grounding	19
8.1.4.1	+/-400Vdc mid-point grounding	19
8.1.4.1.1	Resistive grounding	20
8.1.4.1.2	Solid grounding	20
8.1.4.2	800Vdc grounding:.....	21
8.1.4.2.1	Resistive grounding	21
8.1.4.2.2	Solid grounding	22
8.1.4.2.3	Ground Fault Detector	22
8.2	AC/DC PSU Shelf.....	23
8.2.1	AC/DC PSU.....	23
8.2.2	AC/DC Power Shelf Control Module.....	24
8.3	±400VDC Distribution Busbar	24
8.4	±400VDC to IT rack Distribution Cable.....	25
9	DC Output Interconnect Cables	25
10	AC Input Interconnect Cables.....	27
11	Management, telemetry and communication interface with the sidecar	29
11.1	Management.....	29
11.2	Telemetry.....	29
11.3	Communication	29
12	Operating Environmental Conditions	29
12.1	Subsystem Thermal Design Requirements	30
12.2	L11/Rack-level Operational Requirements	30
13	Regulatory and Compliance Requirements.....	30
13.1	Safety Requirements.....	30
13.2	Electromagnetic Compatibility (EMC) Requirements	31
13.3	Environmental, Eco-Design, and Sustainability Requirements	32
14	Reference section.....	33

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[OWFa 0.9.](#)

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3 Acknowledgements

The Contributors of this Specification would like to acknowledge the following for their feedback:

Microsoft: Laurentiu Olariu, Samir Kala, Joel Jaramillo, Kelsey Wildstone, Brandon DeVaul, Harsha Bojja, Jason Adrian, Andy Regimbal

Meta: David Sun, Dmitriy Shapiro, Ben Kim, John Fernandes, Drazena Brocilo, Mingchun Xu.

Google: Jorge Rodriguez, Xiong Li, Christina Peabody, Vijay Boovaragavan, Matt Tamashiro, Bill Barry, Maziar Mobarrez, Adrian Shanov, Scott McCauley, Tamar Makharashvili.

4 Compliance with OCP Tenets

4.1 Openness

This specification will hopefully serve as the future fundamental base for a disaggregated power rack to deliver $\pm 400V_{DC}$ to a nearby IT rack. The base of the mechanical rack follows the Open Rack standard. Currently three companies have worked together to provide a high-level overview of the Mt. Diablo architecture. The goal is to standardize items such as, high voltage connectors and mating interfaces.

4.2 Efficiency

Transferring power at a higher voltage is more efficient, reduces I²R losses. This disaggregated power rack can be used with multiple generations and SKUs of IT racks; a disaggregated power rack can remain in the same location in the datacenter while IT racks can be swapped as required. This will ultimately reduce the overall infrastructure costs. One objective is to use learnings from this architecture to distribute increased direct current voltage in the datacenter directly to the IT racks to improve overall end to end power distribution efficiency.

4.3 Impact

This is the first disaggregated power rack specification. Standardizing the high voltage rack architecture will hopefully lead to a common supply chain, provide end-to-end efficiency gains, and leverage mainstream EV industry technologies of increased direct current voltage as $\pm 400V_{DC}$ or differential 800Vdc from charging/battery infrastructure.

4.4 Scale

The fundamental advantage of a disaggregated power rack is scalability in terms of rated power, redundancy schemes and backup power.

4.5 Sustainability

Disaggregated power rack has the ability to be scaled for various power ratings allowing it to be re-used for multiple generations of an IT rack. The IT rack can be updated while maintaining the same hardware in the disaggregated power rack, therefore reducing the need to scrap power building blocks.

5 Scope

With increased rack power (from 33kW to 100's of kW), size and power of AI accelerators, and rack/POD size growth, there are significant challenges with interconnect density, power delivery and overall system integration. To solve this, the disaggregated power rack (also known as sidecar) provides a flexible and evolving infrastructure solution.

The disaggregated power rack can be scalable and updated to meet various power requirements from 800kW to 1MW+ (with the option to parallelize power racks together) while keeping the disaggregated IT rack the same.

The rack shall support different power distribution configuration options. A few examples are provided in Figure 1, for illustration purposes, not as a final design solution.

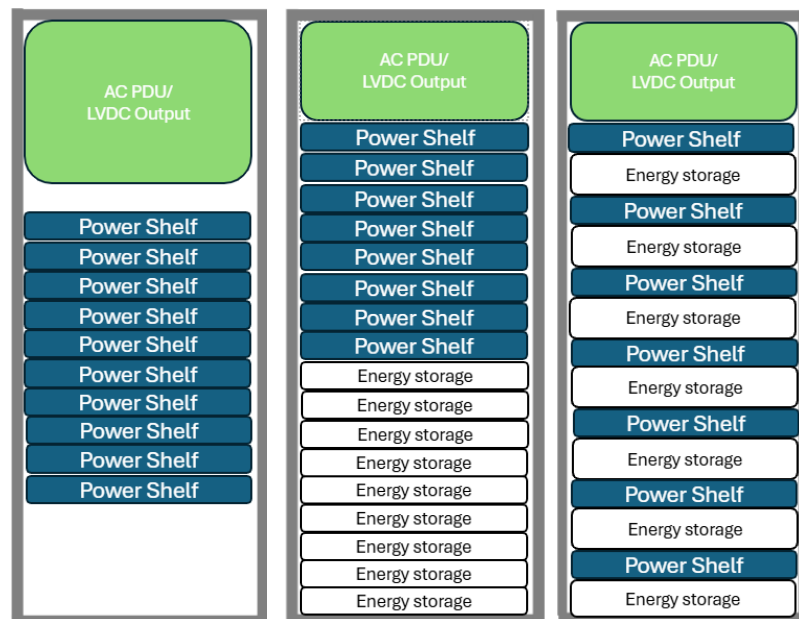


Figure 1: Three examples of power rack configurations.

6 Rack Physical Dimensions

Table 1 included below illustrates the Mt. Diablo power rack dimensions. The height of the rack with casters is not included in the table below. The target loading capacity of the rack is 6000 lbs.

Table 1: Various rack dimensions.

	Height (mm)	Width (mm)	Depth (mm)
<i>Microsoft</i>	2329 $\pm$ 3	600 $\pm$ 2	1200 $\pm$ 2
<i>Meta</i>	2329	600	1219
<i>Google</i>	2329*	711	1219.2

*Option for height up to 2410mm.

Tolerances to be defined in future revision.

6.1 Mechanical Features

- *Sliding shelves to facilitate push in/out of big building blocks such as a 4OU BBU, etc.*
 - *Blind mate connector with static rail/sliding rails for PSU/BBU/CBU*
 - *Center justified busbar placement*
- *Safety doors per compliance section 13*
 - *Option to add a locking door on both the front and back of the rack, full or partial doors*
 - *Option for a switch for intrusion detection or/and emergency shutoff*
- *Reserved space for structural support*
- *Connection for AC Cables (Lug vs Connector)*
 - *Option for connectors instead of lugs*
 - *Example - Quick Connect (Amphenol Surelock) connector*
- *Cable routing*
 - *Options to support AC whips routing*
 - *Option for AC inlet in the back of the top of the rack, DC output on the top of the front of the rack*
- *Accessibility defined per safety hazard in section 13*

7 Voltage Distributions

This section describes AC input voltage and DC output voltage requirements as well as various energy storage options.

7.1 Rack AC Power Requirements

7.1.1 AC Input Voltage

The rack is designed to accept 3-phase AC input (3P+E) voltage into an AC PDU (alternative current power distribution unit), which then distributes the AC power as input to the AC/DC PSU (power supply unit) modules.

The rack is configurable to support both single 3-phase AC input feed or dual AC input for N+N redundancy feed, and a wide range of input voltage, as listed in Table2.

Table 2: Various AC input option configurations.

Parameter	Nominal1	Nominal2	Nominal3	Min/Max
WYE 5Wire 3L+N+PE	480 V_{rms}	415 V_{rms}	400 V_{rms}	$\pm 10\%$
Line to Neutral L+N	277 V_{rms}	240 V_{rms}	230 V_{rms}	$\pm 10\%$
Delta 4 Wire 3L+PE	480 V_{rms}	415 V_{rms}	400 V_{rms}	$\pm 10\%$
Frequency	50/60 Hz	50/60 Hz	50/60 Hz	$\pm 3\text{Hz}$

7.1.2 AC Input PF and THD

The power quality metrics, such as power factor (PF) and current harmonic distortion are listed in Table 3 below.

Table 3: Power quality requirements.

Parameter	@480V_{AC} Vin	@415V_{AC} Vin	@400V_{AC} Vin
<i>PF load <20%</i>	>0.95	>0.95	>0.95
<i>PF load ≥20%</i>	>0.99	>0.99	>0.99
<i>THD 5% < load <15%</i>	<15%	<15%	<15%
<i>THD 15% ≤ load <30%</i>	<10%	<10%	<10%
<i>THD load ≥30%</i>	<5%	<5%	<5%

7.1.3 AC Loss (Holdup and ride-through)

Holdup notion applies to built-in PSU bulk storage that allows time until other form of energy support is engaged and activated to support the rack functions in case of AC loss. Separate from holdup, the ride-through capability of the PSU defines running without interruptions during voltage dropouts and sags/swells.

7.1.3.1 PSU ride-through without energy storage

Line Overvoltage: Follow ITIC curve for overvoltage and requires PSU to ride-through and not latch-off.

Line Sag: Follow both ITIC and IEC 61000-4-34 and requires PSU to ride-through and not latch-off.

Minimum holdup without energy storage requirement is up to 20msec at 100% loading. Addition of system distributed holdup is acceptable, between the AC/DC PSU in the Mt. Diablo rack and with the downstream DC/DC converter, located outside the rack.

7.1.3.2 PSU ride-through with energy storage

Shall ride-through any duration within the energy storage hold up time range.

The PSU/Shelf hold-up energy/time shall be enough covering the smooth transition from AC drop out to energy storage ramp up at the worst-case condition, which can be the AC drop at the lowest point of bulk voltage during peak load as defined in 7.3.2.

Holdup with energy storage requirement shall be decided per solution specific requirements, sufficient to cover transition time.

7.2 Energy Storage Solutions

The rack is designed to support various storage solutions such as battery backup unit (BBU) and capacitor bank energy storage units (CBU). Depending on the user's requirement the number of BBUs and CBUs can be adjusted.

7.2.1 BBU Option

Rack shall support BBU options. Design shall support power ranges per electrical specification.

- *Optional active management via microcontroller for secure access*
- *Optional module interface with a Rack Management Unit -interface standard defined in section 11*

7.2.1.1 Battery Backup Time

If BBU option is utilized, battery backup time shall support a range of 45 to 90 seconds holdup at 100% loading.

7.2.2 Capacitor Bank Option CBU

The rack design shall support capacitive bank energy storage, although power and duration may be specific to each application, and selection may differ per platform. Design shall support power ranges per electrical specification.

- *Optional active management via microcontroller for secure access*
- *Optional module interface with a Rack Management Unit -interface standard defined in section 11*

7.3 Rack DC Power Requirements

7.3.1 DC Output Voltage for Nominal $\pm 400\text{V}_{\text{DC}}$

DC output regulation parameters are listed in Table 4. COM means common wire (neutral polarity between the $+400\text{V}_{\text{DC}}$ and -400V_{DC} output. Voltages are measured at the output connector of the AC/DC PSU module or/and power shelf.

Table 4: DC output voltage parameters.

Parameter	Nominal at no load	Nominal at full load	Min/Max
+400 to COM	410V_{DC}	400V_{DC}	$\pm 0.5\%$
-400 to COM	-410V_{DC}	-400V_{DC}	$\pm 0.5\%$
800 to 0/RTN	820V_{DC}	800V_{DC}	$\pm 0.5\%$
Ripple and noise			$\pm 1\%$ pk_pk
$V_{\text{droop dc}}$			<i>built in the Nominal setpoint ($10\text{V} \pm 0.5\text{V}$)</i>
Output voltage transient overshoot/undershoot			$\pm 3\%$ from typical set point

7.3.2 DC Output Power for Nominal $\pm 400\text{V}_{\text{DC}}$

The rack shall be capable of delivering the following power at the various AC input voltages. The AC/DC PSU module shall be able to support short peak power requirements, as stated in the Table 5 below.

BBU backup should not be triggered during the peak power loading condition.

The PSU input current waveform shall not be clamped during pulse loading operation.

Table 5: Rack power capabilities.

<i>Parameter (min)</i>	<i>@480V_{AC} Vin Option1</i>	<i>@415V_{AC} Vin Option 2</i>	<i>@400V_{AC} Vin Option 3</i>	<i>Vendors</i>
<i>Rack average power DC load</i>	<i>800kW to 1.1MW</i>	<i>Up to 1.1MW</i>	<i>Up to 718kW</i>	
<i><2 msec load step</i>	<i>175% of TDP</i>			<i>MSFT Meta</i>
<i><0.5 msec load step</i>	<i>180% of TDP</i>			<i>MSFT Meta Google</i>
<i><50 msec load step</i>	<i>150% of TDP</i>			
<i>1 sec moving average</i>	<i>100%</i>			

TDP or Thermal Design Power is the thermal load associated with the power supply operating continuously at 100% of its rated electrical output power under specified operating and environmental conditions.

The power supply rating is specified in section 8.2.1.

7.3.3 DC Output – Dynamic loading

The DC output voltage shall not vary by more than specified for undershoot and overshoot with 3ms settling time (with and without capacitive loading on a single unit of 10mF). The measurement shall be from the new steady state value (due to droop) to the voltage spike/dip peaks during a transient load. Voltages are measured at the output of the AC/DC PSU module or/and power shelf.

BBU backup should not be triggered during the dynamic loading operation. AC input current shall be regulated by PFC.

Dynamic load parameters are listed in Table 6, and load profiles in Table 7.

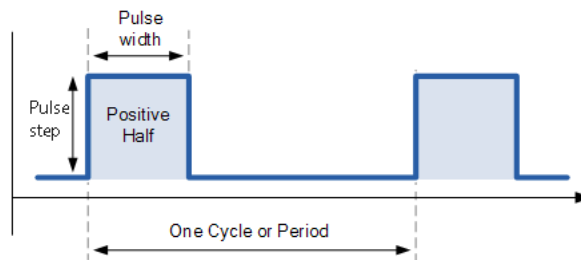
Table 6. Dynamic load requirements.

Step load increase or decrease	Frequency	Slew rate per PSU	Max undershoot and overshoot
50% step load (10% min. load)	Up to 10kHz	1A/us	±3%
90% step load (10% min. load)	Up to 10kHz	1A/us	
140% step load (10% min. load)	Up to 10kHz	1A/us	

Dynamic load profiles under test include but not limited to the ones shown in Table 7.

Table 7. Example dynamic load profiles.

No.	Low load	High load	Duty cycle	Frequency
1	10%	60%	50%	20Hz, 100Hz, 500Hz, 1kHz
2	50%	100%	50%	
3	10%	100%	50%	
4	10%	150%	50%	
5	10%	60%	50%	10kHz
6	50%	100%	50%	10kHz
7	10%	100%	50%	6.5kHz
8	10%	150%	50%	4kHz



Pulse load profiles under test include but are not limited to the ones shown in Table 8.

Table 8: Example pulse load profiles.

No.	Low load	High load	T_low	T_high	Average load	Frequency	PSU slew rate
1	70%	130%	0.05ms	0.05ms	100%	10kHz	1A/us
2	20%	140%	0.1ms	0.1ms	80%	5kHz	1A/us
3	40%	175%	2.5ms	2ms	100%	222Hz	1A/us
4	0%	80%	1ms	1ms	40%	500Hz	0.1A/us
5	20%	140%	50ms	50ms	80%	10Hz	1A/us
6	60%	140%	50ms	50ms	100%	10Hz	1A/us
7	30%	140%	28.6ms	50ms	100%	12.7Hz	1A/us
8	30%	175%	0.43ms	0.4ms	100%	1.2kHz	1A/us

The designer shall translate this test performance to system integrator conditions.

7.3.4 End to End Output Power Conversion Efficiency

End to end output power conversion refers to full conversion chain from AC input to DC output, including cooling, distribution, control and energy/backup power losses. Minimum efficiency values are shown in the Table 9 below. AC input is measured at the input to the AC PDU and DC Output is measured at the output of the DC PDU (direct current power distribution unit).

Table 9: Total Rack Efficiency.

Parameter	@480V_{AC} Vin	@415V_{AC} Vin	@400V_{AC} Vin
@20% load	>95%	> 95%	> 95%
@50% load	> 98%	>97%	>97%
@100% load	>97%	>96.5%	>96.5%

7.4 Multi Rack Parallel Option

Power rack shall have optional design features that enable paralleling multiple racks to increase power delivery.

Current sharing between racks including droop and active sharing shall be implemented at AC/DC power shelf level or/and rack level.

Synchronization and control features shall be implemented to ensure synchronized power up and power down for the case of multi-rack parallel option.

8 Power Rack Building Blocks

8.1 AC & DC PDU

The 3 phase AC input and DC $\pm 400V_{DC}$ Output Protection and Control Modules are estimated to take up to 15OU of space and described below.

8.1.1 AC PDU Configuration

The AC PDU takes in the AC power from the overhead busway and outputs power to each of 3 phase power shelves inputs.

The AC PDU shall be designed to:

- *Accept input connection to quantity up to 16x200Aac cords or 24x100Aac cords*

- *Include protection fuses*
- *Accept either input connection with two-hole compression lugs or connectorized*
- *Include an optional AC Panel/Cabinet*

The output of the AC PDU 3-phase power is split into smaller rated cables (ex. 200A to 4x50A) cables to be routed to various power shelves to power the 3-phase PSUs.

8.1.2 $\pm 400\text{VDC}$ Power Distribution

The output of the $\pm 400\text{V}_{\text{DC}}$ from the power shelves is collected and distributed via a vertical busbar spanning the full height of the rack. The source of the $\pm 400\text{V}$ is generated by the power shelf or energy storage devices and is transferred via the rack busbar which also is connected to the Output Protection and Control Modules.

8.1.3 $\pm 400\text{VDC}$ PDU Output Protection and Control Module

The DC PDU Module shall be designed to support up to 400kW output, with built in manageability, output On/Off, protection and telemetry, and no voltage contact on the output cables.

- *The Output Protection and Control Module shall attach to the $\pm 400\text{Vdc}$ or differential 800Vdc busbar and contain several output connectors that will transfer the power to the IT rack via cables*
- *Multiple output cables per output module, based on two options:*
 - *Option 1: 50kW per cable, qty as needed to support output power range*
 - *Option 2: 100kW per cable, qty as needed to support output power range*
- *The front of the Output Protection and Control Module shall contain physical on/off switches to turn on/off the corresponding output connector.*
- *The Output Protection and Control Module shall contain LED indicators, fuses and relays to protect each output connection in case of over current.*
- *Output voltage disconnect-each output shall disconnect the voltage on the connector before the cable is unplugged from either source or load side and when no output cable is installed.*
- *Optional active management via microcontroller, for secure access*
- *Optional module interface with a Rack Management Unit-interface standard defined in section 11*

8.1.4 PE Grounding

8.1.4.1 $\pm 400\text{Vdc}$ mid-point grounding

There are two options to connect the $\pm 400\text{Vdc}$ midpoint to PE (Protective Earth) Ground:

- *High resistance mid-point grounding PE*
- *Solid contact mid-point grounding PE*

The pros and cons between the two options are addressed in Appendix A.

Mid-point grounding shall be concealed/covered for no-touch safety.

For $\pm 400\text{Vdc}$ distribution, routing in the power rack and to the IT rack may be implemented as 3-wire + PE (+400Vdc, Midpoint/Common, -400Vdc, and PE), or as 2-wire + PE (no midpoint routed to IT rack).

8.1.4.1.1 Resistive grounding

In this configuration, the midpoint may be connected to PE through a high-resistance grounding scheme, as presented below.

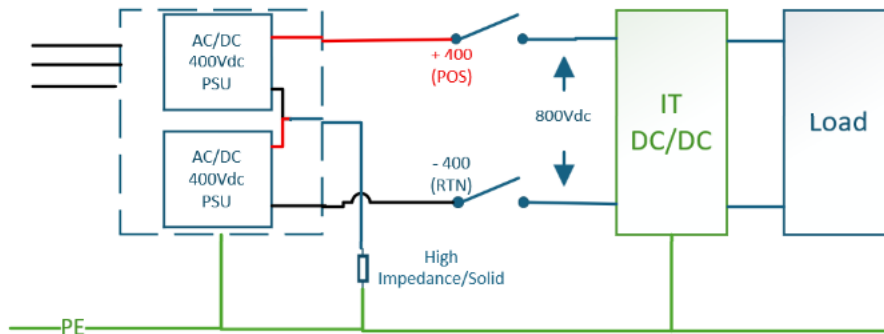


Figure 2: 2-wire output with high resistance grounding to PE.

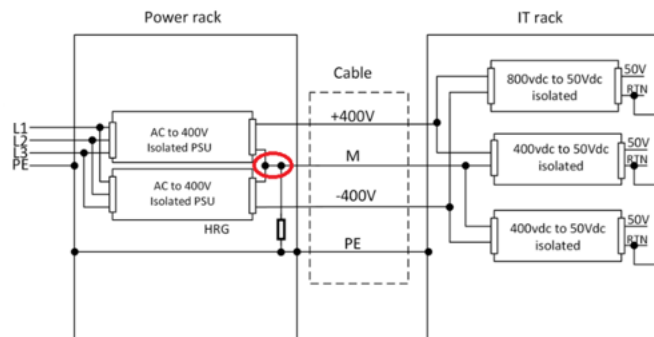


Figure 3: 3-wire output with high resistance grounding to PE.

8.1.4.1.2 Solid grounding

In this configuration, the midpoint may be connected to PE through a solid grounding connection, as presented below.

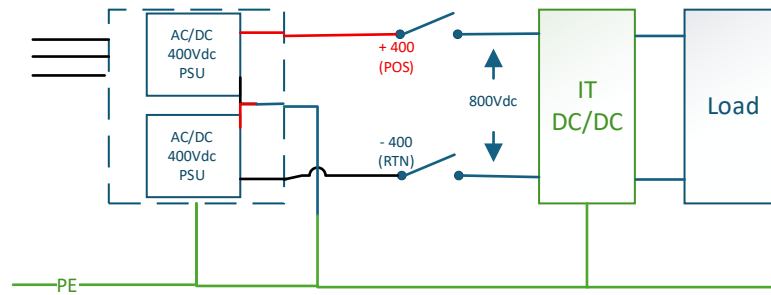


Figure 4: 2-wire output with solid grounding to PE.

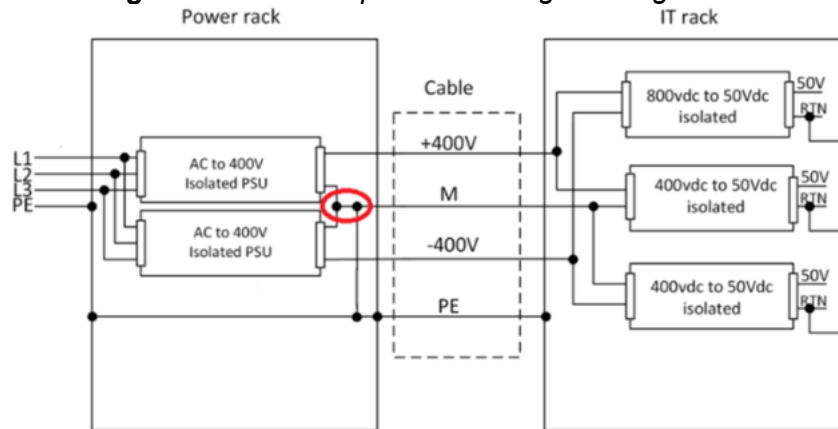


Figure 5: 3-wire output with solid grounding to PE.

8.1.4.2 800Vdc grounding:

For 800Vdc distribution, routing in the power rack and to the IT rack may be implemented as 2-wire + PE (800Vdc, 0Vdc, and PE).

The 800Vdc output may remain floating with high-resistance grounding applied to the return reference, or may be implemented as a single-ended 800Vdc output with the return solidly connected to PE, as applicable to the selected architecture.

8.1.4.2.1 Resistive grounding

Figure 6 describes a possibility of RTN connected to PE (no midpoint access) by a High Resistive Grounding Scheme, for a floating 800Vdc output.

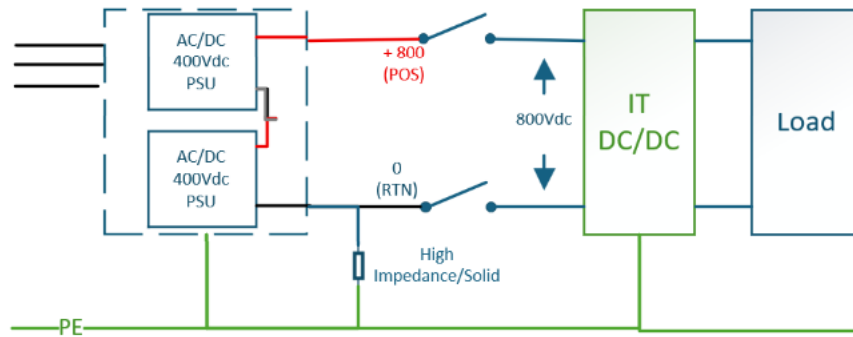


Figure 6: 2-wire output with high resistance grounding to PE.

8.1.4.2.2 Solid grounding

Figure 7 describes a possibility of RTN connected to PE (no midpoint access) by solid connection to PE for a single ended 800Vdc output.

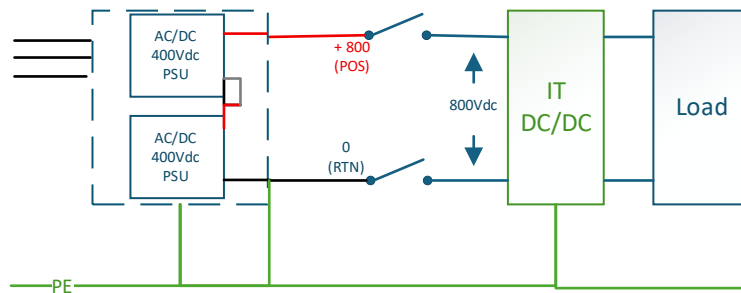


Figure 7: 2-wire output with solid grounding to PE.

8.1.4.2.3 Ground Fault Detector

Ground Fault Detector shall be implemented for either solid midpoint grounding or High Resistive Midpoint Grounding implementation.

For the case of Midpoint High Resistance Grounding, the GFD shall include voltage balance detection circuit.

- *Optional active management via microcontroller, for secure access*
- *Optional module interface with a Rack Management Unit-interface standard defined in section 11*

Residual Current Detection shall be implemented per each output cable/connection to the IT rack.

8.2 AC/DC PSU Shelf

- Multiple solutions are presented for the AC/DC PSU shelf up to a 2OU height, min 21" to 24" wide compatible with rack mechanical specification.
- The power shelf can host various numbers of PSUs up to 2OU shelf based on form factor and output power requirements.
- The power shelf shall be designed as 3-phase AC input and $\pm 400V_{DC}$ output. Connectors selected based on PSU requirements.
- Design shall have droop and active current sharing between PSUs and Power shelves Multiple parallel rack operation defined in section 7.4
- Design shall support power ranges per electrical spec
- Bus clip connector shall have a thermal sensor attached for thermal shutdown
- Optional active management via microcontroller, for secure access
- Optional module interface with a Rack Management Unit -interface standard defined in section 11

8.2.1 AC/DC PSU

Currently there are three versions of the AC/DC PSU modules available in 1OU height form factor. Size information is provided in the table below.

- The quantity of PSUs in a power shelf shall match the number of available output ports on the AC PDU.
- PSU modules are front of rack accessible, hot-swappable, and hot pluggable.
- Complies with electrical requirements in this specification document.
- Galvanic isolated output from AC input and earth/chassis.
- PSU module outputs 400Vdc and is connected at power shelf output as floating output with 3-wire, +400Vdc, -400Vdc and Common/Midpoint/Return
- Design option connected at power shelf output as 2-wire for differential 800V_{DC}, where 800V_{DC} and Return shall be safety isolated from PE ground. Downstream converters shall have safety isolated inputs from PE ground.
- Power range per Table 10 below

Table 10: AC/DC PSU rating and mechanical dimensions.

Parameter	@480V _{AC} Vin	@415V _{AC} Vin	@400V _{AC} Vin
AC/DC PSU Avg DC load, no redundancy (up to)	Solution 1: 30kW Solution 2: 27kW Solution 3: 26kW	Solution 1: 26kW Solution 2: 27kW Solution 3: 26kW	Solution 1: 25 kW Solution 2: 27 kW Solution 3: 26kW

Size (mm)	Solution 1: Option A: L848mm *H40mm *W170mm (w/o handle) Option B: 875mm*H42.2mm *W163mm (w/o handle)	Solution 1: Option A: L848mm *H40mm *W170mm (w/o handle) Option B: L875mm*H42.2mm *W163mm (w/o handle)	Solution 1: Option A: L848mm *H40mm *W170mm (w/o handle) Option B: 875mm*H42.2mm *W163mm (w/o handle)
	Solution 2: L945mm*H45mm*W134mm L933mm (w/o handle)	Solution 2: L945mm*H45mm*W134mm L933mm (w/o handle)	Solution 2: L945mm*H45mm*W134mm L933mm (w/o handle)
	Solution 3: L898.8mm*H40.0mm*W170mm (w/o handle)	Solution 3: L898.8mm*H40.0mm*W170mm (w/o handle)	Solution 3: L898.8mm*H40.0mm*W170mm (w/o handle)

Lower input voltage may require power derating.

8.2.2 AC/DC Power Shelf Control Module

AC/DC power shelf may incorporate a secure control unit, compliant with company specific requirements.

- *Optional active management via microcontroller,*
- *Optional module interface with a Rack Management Unit -interface standard defined in section 11*

Allocated space required per power shelf to fit a control module is listed below in Table 11.

Table 11: Mechanical dimensions for the control module.

Parameter	W (width) (mm)	H (height) (mm)	L (length) (mm)
Meta control unit	N/A	N/A	N/A
Microsoft RSCM	81.2	30	340.9
Google module	42	39.7	885

8.3 ±400VDC Distribution Busbar

- *There shall be a single zone vertical 3 conductor busbar in the rack that distributes +400, -400 and Common. The busbar shall be designed to support up to 1.1MW average load power.*
- *This vertical busbar interconnects with various building blocks such as the AC/DC power shelf, energy storage shelves, Output Control and Protection modules.*
- *The busbar is designed such that it shall be concealed/covered for no-touch safety.*

- *The busbar will be air-cooled and shall meet thermal requirements as described in section 12.1*

8.4 $\pm 400\text{VDC}$ to IT rack Distribution Cable

The $\pm 400\text{V}_{\text{DC}}$ power is brought out of the Mt. Diablo rack via multiple output cables.

- *Cabled cross links to IT rack DC/DC converter shelf can be a minimum of 63A/50kW up to 125A/100kW each cable.*
- *$\pm 400\text{Vdc}$ cable connectors on both ends shall have LMFB short pins to prevent arcing*
- *Each output connector contains at least three power contacts: +400V, Common, -400V; one earth contact and two sense contacts (LMFB). $\pm 400\text{V}$ and common are all rated from 63A to 125A.*
- *Connectors shall have a latching mechanism with an integrated physical switch on the output connector, so the cable cannot be disengaged until the switch has turned off the power of the load and the source at the time of disengagement.*
- *Each output of the $\pm 400\text{V}$ rail shall be individually current limited according to its maximum current rating.*
- *Voltage drop budget shall be 0.1% at 5m length for output cables.*
- *The respective output port shall be de-energized when the output cable is unplugged from either source side or load side. The load side input voltage shall drop below SELV within the safety specified time period.*
- *Output Protection and Control Module outputs may have the option to be turned off or on through a panel mounted switch located on the DC PDU.*
- *To minimize the number of wires in each output cable set and mitigate concerns about current sharing between cables, a single cable is preferred. However, if more than one cable is used, they should be sized appropriately to accommodate the current sharing tolerance.*

9 DC Output Interconnect Cables

This section lists options for DC output interconnect cables.

DC PDU electrical interconnect to IT rack has multiple options, one based on 50kW cables, and one based on 100kW cables.

In both options, output is wired as "3 wire output", $\pm 400\text{Vdc}$ and Common, plus additional pins for PE and 2 signal wires, used for voltage disconnect feature.

Wire gauge is specific per average power or RMS current decided per application. For North America, the parameters are below. Recommending considering design margin of 15%, as needed per application.

- *50kW (63A) - 4x 4AWG, in compliance per NEC derating for 65C ambient, table 310.60(C)(4).*

- 100kW (125A)- 4x 1AWG, in compliance per NEC derating for 65C ambient, table 310.60(C)(4).

Cables are W type, single conductors, 4 conductors bundle.

Also, impedance targets-inductance characterization are specific per application.

Optional:

- EMI shielding or ferrite cores
- IPX4 rated connectors (given liquid cooling environment in IT rack)

Details of options and connectors are listed in Table 12 below.

Connector part numbers are preliminary.

Table 12: DC interconnect options.

Assembly	Electric al interconnect source	Source connector DC PDU->	Source cable plug DC PDU->	Load cable receptacle IT DC/DC shelf->	Load connector IT DC/DC shelf	Electric al interconnect load
50kW output cable 3W to 3W 3W+PE +2S	"3 wire output": +/-400, Common, PE+2 signal	Amphenol® FCI 10185170-04-P013LF	Amphenol® FCI 10184021-003LF	Amphenol® FCI 10184023-003LF	Amphenol® FCI 10184015-002LF	"3 wire Input": +/-400, Common, PE+2 signal
100kW output cable 3W to 3W 3W+PE +2S	"3 wire output": +/-400, Common, PE+2 signal	Amphenol® FCI 10183400-009LF	Amphenol® FCI 10183401-009LF	Amphenol® FCI 10183401-013LF	Amphenol® FCI 10183400-016LF	"3 wire input": +/-400, Common, PE+2 signal
96/100kW output cable 3W to 2W 2W+PE +2S	"2 wire output": +/-400, PE+2 signal	Bizlink® 747-HV-Y3B2S5BNB2L H022CH	Bizlink® 747-HV-Y3A2S5BNN2Y H0Z100	Bizlink® 747-HV-Y3A2S5BNN2Y H0Z100	Bizlink® 747-HV-Y3B2S5BNB2L H022CH	"2 wire input": 800, 0, PE+2 signal

10 AC Input Interconnect Cables

This section lists options for AC interconnect cables.

Two options for AC PDU input cables. For North America, the parameters are below.

- 1. AC PDU interconnects use 3P+PE, Delta connection, 415Vac-480Vac 3 phase, 200A cables.*

There are two options of cables, one as a whip, where all 3P+PE cables are in one bundle, and the other as single-phase cable, where all cables are separated and routed individually as one-phase cables.

All 200A cables use W type wires. Single 200A conductors use 1/0 AWG, where 4 200A conductor whips use 3/0 AWG.

The data center busway connection is done via tap-box or MTS (manual transfer switch). Each option uses different connectors, as detailed in Table 13 below.

Connector part numbers are preliminary.

Table 13: AC interconnect options with 200Aac input.

Assembly	Electrical interconnect source	Source connector	AC cable plug input to AC PDU>	AC PDU connector
200A whip one phase connector 1x1	Tap-box	Mechanical lugs	1x1 connector Amphenol SurLock plug 8mm	Mating receptacle
200A whip 4x1C, Nylon mesh encapsulated	Tap-box, MTS	Ferrule	1x4 connector Molex plug	Mating receptacle of 1x4
200A whip 2x2	Tap-box	Mechanical lugs	2x2 connector Amphenol plug	Mating receptacle of 2x2 Amphenol

AC PDU output cables target two design options, where output cables and connectors selection to power shelves are left at solution implementer:

60A AC output cables

100A AC output cables

Option for 100A AC whip, listed in table 14 below.

- 2. AC PDU interconnects use 3P+PE, Delta connection, 415Vac-480Vac 3 phase, 100A cables.*

All 100A cables use W type wires. These are 4x single 100A conductor, mesh encapsulated assemblies using 2 AWG.

Table 14: AC interconnect options with 100Aac input.

<i>Assembly</i>	<i>Electrical interconnect source</i>	<i>Source connector</i>	<i>AC cable plug input to AC PDU></i>	<i>AC PDU connector</i>
<i>100A whip 4x 1C, Nylon mesh encapsulated</i>	<i>Tap-box, MTS</i>	<i>Ferrule</i>	<i>1x4 connector Molex plug</i>	<i>Mating receptacle of 1x4</i>

11 Management, telemetry and communication interface with the sidecar

11.1 Management

Sidecar/cabinet control module is a dedicated building block that may be used to interface with all Mt. Diablo building blocks.

Standard management interface based on Redfish® is recommended or may use proprietary interface as desired.

A. Hyperscaler specific per solution provider

May incorporate a secure control unit, compliant with company specific requirements.

- a. External interface option like Ethernet, etc.*
- b. Internal interface option like CANbus, etc.*

B. Other

Use communication ports “as-is”, like building blocks/manufacturer provided interface.

11.2 Telemetry

May use standard interface like Ethernet, I2C, PMBUS®, Modbus®, CANbus etc.

Power management may be implemented at the choice of each solution provider.

11.3 Communication

Interfaces may be selected based on the management approach specified above.

- *Sidecar to Datacenter network*
- *Sidecar to sidecar*
- *Sidecar to IT rack*

In-rack communication (building block to sidecar control module) shall be implemented.

12 Operating Environmental Conditions

- *The Mt. Diablo power rack and all of its building blocks placed inside the rack is designed to be fully air-cooled.*
- *Ambient temperature range: -5°C to 45°C (preferred), -5°C to 35°C (required)*
- *Lower range above, specified as ‘required’, may be influenced by component temperature ratings and lifetime requirements in sub-systems*
- *Relative humidity: 10% to 90% (non-condensing)*

- *Altitude without de-ratings: up to 3050m (10,000 ft)*

12.1 Subsystem Thermal Design Requirements

- *This section covers sub-systems such as PSU, BBU, CBU, etc.*
- *Air inlet and outlet temperature difference: Building blocks should be designed to meet a minimum value under a specified load profile/range and environmental conditions which may be specific to each customer.*
- *Thermal margin: Adequate margins should be reserved to de-rated values on all critical components. In general, a margin of $\geq 4\%$ of derated temperature rating or $\geq 3^{\circ}\text{C}$ must be met under rated load and elevated or worst-case environmental conditions. If this requirement cannot be met, failure conditions should be reviewed with the customer. Thermal monitoring: Building blocks shall provide the following parameters via the defined communication protocol. These include (but are not limited to) inlet air temperature, exhaust air temperature, critical component temperatures, fan speed reading(s), fan failure signal(s), etc.*

12.2 L11/Rack-level Operational Requirements

- *Airflow direction: Front-to-back*
- *Airflow containment: Appropriate containment features such as side panels, etc. should be added to the L11 assembly to ensure all sub-components fit well while mitigating airflow or hot air recirculation from the exhaust side to the cold aisle.*
- *Optional: Rack (safety) doors: Must be designed or selected to minimize back pressure on sub-systems and this pressure drop must be accounted for as part of the sub-system fan sizing/selection.*

13 Regulatory and Compliance Requirements

13.1 Safety Requirements

Both the fully integrated power rack system and associated subcomponents/ assemblies shall be designed to comply with the safety requirements outlined in the applicable safety standards (e.g. IEC/UL 62368-1, etc.) including all national deviations in addition to the following requirements:

- **SCCR Rating:** *AC Mains connected assemblies shall be designed to withstand an available short circuit fault current of 10kA to 40kA, dependent of specific of each application.*
- **Cable assemblies and power cables:** *Cables rated above 60Vdc or 42.4Vac shall be UL certified with minimum temperature rating of 90°C and of a type suitable for oil-resistant, damp locations, and hard usage conditions per the NEC (e.g. SJO, SJTOO, SO, SOO, SOOW, STO, W, etc.).*

- **Accessibility:** Components and circuits, including electrical connections intended to be connected/disconnected during either normal or servicing operations while the power rack system is energized, exceeding PS2 limits shall not be accessible while electrically live or energized. If access to components and circuits exceeding PS2 limits is required for either normal or servicing operations, an interlock, power off switch, or similar mechanism shall be provided for de-energization prior to gaining access.
- **Creepage and Clearance:** Design of Sidecar modules and connectors must comply with applicable safety standards for spacing requirements, e.g., IEC 62368. The designer/implementer may use discretion to exceed the standard requirements when appropriate for their use case. Use cases shall include AC input and DC output parameters, across thermal and environmental conditions, including peak potential, transient or test conditions.
- **Overcurrent Protection:** outputs shall be provided with overcurrent protection.
- **Protective earthing and bonding:** output cables shall be provided with dedicated protective grounding for connections between both the Power and IT Racks to ensure a safe and reliable ground for fault currents. All protective grounding terminals shall be securely bonded and marked in compliance with IEC 60417 (ref. no. 5019).
- **Leakage current:** The power rack system shall not have a leakage current exceeding 3.5mA (AC) and 10mA (DC).
- **Fault Detection:** Ground Fault Detection features shall be provided for effective protection against fault conditions.
- **Stability:** The power rack system shall remain stable and not tip over when tilted up to 10° in any direction.
- **Energy Storage Systems (ESS):** Energy Storage Systems (ESS), including battery modules and cells, shall be designed to comply with the safety requirements outlined in all the applicable safety standards (e.g. UL 9540, UL 9540A, UL 1973, IEC 62133, etc.), NFPA 855, and transportation requirements (e.g. UN 38.3, IATA DGR, IMO International Maritime Dangerous Goods Code, etc.).

Fire propagation tests per UL 9540A shall be performed at the cell, module, and rack levels. No external flames are permitted during rack-level testing and shall comply with the criteria not to trigger the installation base fire tests.

13.2 Electromagnetic Compatibility (EMC) Requirements

The fully integrated power rack system and associated subcomponents/assemblies shall be designed when integrated together to comply with requirements for Class A devices when tested according to CISPR 32 and CISPR 35 standards, and applicable national regulations

(i.e. FCC CFR 47, part 15 in the USA, ICES-003 in Canada, EN 55032 and EN 55035 in Europe, etc.) across the full range of supported operations and configurations (i.e. idle, normal, minimum/maximum workloads, etc.) in addition to the following requirements, listed in Table 15.

Table 15: Additional EMC requirements.

Test	Test Method	Requirement
Radiated and Conducted Emissions	ANSI C63.4/CISPR 32	Min -6 dB margin
Electrostatic Discharge (ESD) - Contact Discharge	EN 61000-4-2	Preferred ± 5.6 kV, Criteria A, /min ± 4 kV, Criteria A,
Electrostatic Discharge (ESD) - Air Discharge	EN 61000-4-2	Preferred ± 11.2 kV, Criteria A /min ± 8 kV, Criteria A
Surge	EN 61000-4-5	Differential Mode: Preferred ± 2 kV, Criteria A /min ± 1 kV, Criteria A Common Mode: Preferred ± 4 kV, Criteria A /min ± 2 kV, Criteria A
Radiated Immunity	EN 61000-4-3	Min 10V/m Criteria A

13.3 Environmental, Eco-Design, and Sustainability Requirements

The fully integrated power rack system, associated subcomponents/assemblies, and any packaging shall be designed to comply with worldwide environmental, eco-design, and energy efficiency laws and regulations (e.g. RoHS Directive 2015/863/EU, REACH Regulation (EC) No 1907/2006, WEEE Directive 2012/19/EU, SCIP and EPA 40 CFR751, Commission Regulation (EU) 2021/341, etc.).

14 Reference section

Additional reference information listed in Table 16.

Table 16: References.

Document number	Description	Comments
UL/IEC 62368-1	Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements	
IEC 62133	International safety standard for rechargeable batteries	
UL 9540	Standard for Safety of Energy Storage Systems and Equipment	
UL 9540A	Fire-propagation and thermal-runaway test method for battery energy storage systems (ESS).	
NFPA 855	Standard for the Installation of Stationary Energy Storage Systems	
CISPR32/35 EN 55032/35	Electromagnetic compatibility of multimedia equipment	
EN 61000-4-2	Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test	
EN 61000-4-34	Electromagnetic compatibility (EMC) – Part 4-34: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests for equipment with mains current more than 16 A per phase	
ITIC	Information Technology Industry Council (ITIC), ITI (CBEMA) Curve Application Note, October 2000" with its itic.org URL	
DMTF, DSP0266	Redfish Specification	

Other standards referenced in this document, as listed.

Appendix A

This section presents a simple list of pros and cons related to two types of PE grounding methods.

- High Resistance Grounding (HRG)

- No arcing or fire risk when +/-400V short to PE

- No serious injury to human body if touching +/-400V due to limited leakage current

- Increased spacing requirements of downstream DCDC -to be confirmed by DCDC Designer/safety.

- Complex design and maintenance

Pro1: No electric shock risk if touching +400 V or - 400 V with reference to ground.

Electric shock risk still exists between +400 to -400.

Pro2: Mitigates arcs due to a line to ground fault. Note: does not protect against line-to-line faults

Con1: Electric shock risk if touching +400 V or - 400 V under single fault condition where the other leg faults to ground

Con2: Fault detection is required to effectively resolve a fault to ground before a second fault occurs.

Con3: Putting fault detection at payload rack tray level may be expensive. Having fault detection on per rack level (or even Sidecar level) will be difficult to troubleshoot.

Con4: First fault to ground will not disrupt operation and therefore is at risk of being a lower priority to resolve. Second fault to ground can create a fire/electric shock risk.

Con5: Sensors must be calibrated and tested on a recurring basis. A defective sensor must be replaced immediately. If the sensors are not operating properly this could give you a false sense of security.

Con6: Multiple sources in parallel would reduce the impedance to ground and increase the touch current

Con7: A component in a payload rack that was designed for high impedance grounding scheme may not be suitable for use in a low impedance grounding scheme. If the component is deployed in a Data Center with DC bus but it does not employ a high impedance grounding scheme, careful review of the component must be done to ensure compatibility. For example, a component designed for use in a high impedance grounding system may not have input fuses or functional insulation may have been used between the 400V to chassis.

- Solid Grounding (SG)

- Simple design and DC maintenance

- Safety distance based on 400Vdc.

- Blown fuse or burnt component when +/-400V short to PE

- In certain configurations, grounding current may need to be mitigated to prevent potential issues.

Pro1: Widely used solution for AC power distribution.

Pro2: Fuse instead of sensors-based circuit protection to cut power on a fault condition

Pro3: Easier to identify the problem circuit

Pro4: Safety standards have clear requirements for products used on a system with low impedance grounding

Con1: HV parts shall not be accessible, as high body current discharge possibility exists

Con2: Arcing may occur until fuse operates

Con3: The bond between the accessible conductive part and ground must be able to carry fault current until overcurrent protection opens.

Con4: multiple power racks with solid grounding generate multiple ground loops

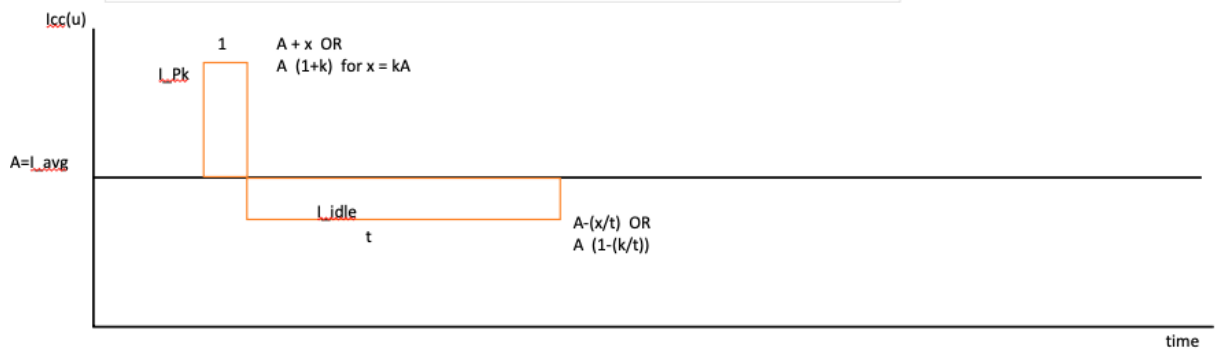
Appendix B

This section describes estimating average and RMS values to determine impact on thermal power estimate.

- Average current vs RMS current thermal impact

Let $I_{cc}(u)$ and $V_{cc}(u)$ be Random Variables, able to take any value from a universe of values (u).

Let function $E\{\}$ be Expected Value, i.e., average, of a given Random Variable being operated on.



$$A = E\{I_{cc}(u) \text{ at GF}\} = I_{avg}$$

$$A+x = I_{Pk} = E\{I_{cc}(u) \text{ Worst Case Max}\}$$

$$I_{rms}^2 = \frac{1(A+x)^2 + t\left(A - \frac{x}{t}\right)^2}{1+t}$$

$$\frac{I_{rms}}{I_{avg}} = SQRT\left(1 + \frac{k^2}{t}\right) \text{ for } x = kA$$

Implementations of GPUs CPUs Average (Thermal) Power algorithms could measure and average the processor power. Within the processor, the dominant power is the Dynamic Power which is linear with Current, i.e., $P_{dyn} = I_{dyn} * V_{cc}$, where $I_{dyn} = C * V_{cc} * Freq.$, the controlled and measured Processor Average Power will render a resultant Average Current proportional to Average Power.

On the other hand, power losses in hardware circuitry (such as VRs) are result of current over Real Resistance. This VR average power calculation requires use of I_{rms} (see below).

I_{RMS} to I_{AVG} ratio is the VR steady state thermal "gain" or how much thermally bigger the VR needs to be when compared to one just designed to I_{AVG} rendered by processor at TDP.

VR thermal gain is dependent on the magnitude of I_{Pk} , i.e., $k!!$... the higher the I_{Pk} , the higher the impact on the VR.

You need Average Power to determine thermal power (you get joules out of P_{avg})

You need RMS current to determine Average Power at the VR ckt.

$$P_{inst} = I_{cc}(u)^2 * R$$

$$P_{avg} = E\{P_{inst}\} = E\{I_{cc}(u)^2 R\}$$

$$P_{avg} = E\{I_{cc}(u)^2\} R$$

$$P_{avg} = (I_{RMS})^2 R = \frac{(V_{RMS})^2}{R} = I_{RMS} V_{RMS}$$