

800 VDC changes the

protection strategy.

Coordinate protection, fault isolation, and system safety—from source to load.

PROTECTION • COORDINATION • SYSTEM SAFETY



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DATA CENTER FACILITY - POWER DISTRIBUTION Sub-Project



General

AGENDA

Three lenses for predictable 800 VDC protection

Architecture sets the structure. Coordination defines the response. Safety validates the system.

01 ARCHITECTURE 

System-Level Protection Architecture

Coordinate fault detection, performance targets (e.g clearing time), and system recovery across the full 800 VDC system.

→ DESIGN SYSTEM BEHAVIOR

02 COORDINATION 

DC-Specific Coordination Challenges

Address absent zero-crossing, persistent DC arcs, and selective isolation with validated coordination.

→ COORDINATE FAULT RESPONSE

03 SAFETY 

Integrated Safety Frameworks

Extend standards to interoperability, fault behavior, and resilience under transient conditions.

→ VALIDATE END-TO-END SAFETY

01

System-Level Protection Architecture

Moving beyond device-level protection to coordinated system design



General

The design question has changed

From “which device is fastest?” to “which system response is predictable?”

Yesterday’s question

- Which breaker clears fastest?
- Which device has the highest rating?
- Which curve coordinates on paper?

800 VDC reality

- Fault current is shaped by converters.
- Stored energy dominates the first microseconds.
- Architecture determines what must remain online.

The right question

- Can the entire source, protection, grounding and load system respond predictably under fault?

Predictable outcomes come from co-design and system validation, not device speed alone.

System-first by design

From “which device is fastest?” to “which system response is predictable?”

1

ARCHITECT

- Set redundancy & recovery strategy
- Grounding scheme
- Source/load behavior

2

CO-ENGINEER

Match protection to converter fault behavior and system energy

- Optimized: Current controlled behavior integrated within the converter, paired with proven electromechanical breakers
- Design-minimized: external SS protection distributed without that co-design

3

VALIDATE

Use digital models, HIL or laboratory to prove selectivity, stability and recovery before deployment.

System-first by design

From “which device is fastest?” to “which system response is predictable?”

CO-ENGINEERED SYSTEM

- Protection matched to converter behavior
- System-level selectivity proven before deployment
- Conventional and solid-state devices used where each adds value

DESIGN-FREE ASSEMBLY

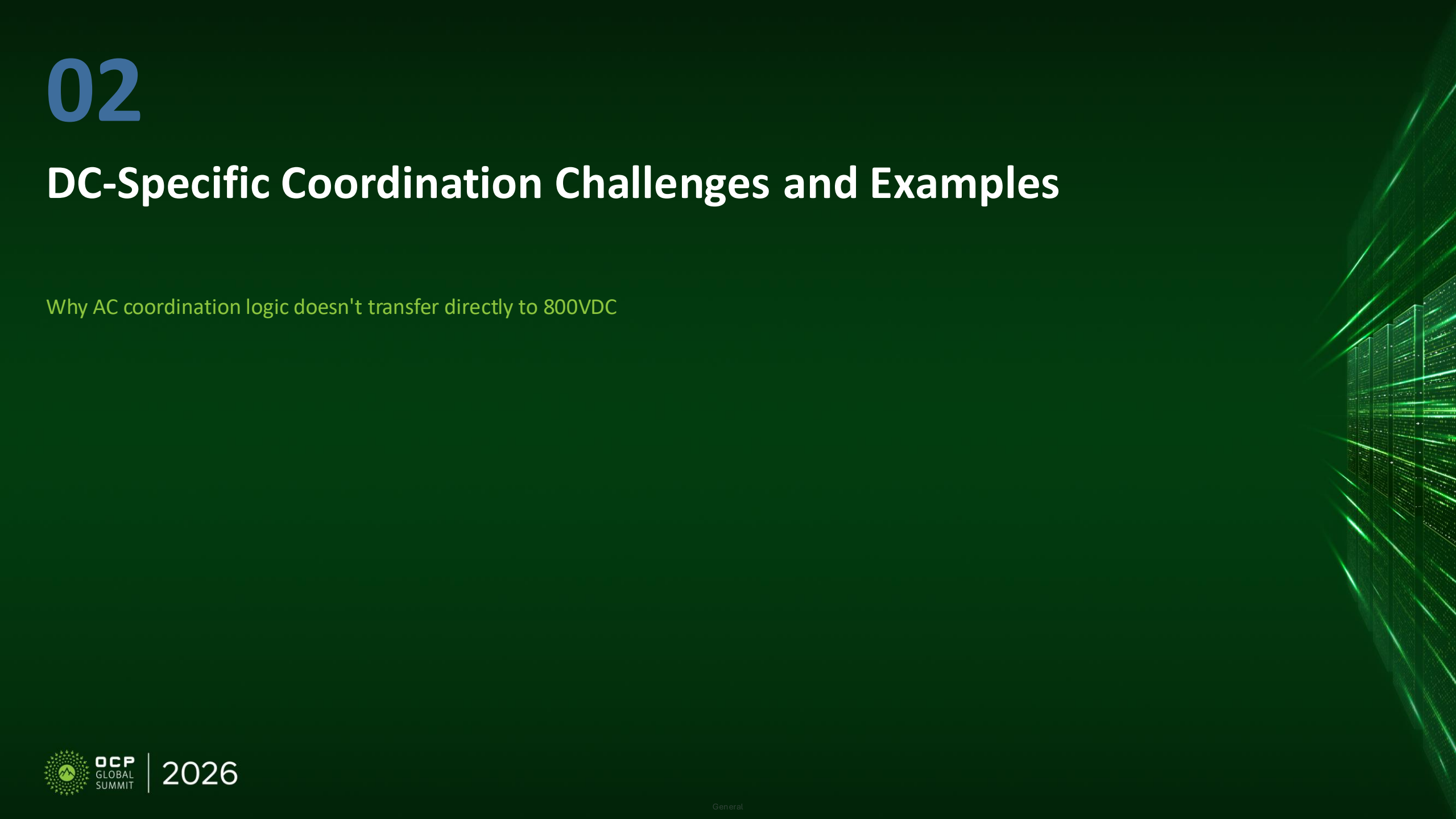
- Devices added after architecture decisions
- Speed optimized locally, not necessarily system-wide
- Higher risk of over-specification or mismatched behavior

- **Conventional EMCB and ETU technologies can deliver full selectivity with controlled or current limiting sources**
- **SSCB become decisive when self-protecting sources demand fast isolation and rapid shutdown if architecture topology do not allow enough hold up time**

02

DC-Specific Coordination Challenges and Examples

Why AC coordination logic doesn't transfer directly to 800VDC



General

Protection coordination is a system outcome

Source behavior, protection technology, and distribution architecture must work together.

01

SOURCE BEHAVIOR

Converter topology & impedance • Current limiting—level or duration • Under-/overvoltage self-protection

02

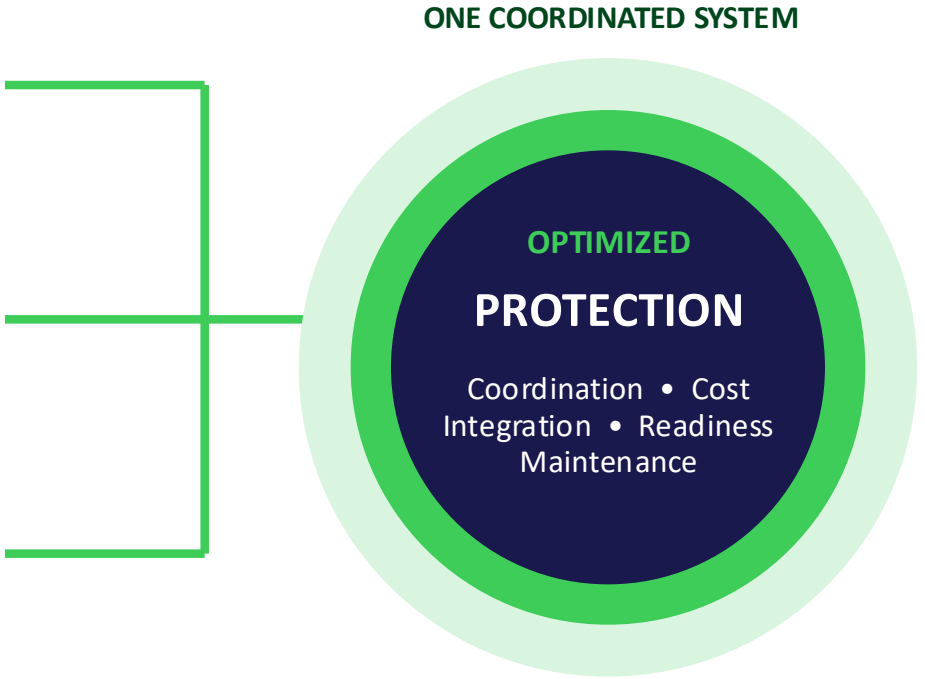
PROTECTION TECHNOLOGY

Fuse • Electromechanical circuit breaker • Hybrid circuit breaker • Solid-state circuit breaker

03

ARCHITECTURE TOPOLOGY

Grounding scheme • Redundancy—N+1, 4-makes-3, ATS, STS…

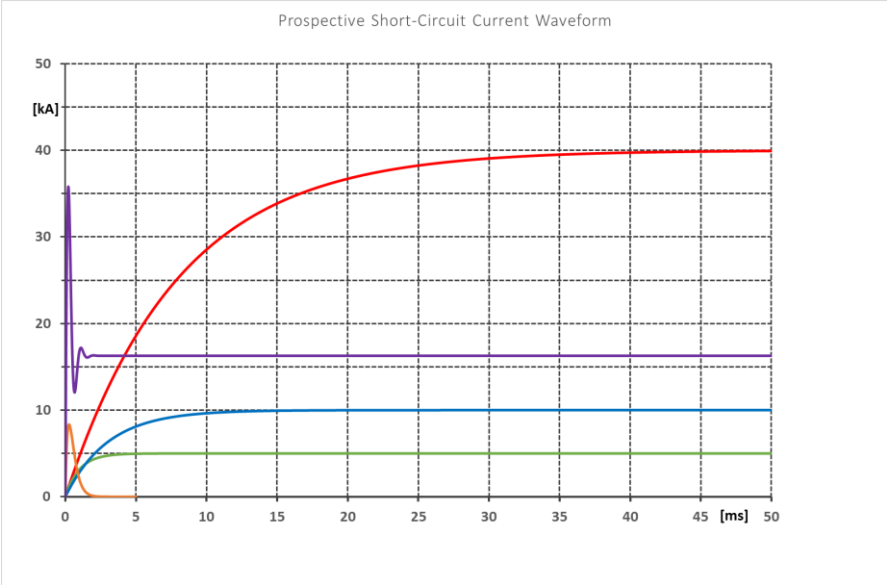


Design the system—not the device in isolation.

Controlled fault current (DC UPS, some SST): traditional and solid-state protection can both react in time.

There is no single “800 VDC fault”

The waveform depends on the source and the energy already stored in the system



Red, Blue, Green curves **“Non-Limiting Source”**

« Inductive » type of current waveforms following an exponential growth which is linked a time constant of L/R.

This type of current is provided by sources such as **PV, Battery, Fuel Cell, Rectifier**, and is the type of waveform UL standard are requesting for short-circuit tests

Purple and Orange curves **“Limiting Source”**

« Capacitive » type of waveform which can be found at the **output of an active converter** (DC UPS, SST, …). The waveform is usually divided in 2 steps, a capacitor discharge with a high rate of rise of current following by an infeed current from the upstream source, limited or not.

Currently, Fuse and Electromechanical Circuit Breaker are tested and certified only following Non-Limiting type of circuit. This may lead to misunderstanding of protection performances.

Implication: Test waveform and source control behavior must be explicit in every coordination study.

Protection choice is a four-way trade-off — not a speed race

Faster interruption improves isolation, but cost, integration effort and readiness determine what can be deployed at scale

	FUSE Traditional / aR	EMCB Magnetic or ETU	HCB Hybrid breaker	SSCB Solid-state breaker
BREAKING TIME*	0.5–5ms	1–20ms	0.2–1 ms	< 10 µs
				FASTER ISOLATION →
COST	● ○ ○ ○ Low	● ● ○ ○ Low	● ● ● ● Medium–high	● ● ● ● High
INTEGRATION EFFORT	● ○ ○ ○ Low	● ○ ○ ○ Low	● ● ○ ○ Medium	● ● ● ● High
TECHNOLOGY READINESS	ESTABLISHED Standards gap for branch protection above 600 Vdc Limited protection features	ESTABLISHED Performance remains source- and waveform-dependent	DEVELOPING Topology, controls and fault behavior must be qualified	ADVANCING Cooling and economics still getting shaped

Select at design phase & optimize the system for key factors:

Match the device to source behavior, protected boundary and rack architecture — not breaking time alone

Breaking times mentionned in this table refers to branch protection device

Architectural Redundancy Decides What's at Stake

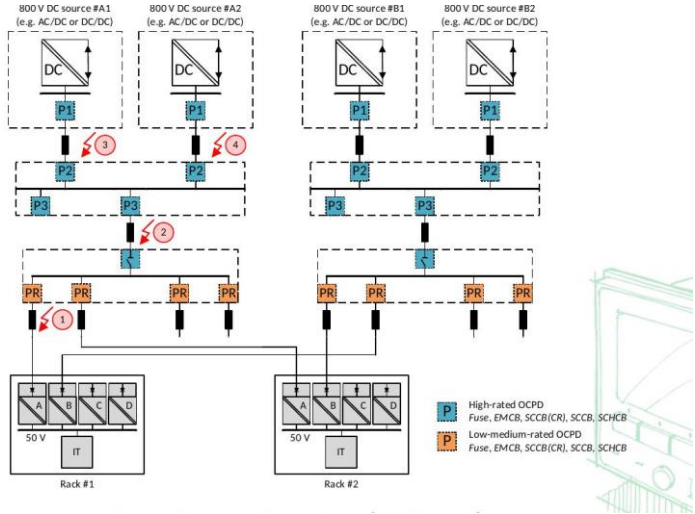
Protection speed changes recovery in every topology — but only one architecture puts the IT load itself at risk.

REDUNDANT PATHS

Multi-corded / redundant racks

IT load stays online

Redundancy guarantees load continuity; protection speed determines how quickly the affected powertrain recovers.



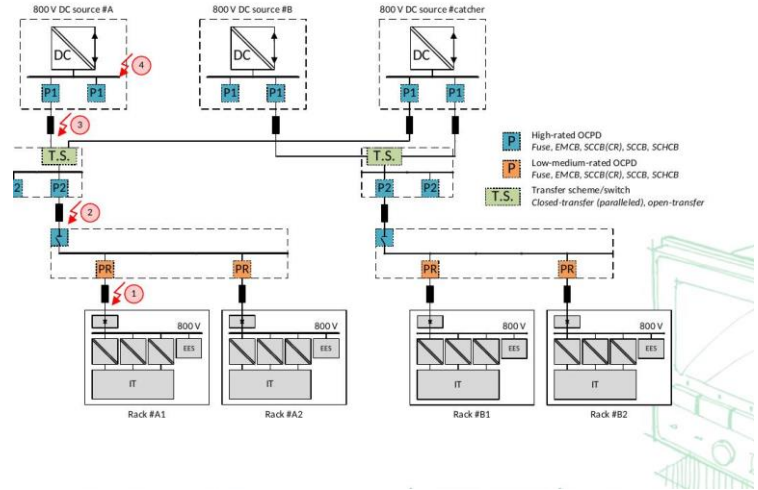
Favors uptime by design

TRANSFER-DEPENDENT PATH

Single-corded racks with transfer schemes

IT load is on the clock

With no rack-level redundancy, clearing must complete inside the transfer and rack hold-up window.

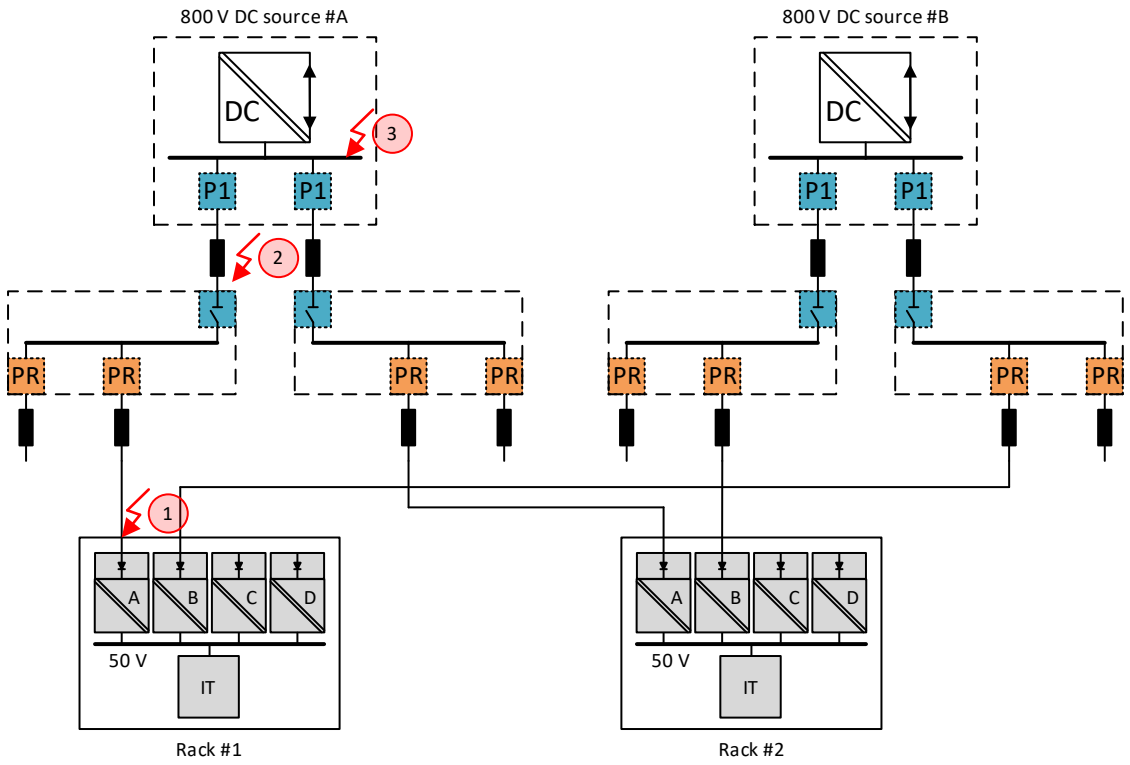


Fault clearing < transfer < rack hold-up

Miss the window → IT load loss; simplicity comes at uptime's expense.

The load stays online — even if one source shuts down

Redundancy preserves load continuity; coordination isolates the fault and restores the source.



***Load Continuity:** Ensuring IT load is supported (not dropped)

****Powertrain Continuity:** Localizing faults and minimizing disruption and time-to-repair within the affected/faulty powertrain

SOURCE MAY SHUT DOWN —THE LOAD STAYS ON

The critical sequence is to isolate the fault, then restart the affected source.

A

Source shuts down

Without coordination, the source may trip while the redundant path keeps the load energized.

B

Isolate the fault

- Open the correct protection device and contain the faulted section.
- Size the upstream OCPD to trip—even if the source isolates first—to speedily identify fault location and repair.

C

Restart the source

Restore automatically after isolation where the control scheme supports it.

SEQUENCE → isolate • verify • restart

OUTCOME → load remains online

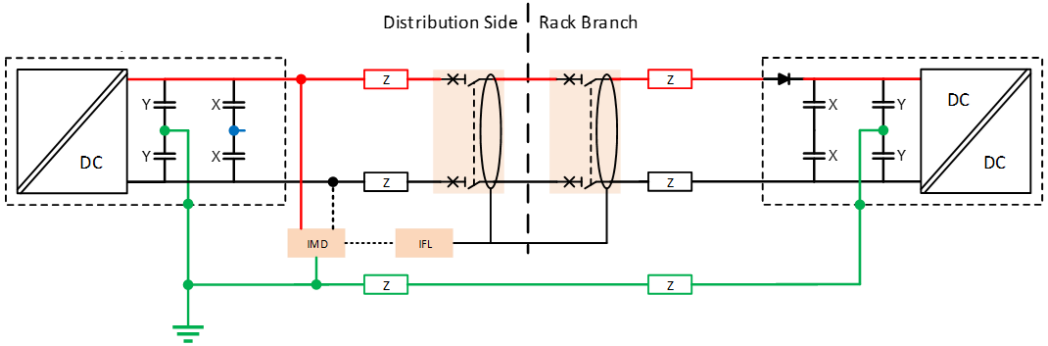
Grounding Scheme: Uptime vs. Simplicity

The grounding scheme sets the first-fault behavior before protection technology is selected.

UNGROUNDED (IT)

First fault → keep operating

Uptime advantage, with active monitoring

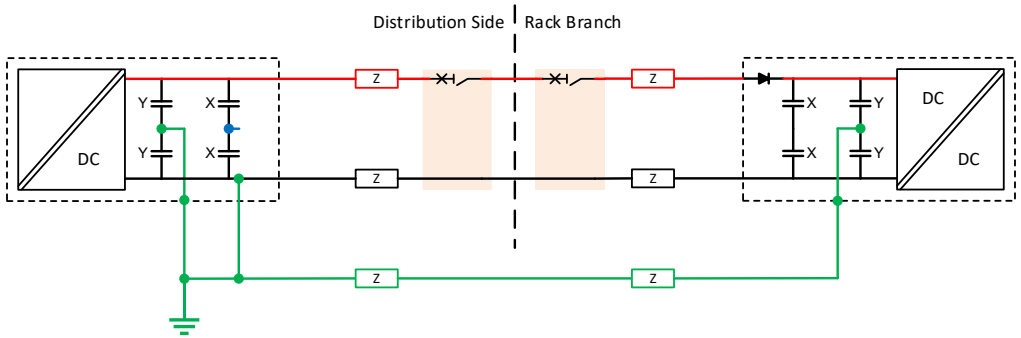


- Keeps running through the first insulation fault, creating time for a planned repair.
- Requires continuous insulation monitoring to detect a second fault before it compounds.

SOLIDLY GROUNDED (TN-S)

First fault → trip immediately

Simple clearing, with an uptime trade-off



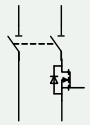
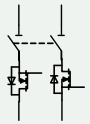
- Clears the first fault immediately with familiar protection behavior.
- Trips the powertrain on any first fault; architectural redundancy must carry the load.

Choose grounding first: IT favors uptime; TN-S favors simplicity.

Grounding Scheme – Impact on Protection Selection

Grounding topology determines whether an SSCB can be applied — and how many poles it must protect

Grounding Scheme Variations

SSCB Topology	Solidly Grounded Unipolar · 2 Wires	Solidly Grounded Bipolar · Midpoint grounded distributed (3 wires) or not (2 wires)	Ungrounded / HRG Unipolar · 2 Wires	Ungrounded / HRG Bipolar · 3 Wires
One Protected Pole Better cost, footprint & efficiency 	**CAN BE USED**	**NOT SUITABLE** Must protect and/or disconnect 2 wires (+ and –)	**CONDITIONAL** Opens only after 1st-fault detection by monitoring device to detect and open at first fault; needs validation & interoperability certification	**NOT SUITABLE** Must protect and/or disconnect all wires
Two Protected Poles Higher cost, footprint & losses 	**CAN BE USED**	**CAN BE USED**	**CAN BE USED** If one pole can operate at system voltage level	**NOT SUITABLE** Must protect and/or disconnect all wires

Two protected poles unlock the widest grounding compatibility but has implications to cost, footprint and efficiency

Can be used Conditional Not suitable

03

Integrated Safety Frameworks

Expanding standards toward end-to-end system safety



General

Device standards are necessary. System standards make safety predictable.

Safety must be verified through whole-system behavior under faults, transients and component interactions.

PRODUCT STANDARDS ALREADY COVER

A strong device-level baseline

- Fuses & breakers are not tested according to system behavior
- DC ATS/ STS standards need to be evolved to match application requirements
- Switchboard & busway limited 1000 Vdc

SYSTEM-LEVEL QUESTIONS REMAIN

Predictability is still the gap

- Liquid-cooling acceptance and test protocols remain unresolved
- Converter–protection interactions are not certified as one system
- Standards bodies need direct engagement while requirements are still forming

SYSTEM STANDARDS MUST DEFINE THREE OUTCOMES

INTEROPERABILITY

Converters and protection coordinate predictably across the full architecture.

FAULT RESPONSE

The system response is defined and testable from the instant a fault occurs.

TRANSIENT RESILIENCE

Safe operation holds through switching transients, load steps and abnormal conditions.

Shift the certification question from “Does the device pass?” to “Does the system behave predictably?”

What the ecosystem needs next

A shared evidence model for 800 VDC system safety

1	**COMMON FAULT PROFILES**	Agree source and stored-energy waveforms for qualification.
2	**DECLARED RESPONSE CONTRACTS**	Specify detection, limiting, isolation and recovery behavior.
3	**SYSTEM-LEVEL VALIDATION**	Prove coordination with models, HIL and representative hardware.
4	**OPEN INTERFACES + DATA**	Enable interoperable protection by enabling convergence between conversion & protection parameters and intedependencies

Open standards should define the behavior to prove, while allowing multiple technologies to compete.

CALL TO ACTION

Validate the system before you scale it

Move from device selection to coordinated architecture, ecosystem readiness and field-proven deployment.

1

DEFINE

System KPIs

Set system-level performance targets, then optimize the architecture to deliver them.

2

ALIGN & UPSKILL

The ecosystem

Amend codes-and-standards, upskill consultants, contractors and AHJs for safe deployment.

3

MATCH

Readiness

Stage the rollout so technology maturity and personnel capability advance together.

4

PILOT

Before scale

Validate the complete system in a pilot and resolve practical challenges before deployment.

Define → align → match readiness → pilot → scale

At 800 VDC, the winning protection strategy is not the fastest device. It is the most predictable system.

Thank You!

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