

LVDC direct-to-server and power shelf Challenges and solutions

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Agenda Items

- Power conversion in LVDC
- LVDC – maximize the benefits
- LVDC – Challenges to overcome
- LVDC Power conversion
  - Rack mounted solutions
  - Board mounted solutions
- LVDC Board mounted conversion challenges and proposed resolution
- Call to action

LVDC – Key architectures





- 50V : 12V Non-isolated DCDC





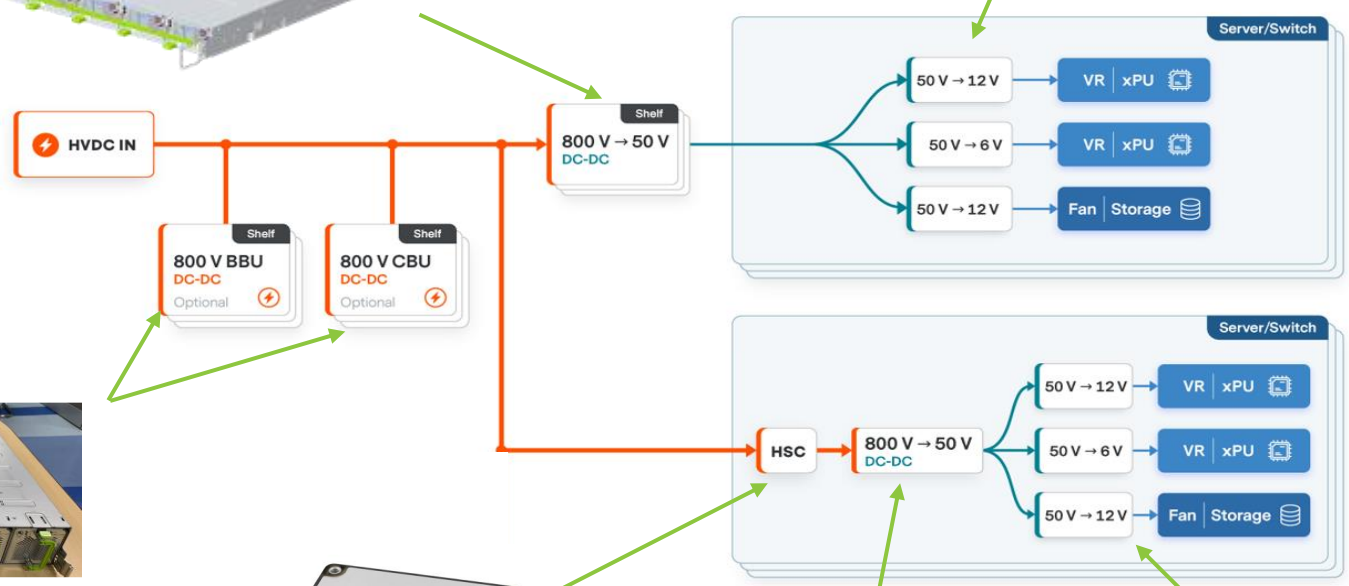
- LVDC in/out Hot-swap controller



- LVDC:50V Isolated DCDC



- 50V : 12V Non-isolated DCDC



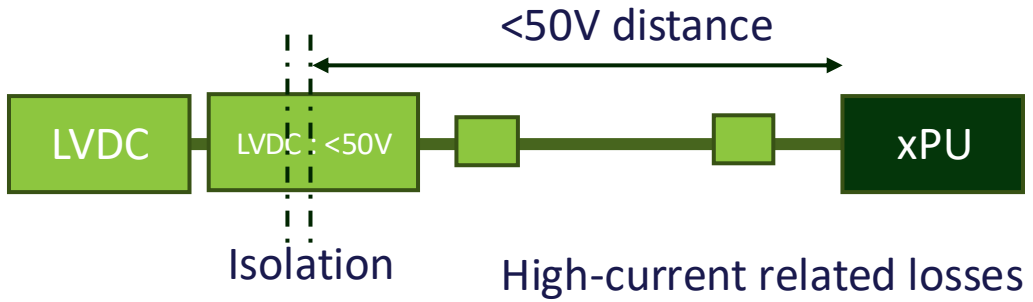
LVDC - Distribution and benefits

- The Motivating factors behind LVDC distribution are well know and documented and is a key enabler to achieve the power-delivery required for next-gen IT racks.

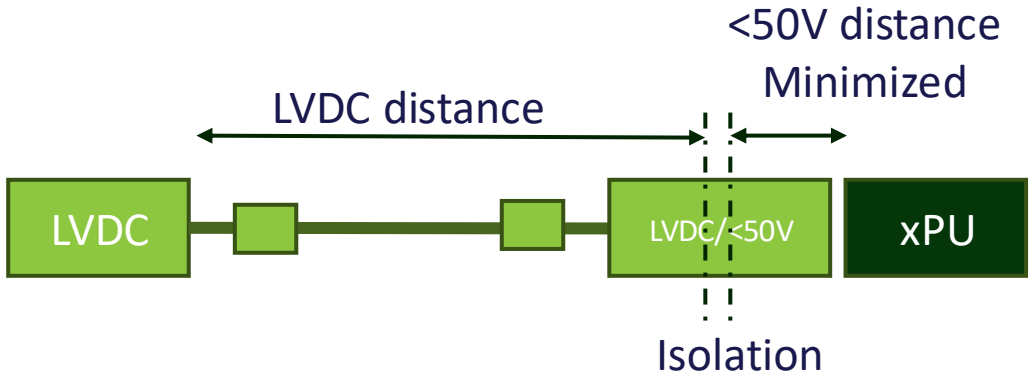
- The task is to convert the **LVDC to <1V** with voltage-conversion steps along the way. The questions are
  - Where should those voltage-conversion steps happen?
  - What are the voltage levels that should be used?

- The 'deeper' the LVDC goes (closer to xPU device), the more benefit is realized.
  - "deep" means does it remain at the connection point of the equipment or penetrate further into the rack-mounted equipment

- The trade-off is that LVDC is more challenging to accommodate the "deeper" it goes into the equipment.



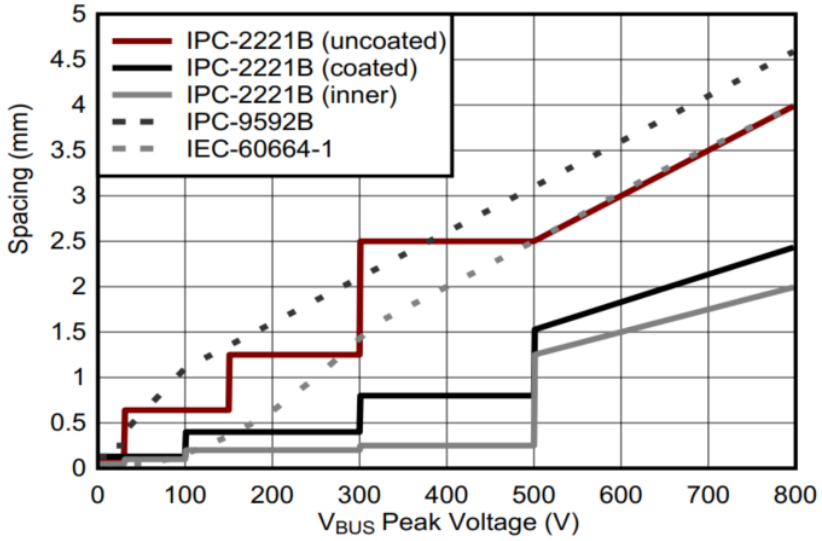
High-current related losses
- Distribution
- Connectivity



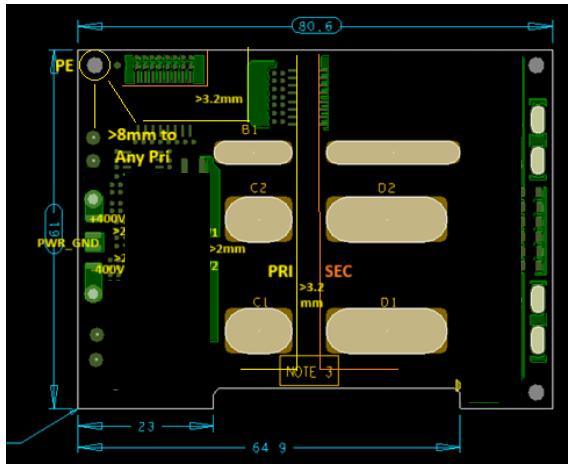
High-current related losses minimized

Challenges to overcome

- SAFETY
  - The biggest and most challenging aspect is inherently safe power conversion
  - Isolation/Insulation does not just apply to cables, bus-bars and connectors
  - For power-Conversion it applies to
    - Input-to–output, Input-to-ground and output to ground.
- “LVDC” has been adopted by the community to relate to +/-400Vdc or 800Vdc
  - From the Safety Standards, Low Voltage (LV) is only voltage LESS than 60Vdc; Typically known as ELV or SELV
  - Voltages that exceed 60Vdc are, by definition HAZARDOUS
- WHO are we protecting
  - Installers, Production Operators and maintenance staff
  - Production staff of the equipment.

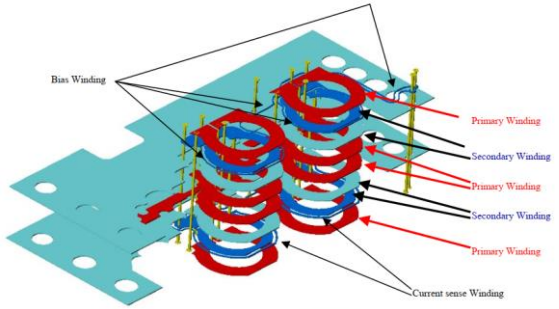


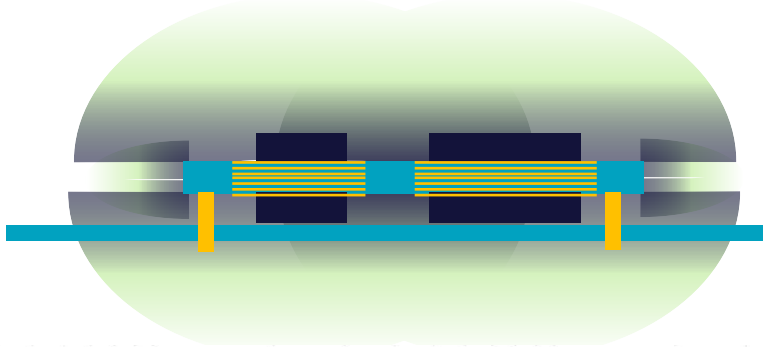
- Layouts to follow
  - IEC62368
  - IEC60664
  - IPC-2221B

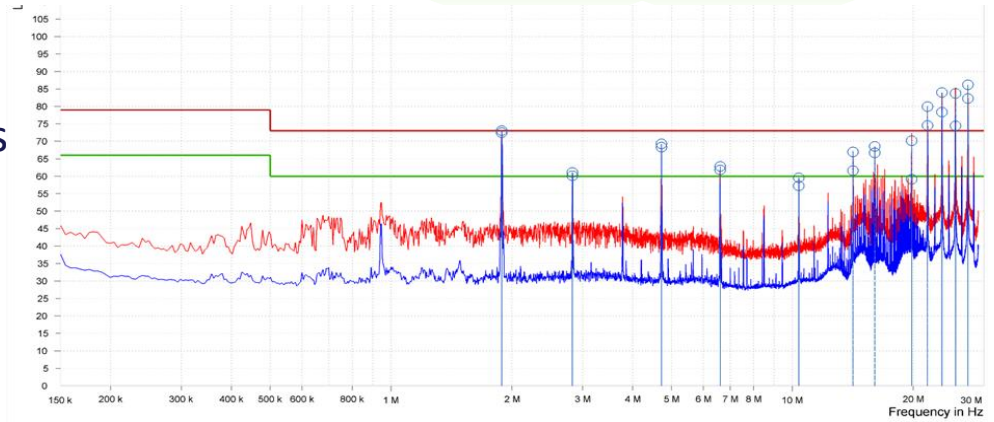


Challenges to overcome

- What about EMI? (THE most common question asked today)
  - EMI must be considered if the voltage supplies to more than one piece of equipment, and becomes more important with more equipment
  - 50V systems have been historically limited to how many pieces of equipment supplied over short distances (within 1 IT rack) – Effects of EMI not “so” critical.
  - Switching frequencies now exceeding 1MHz = lowest conducted-EMI noise limits
  - Conducted EMI (Rack and BMP)
    - Particularly important for Scaling Multiple cabinet connections
  - Radiated EMI (BMP).
    - Particularly important when deploying BMP power conversion in close proximity to target devices.

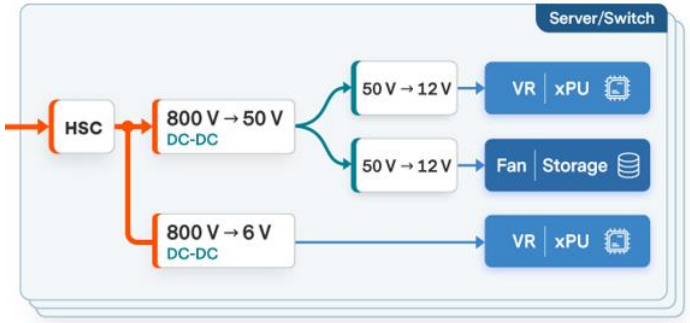


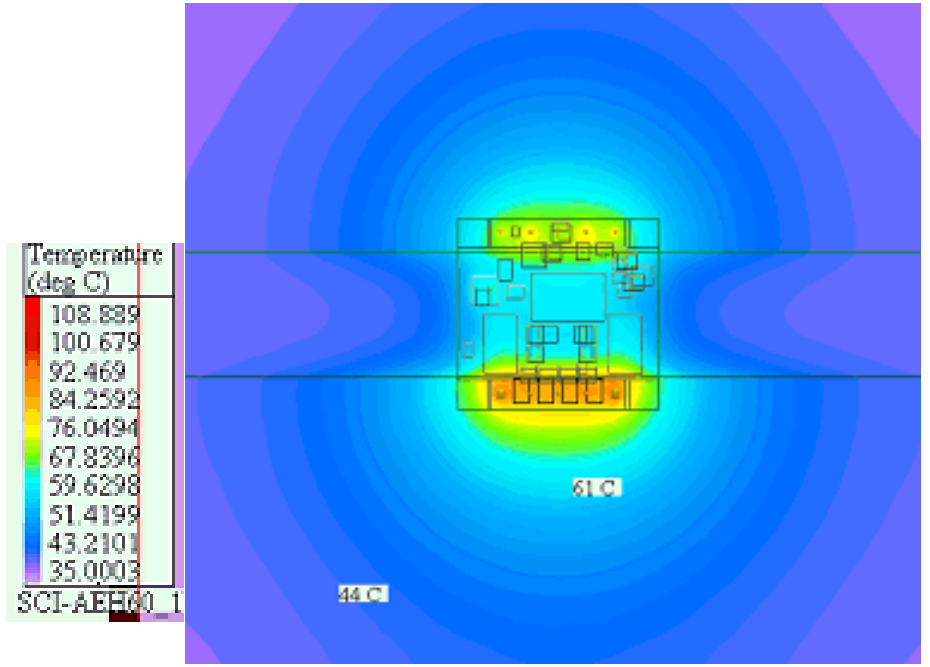




Challenges to overcome

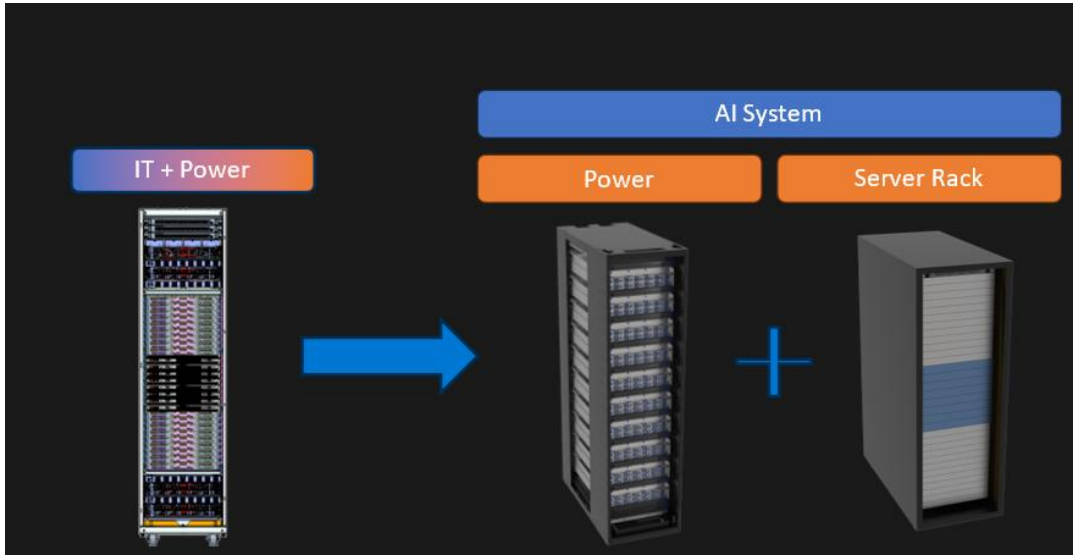
- Distribution current.
  - The Lower voltages; keeping the distance that they are supplied as small as possible means less losses and less parasitic effects.
  - Choosing the right power-conversion steps with corresponding output current is critical for success.
- Cooling.
  - General statement; power conversion architectures are transitioning toward fluid-cooling
  - Leakage is a tangible reality, and leaking fluid is not desired.



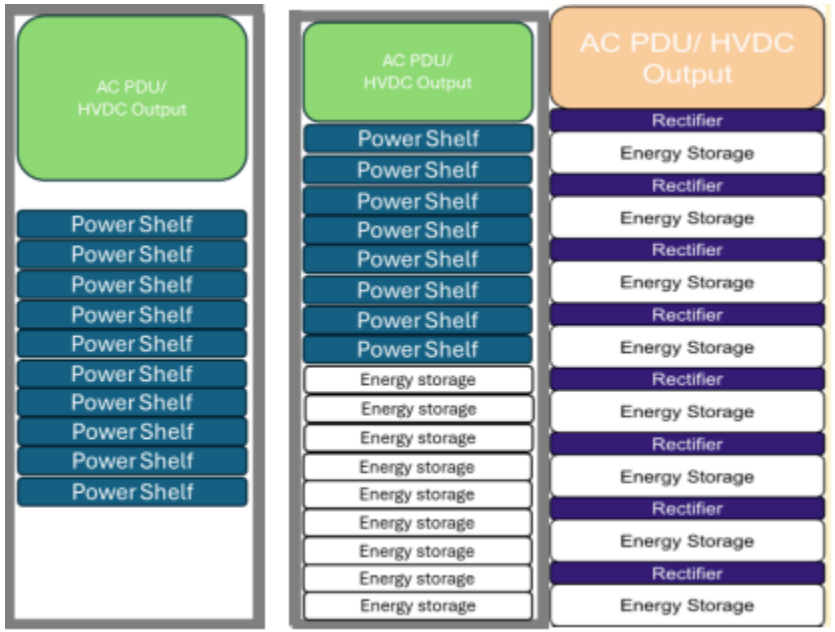


LVDC Solutions

- **Option 1 - Rack-mounted**
  - Mt Diablo (3 Phase AC **to** 800V or +/-400V)
  - Down Conversion (800V & +/-400V **to** 50V)



  - Can take the advantages of LVDC distribution in the rack
    - Smaller connectors, cables and bus-bars
    - Lower conduction losses.
  - Down conversion Options
    - LVDC to 50V
      - The 100KW Power Shelf
      - The 160KW Power Shelf.

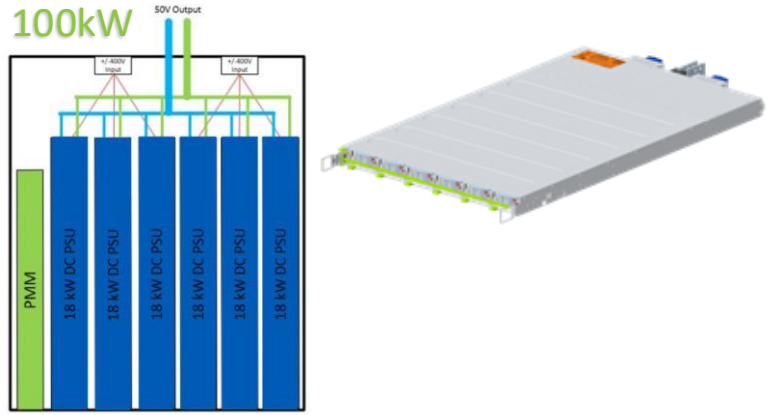


Three examples of power rack configurations.

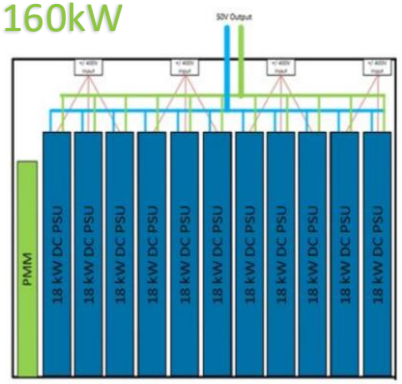
Rack mounted power solutions

	160KW Power Shelf	100kW Power Shelf
PSU Rating	18KW	18kW
Input Cable	4x HVDC 6 pin connectors: +400V, -400V, Return, Earth, Sense1 and Sense2 I/P Current : 4x62.5A	2x HVDC 6 pin connectors: +400V, -400V, Return, Earth, Sense1 and Sense2
Shelf output connector	Bolted, BK5000 28mm thick : 4kA	Bolted, BK2000
Shelf output connector temp monitoring	Yes, with thermistor	Yes, with thermistor
External busbar temp monitoring	Yes, with sensing circuit	Yes, with sensing circuit
Shelf (W x H x D)	855mm x 46mm x 1086mm	537mm x 46mm x 867mm
PSU (W x H x D)	83.4mm x 40mm x 680mm	83.4mm x 40mm x 690mm

100kW



160kW

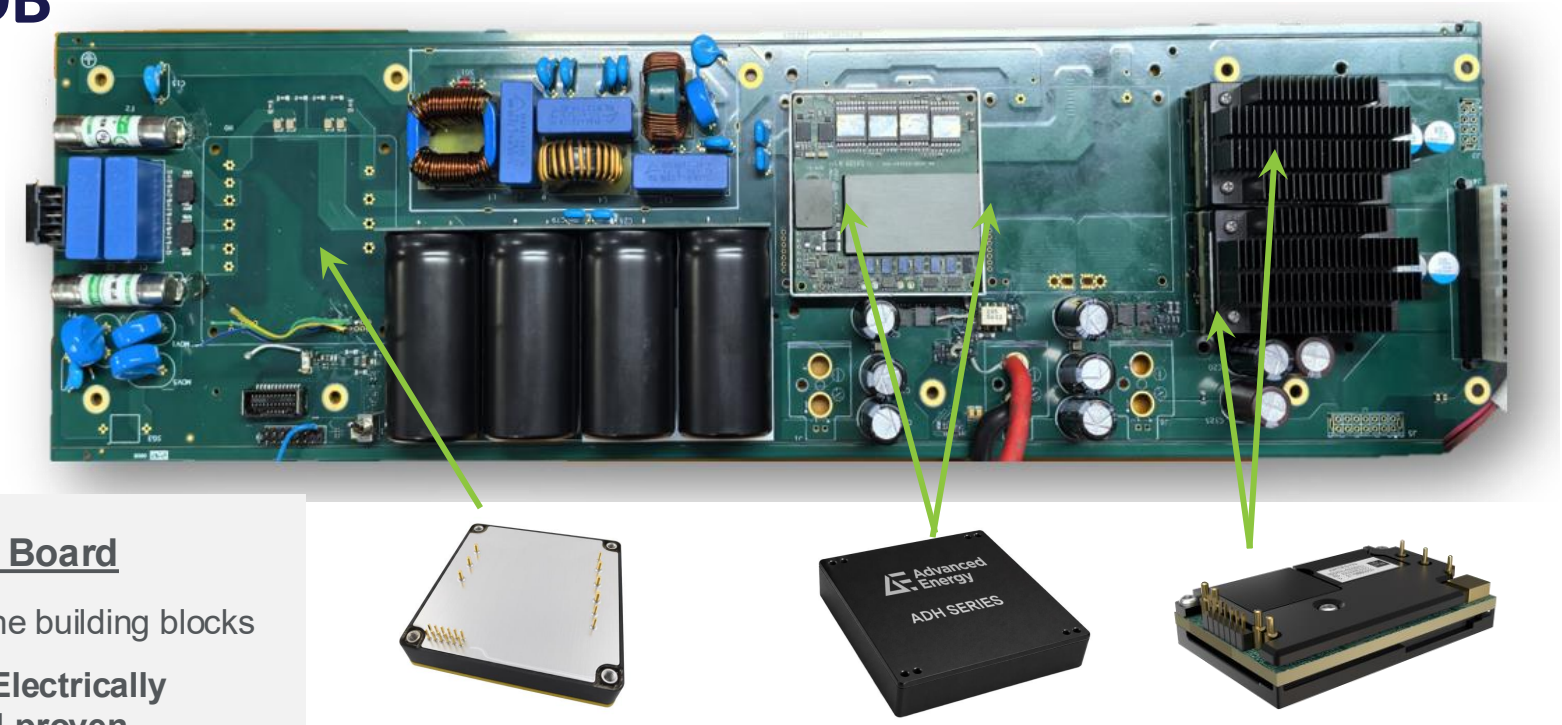




100kW and 160kW both uses 18kW PSU, Same PMM as HPRv2

LVDC Solutions

Option 2 - PDB



Power Distribution Board

- The integration of the building blocks
- **Safety approved, Electrically characterized, EMI-proven.**
- **Includes the hold-up capacitance**
- **Fusing and digital control**
- **Accelerated development speed!**

Hot Swap Controller

- Active inrush and discharge with Discharge
- Digital Monitoring
- Auxiliary Output.

800V to 50V

- DCDC modules.
- At >98% efficiency
- Isolated, non-regulated

NIBC 12Vout Bricks

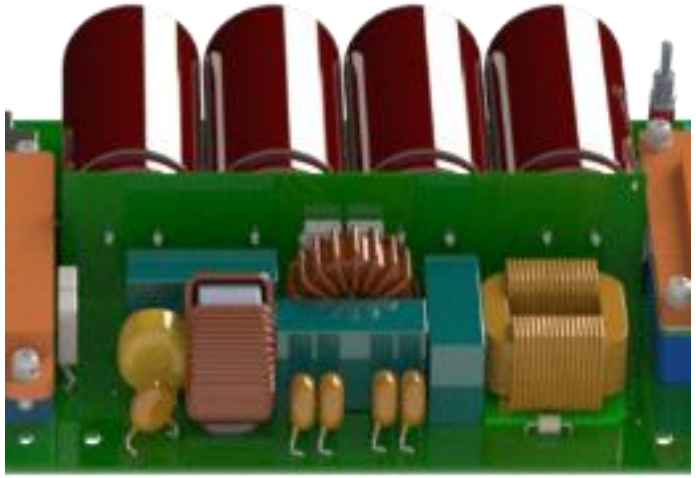
- 50V connection and systems
- Regulated 12V needed with current-sharing

Challenges

- Isolated DCDC Power conversion density now exceeding 2000W/in^3
  - Designs have to provide significant Isolation and Insulation distances.
  - We have large components to accommodate
    - Hold-up capacitors
    - Connectors
    - EMI filters
    - Fuses
- Other bus voltage
  - Voltage-transients, short-drop-out of input etc

Hold-up caps are large proportional to time, but will have in-rush to manage

Multi-stage EMI filter needed due to power demand and switching frequency





Large fuses and connector for LVDC rating



Large or many-way connectors required for <50V

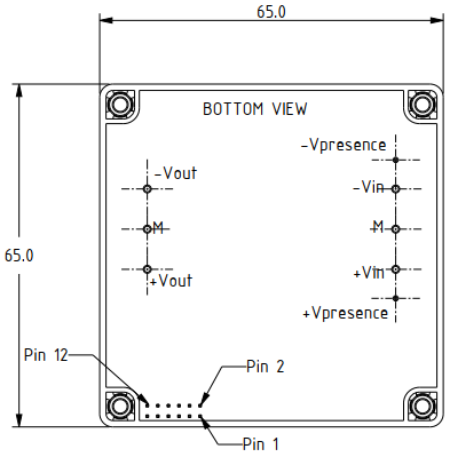
Hot Swap Controller

- Input and output voltage is the LVDC
- Standard ½ brick size
- Controls the INRUSH current caused by the hold-up capacitors on hot-plug of the rack-mounted equipment
- Controls the DISCHARGE of the hold-up capacitors on hot-extraction of the rack-mounted equipment
- Integrated PTC to support these functions
- Provides ISOLATED 12V Auxiliary output for house keeping circuity on the PDB assembly
- Provides digital control and monitoring
  - IDEAL point to monitor and report input voltage and current.
- The Unit must be fully thermally managed for fluid-cooled baseplate attachment





Unit: mm



LVDC input to 50V DCDC BMP

- The DC-DC conversion needs to be Specified as
  - Power-rated to be convenient building blocks
  - Standard size, ½ bricks for easy and flexible integration
  - Input voltage to accommodate all LVDC variations
  - Output voltage current are 50V or 12V variants.
  - Reinforced Insulation needed for safety
  - Isolated for safety
  - Un-regulated as the LVDC is tightly controlled
  - High efficiency, >98% efficiency is a must-have
  - Contact-cooled to fluid-cooled baseplate
  - Digital control and monitored

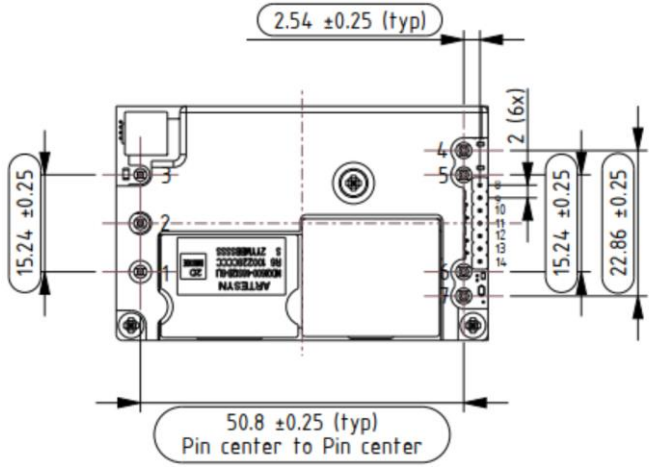


- Thermally optimized design for baseplate to be thermally bonded to fluid-cooled cold-plates

50Vin to 12V BMP

- Re-use of existing platforms used in 50V systems
- Non-Isolated (ELV input, ELV output)
- Regulated required for 12V down-stream use.
- Standard ¼ brick modules
- Optimized for fluid cooled baseplates
- Highly efficient, 98%
- Many different power levels available
  - 900W
  - 1300W
  - 1600W
  - >2500W





Pin No	Name	Function
1	Vin+	Positive input voltage
2	Remote ON/OFF	Remote control
3	GND	Negative input voltage
4	GND	Negative output voltage
5	GND	Negative output voltage
6	Vo+	Positive output voltage
7	Vo+	Positive output voltage
8	PG	Power good
9	-Remote sense/Sig-ground[1]	Negative remote sense/signal ground
10	DATA	PMBus™ Data
11	SMBAlert	PMBus™ Alert signal
12	CLK	PMBus™ Clock
13	Addr	PMBus™ Address
14	+Remote sense/Current share[2]	Positive remote sense/current share

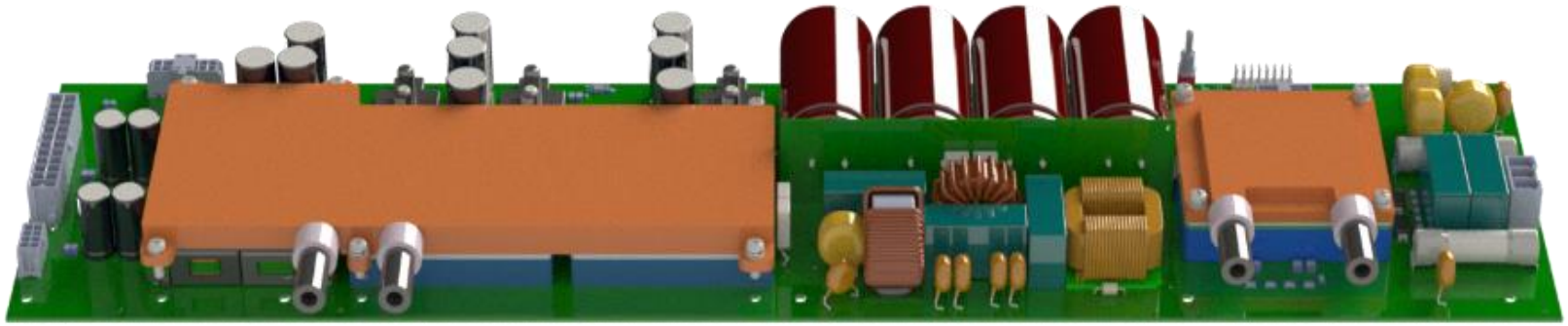
- Thermally optimized design for baseplate to be thermally bonded to fluid-cooled cold-plates

Challenges Overcome using a PDB sub-assembly.

- Safety approved sub-assembly
- Cooling, thermally optimized and characterized
- Power density optimized for DCDC
- Fast Time To Market – using Scalable standard building blocks
- Control and monitoring – using digital controlled units

- EMI; Conducted and Radiated. Characterized and approved
- Hold-up function sized for the application requirement
- Inrush limiting sized for the in-rush
- Active-discharging for safe handling of equipment.

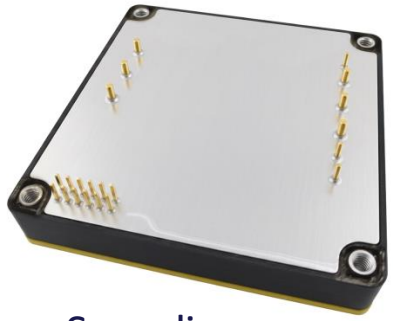
- Customized packaging of modular building blocks



AE's Prototype and Production units

HSC module

- 12KW
- LVDC-in, LVDC-out



Sampling

LVDC ; <60Vdc

- 4KW 50V
- 6KW 50V
- 3KW 12V



Sampling

Non Isolated Bus Converters

- 900W
- 1300W
- 1600W
- >2500W Sampling



LVDC 100KW Power Shelf



Sampling

LVDC 160KW Power Shelf



Sampling

Power Management Controllers



Sampling

Call to Action

- Get involved in the Rack and Power Project/Sub-Project Community!
- Is there a need for a standardized OCP compliant PDB?
- Involvement within the community is key for the success of next generation power specifications.
- Defining individual requirements are key to creating an overall industry specification.

- Project Wiki with latest specification : https://www.opencompute.org/wiki/Open_Rack/SpecsAndDesigns
- Mailing list: https://www.opencompute.org/projects/rack-and-power

Thank You!

