OCP GLOBAL SUMMIT

Beyond Power Density

Building a Safe 800V DC Ecosystem



Joe Skorjanec | Eaton

50VDC and 800VDC solve different problems

Higher voltage improves distribution efficiency and power density, but moves the system into a fundamentally different safety domain.

Architecture	Nominal voltage	Polarity	Ground / reference	Primary benefit	Safety implication
Telco −48VDC	−48V (typically −42 to −56V)	Negative	Ground-referenced	Legacy telecom distribution	Lower-voltage shock domain; architecture-specific grounding
PoE++ / 802.3bt	~52–57V	Floating	Isolated	Power + data on network cable	Energy and power are intentionally limited by the system
OCP 50V-class rack bus	~48–54V (up to ~60V class)	Positive	Floating or grounded by design	High-current, short-distance rack distribution	Familiar lower-shock-hazard design space, subject to full source classification
800VDC distribution	**~800V**	**Positive / return**	**Defined by system grounding strategy**	**Much lower current for the same power; efficient row-to-rack distribution**	**Hazardous voltage: controlled access, insulation, interlocks, DC-rated interruption and verified isolation required**

For the same power
800V ≈ 1/16 the current of 50V

60VDC is a useful safety marker, not a complete safety verdict.

At 800VDC, the ecosystem must actively prevent contact and rapidly control fault energy.

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800VDC is hazardous, but it is not transmission HVDC

Voltage class and hazard class answer different questions. Always state the actual voltage and governing standard.

MISCONCEPTION

“800VDC = HVDC”

FORMAL IEC-ORIENTED VIEW

800VDC remains inside the broad low-voltage DC system domain, whose upper boundary is 1,500VDC.

IEC VOLTAGE CONTEXT + UL/IEC 62368-1 ENERGY CLASS

800VDC

ES1	EXTRA-LOW VOLTAGE	LOW VOLTAGE DC	ABOVE LV	TRANSMISSION HVDC
≤ 60VDC	≤ 120VDC	>120 to 1,500VDC	> 1.5kVDC	typically 100–800kV
UL/IEC 62368-1 lower electrical-energy class*	IEC protective-measure boundary	Broad IEC system-voltage domain	High-voltage domain	Bulk grid transmission technology

Recommended terminology: “800VDC distribution” or “800VDC power architecture”

! LOW VOLTAGE ≠ LOW HAZARD

800VDC still requires controlled access, insulation, interlocks, DC-rated interruption and safe isolation.

*ES1 classification also depends on source-current and fault-condition limits, not voltage alone.

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The transition is bigger than a voltage change

Moving conversion out of the compute rack also moves the safety concerns into the white space.



CONVERSION	DISTRIBUTION	PROTECTION	SERVICE	OPERATIONS
Where AC becomes DC	Where 800V travels	Where faults clear	Where people interact	How recovery works

Design the architecture and the safety system together.

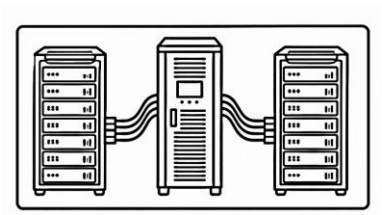
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Three approaches to 800V DC

This session focuses on power racks (previously known as sidecars). MVSST is shown as part of the broader DC architecture evolution.

SIDE POWER RACK

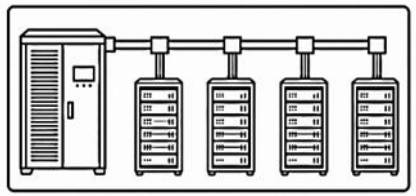




- Adjacent AC-to-DC conversion
- Dedicated 125A circuits
- Point to point outputs
- Contained in rack-to-rack envelope

Rack to rack system

POWER CENTER

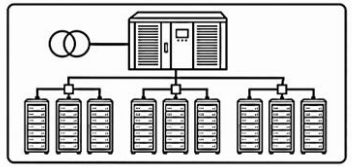




- Central or row-level conversion
- High-current DC output (1250A)
- Overhead busway distribution or RPP cable fed
  - Protected 125A tap-offs

Row or Pod distributed infrastructure

MVSST





- Direct MVAC-to-800VDC conversion
- Building or data-hall power block
- Feeds DC switchboard / busway
- Broader facility architecture

Facility DC architecture

PRESENTATION FOCUS: POWER RACK ARCHITECTURES

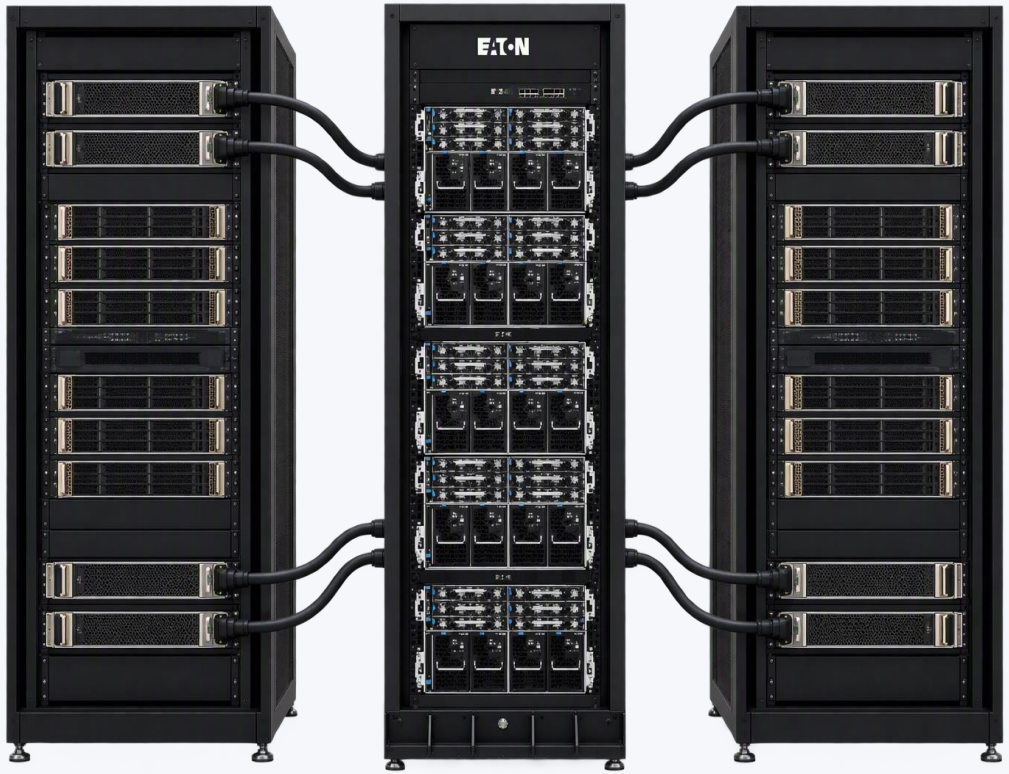
Architecture determines the location of conversion, protection, isolation and service boundaries.

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Approach 1: point-to-point Side Power Rack

Short, dedicated 125A DC paths connect an adjacent power rack to DC-DC shelves in the compute rack.



SYSTEM CHARACTERISTICS

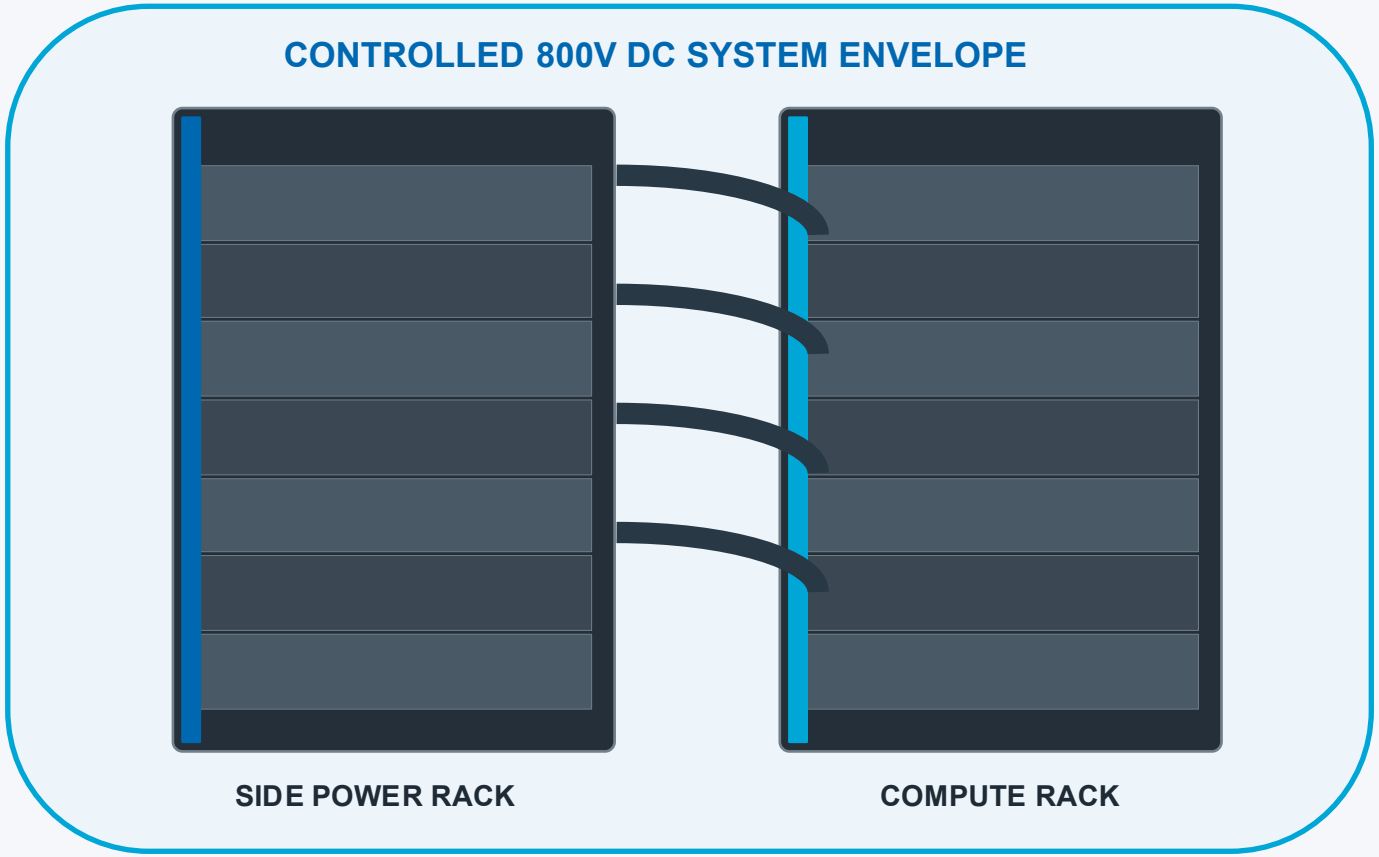
- AC-to-800VDC conversion adjacent to compute
- One 125A output per protected circuit to one DC-DC power shelf in compute rack
- Optional battery backup integrated in rack
- Multiple paths support capacity and redundancy
- Source protection close to cable origin

≈100 kW per 125A circuit at 800V

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Side Power Rack: keep 800V DC inside a controlled envelope



- Mechanical pass-through protects routing from external access
- Door and panel block access and controls exposure
- Protection device remains close to source
- Connector interlock trips before separation
- Isolation zone can be limited to one path

Contained does not mean unregulated. It means the system boundary is explicit.

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Approach 2: Power Center with overhead busway

The DC distribution pathway becomes part of the white-space electrical infrastructure.



DISTRIBUTION CHAIN

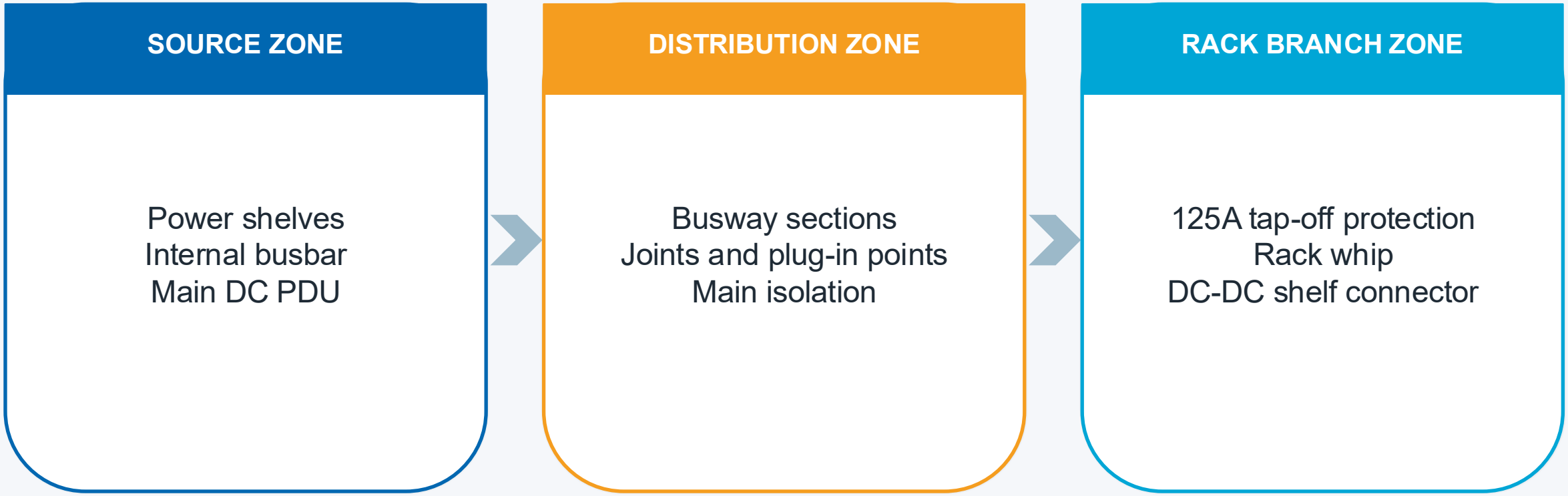
- Power shelves
- Touch-safe busbar
- DC PDU
- Overhead busway
- 125A tap-box to connector drop
- 800V-54VDC power shelf
- Busbar distribution to compute

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Power Center: three safety zones

A selective protection strategy prevents a single branch fault from becoming a row-level event.



Design question: what can be isolated without de-energizing the entire row?

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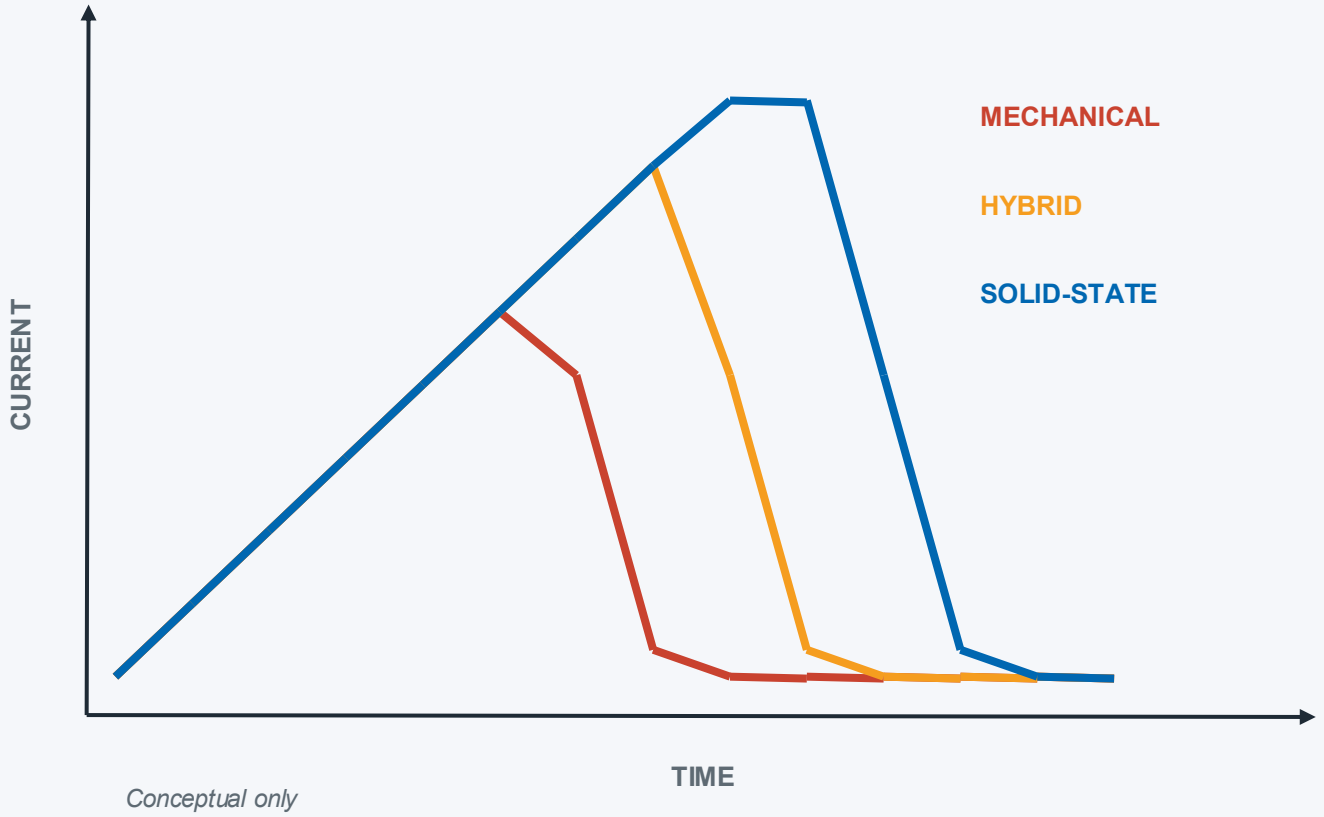
Different architecture, different risk concentration

DESIGN DIMENSION	SIDE POWER RACK	POWER CENTER
CIRCUIT LENGTH	Short, dedicated	Shared trunk + short branches
SOURCE-LOAD RELATIONSHIP	Known point-to-point	Many loads on common distribution
PROTECTION LOCATION	At each rack output	Main + coordinated tap-off protection
ISOLATION ZONE	Individual path / adjacent rack	Branch, section, row or pod
PRIMARY COMPLEXITY	More cables and connectors	More joints and coordination
FAILURE CONTAINMENT	Shelf or rack path	Requires selective branch clearing

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DC fault behavior changes the protection discussion

Fault current is shaped by the source, cable or busway impedance, local capacitance and clearing behavior.



Conceptual only

- No natural current zero crossing
- Capacitors or battery may feed the fault after converter shutdown
- Fast interruption can reduce incident energy
- Device rating must match DC voltage and system time constant
- Model available fault current and clearing time

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Circuit protection needs four coordinated layers

1	**DETECTION**	Overcurrent • dI/dt • insulation • residual current
2	**FAST INTERRUPTION**	E-Fuse/Solid-state, hybrid or DC-rated mechanical device
3	**PHYSICAL ISOLATION**	Air gap • disconnect • lockable state
4	**BACKUP PROTECTION**	Fuse • upstream shutdown • coordinated selectivity

One component does not need to perform every safety function.

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EPO is a system sequence, not just a red button



1

SIGNAL

Emergency command received

2

STOP

Block new converter energy

3

TRIP

Open DC output protection

4

ISOLATE

Disconnect BBU and backfeed

5

DISCHARGE

Reduce stored energy

6

VERIFY

Confirm safe voltage state

Converter shutdown ≠ electrically safe work condition

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Connector safety: prevent separation under load

The interlock should initiate source-side isolation before the main power contacts separate.



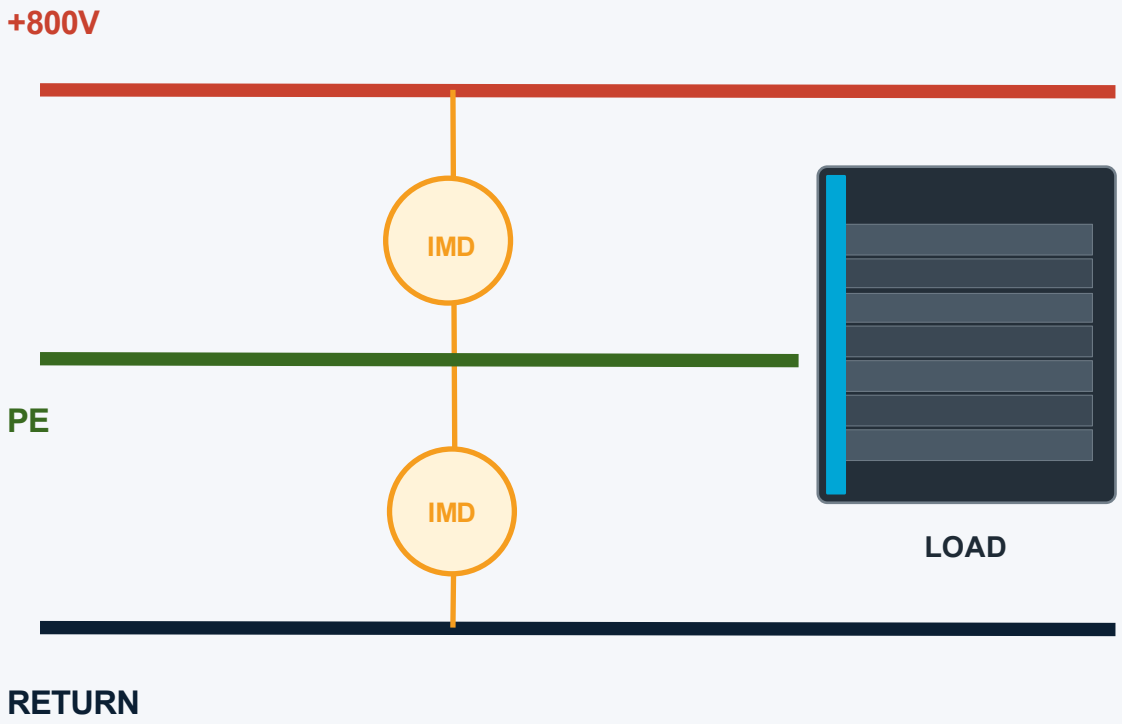
1	**LATCHED**	Mechanical retention
2	**INTERLOCK OPENS**	Trip command to source
3	**CURRENT CLEARS**	Protection interrupts
4	**POWER SEPARATES**	Touch-safe state

Not a disconnect under load device unless specifically designed and certified for that duty.

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Grounding, bonding and fault monitoring

Grounding determines fault behavior. Monitoring determines whether the first fault becomes a hazardous second fault.



- Bond every exposed conductive enclosure
- Define the DC reference: solid, resistance or impedance grounded, or unearthed
- Use insulation monitoring for floating or impedance-referenced systems
- Alarm and locate the first fault before a second occurs
- Use residual-current monitoring where it improves branch fault location

Point-to-point circuits may use branch-level fault detection and isolation instead of a dedicated IMD

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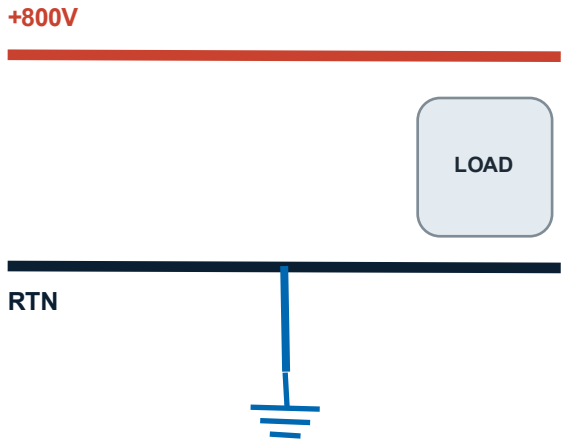
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Three leading 800VDC grounding strategies

Each strategy changes first-fault current, detection method, touch potential and the required isolation response.

SOLIDLY GROUNDED

CLEAR REFERENCE

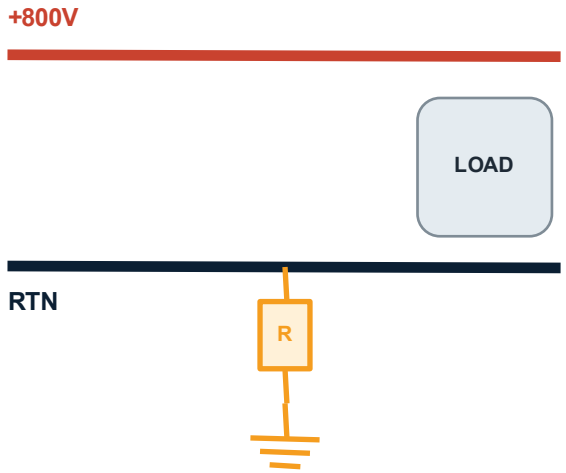


- Return conductor intentionally bonded to PE
- Ground fault can produce high current
- Conventional current-based protection can trip quickly

Tradeoff: higher first-fault current and immediate interruption expected

HIGH-RESISTANCE GROUNDED

CONTROLLED FAULT CURRENT

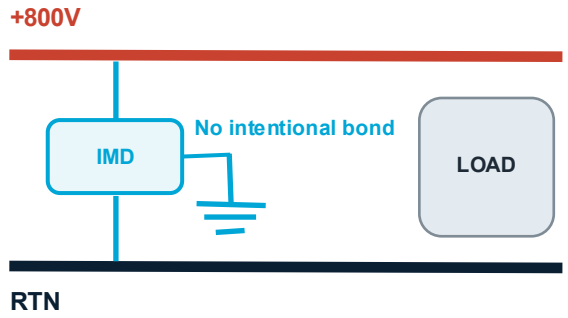


- Return or midpoint connected through a sized resistor
- Limits first-ground-fault current
- Requires resistor monitoring and coordinated detection

Tradeoff: balances fault-current control with a defined ground reference

UNGROUNDED / FLOATING

MAY CONTINUE OPERATING ON FIRST FAULT



- No intentional connection from either pole to PE
- First ground fault may not force immediate shutdown
- IMD monitors insulation resistance to ground

Tradeoff: insulation faults require monitoring and fault-location procedures

There is no universal winner: grounding must be selected with protection zoning, fault detection, insulation coordination and operating procedures.

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Safe serviceability must be designed in

Hot-swap capability, de-energized service and stored-energy control are different operating states.



SAFE WORKFLOW

- Identify every AC and DC source
- Execute controlled shutdown
- Open and lock isolation points
- Wait for validated discharge
- Test for absence of voltage
- Service and restart under control

Design enablers: lockable isolation • test points • discharge indication • clear one-line diagrams

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FIVE PRINCIPLES FOR A SAFE 800V DC ECOSYSTEM

1	DEFINE THE BOUNDARY	Know where 800V begins, travels, branches and ends.
2	LIMIT FAULT ENERGY	Detect quickly, interrupt quickly and coordinate protection
3	PREVENT ENERGIZED ACCESS	Use touch-safe construction, enclosures and interlocks.
4	ISOLATE EVERY SOURCE	Include converters, batteries, capacitors and backfeed.
5	DESIGN FOR THE TECHNICIAN	Make isolation, verification and restart predictable.

Safety will come from coordinating the complete ecosystem, not from one breaker, connector or standard.

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