Surge Protection and Grounding in Class 4 Fault-Managed Power Systems

Who are we?

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Sr. Director of Product Management

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Who is VoltServer?

- Inventors of FMP
- +10 Years of Deployments
- +50MW In Service Globally

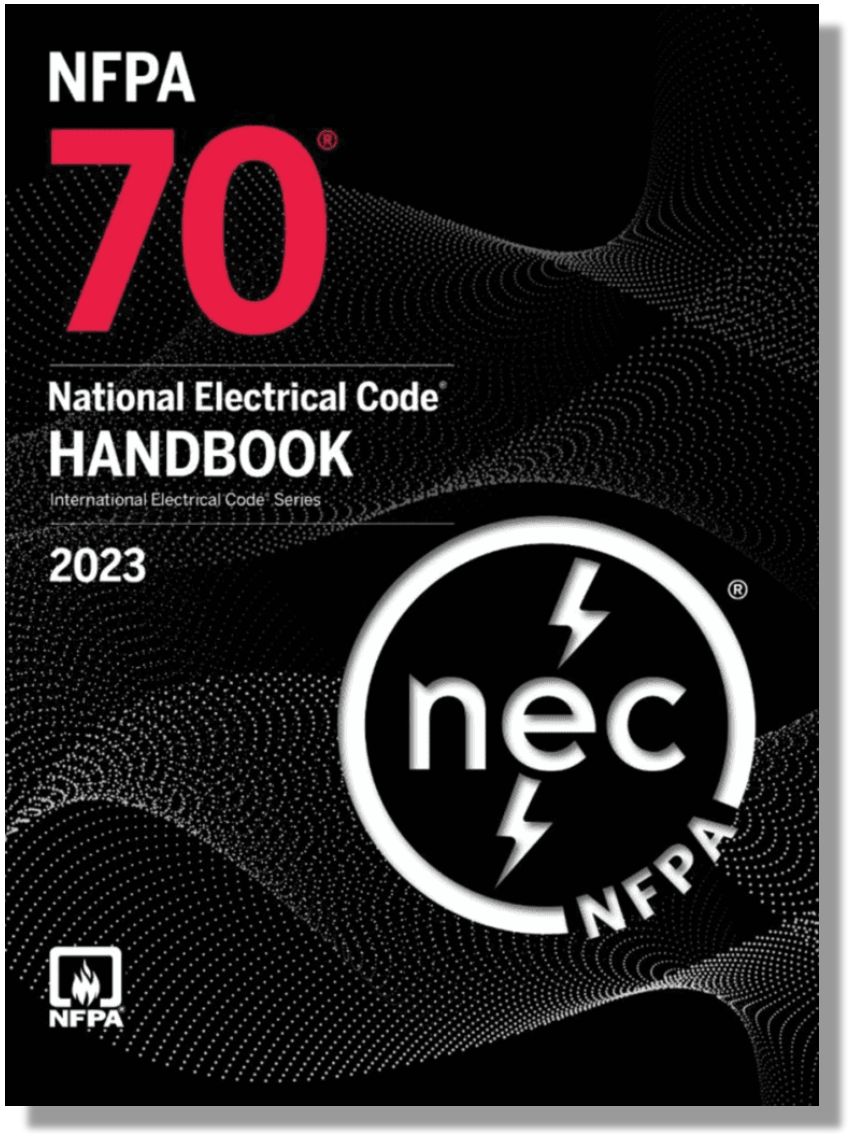
VOLTSERVER® DIGITAL ELECTRICITY®

PEG PROTECTION ENGINEERS GROUP

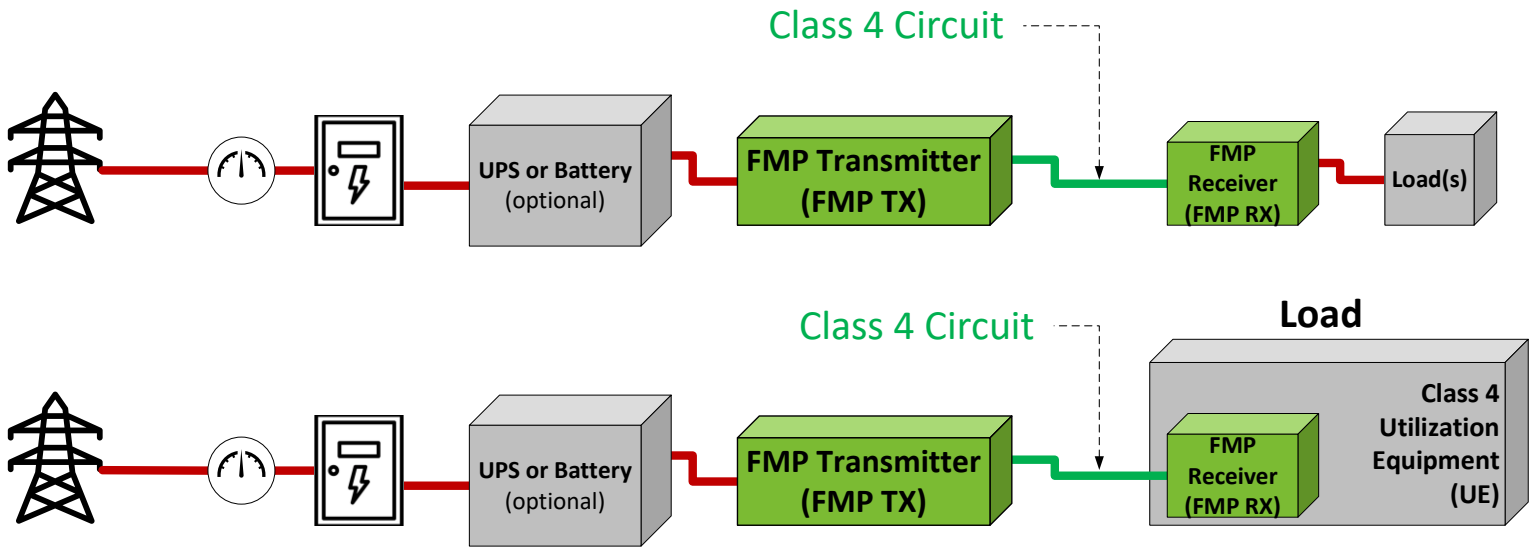
What is Class 4?

- NFPA 70, 2023 ed. (NEC) → Chapter 7 → Article 726

  → **Class 4 Circuits**
- Referred to as “Fault-Managed Power Systems” (FMPS).
- Can deliver hundreds or thousands of watts of power safely.
- Voltages up to 450V AC or DC.
- FMPS are not limited by the maximum output of the source
- FMPS intelligently limit the amount of energy that can go into a fault.
- Limiting the fault energy mitigates the risk of shock or fire and allows the installation of Class 4 circuits using methods like power-limited circuits.
- Class 2 and Class 4 circuits can share the same pathways



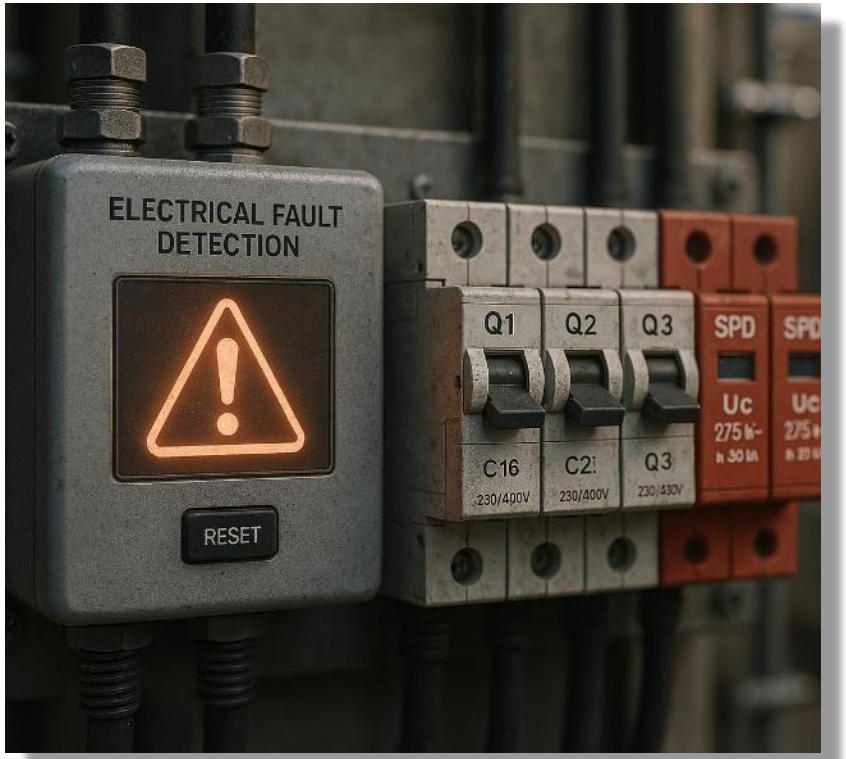
What is FMPS?



- Safety Standards:
  - **UL 1400-1: FMP TX and FMP RX**
  - **UL 1400-2: FMP Cables**
- Hazards based safety approach
- No power limit
- Limit energy transferred into a fault to mitigate shock and fire hazards

The system is comprised of the FMP TX, CL4 Rated Cable, and FMP RX, suitable for supplying a Class 4 circuit under NEC Article 726 with wiring methods defined in NEC Article 722.

Fault Protections

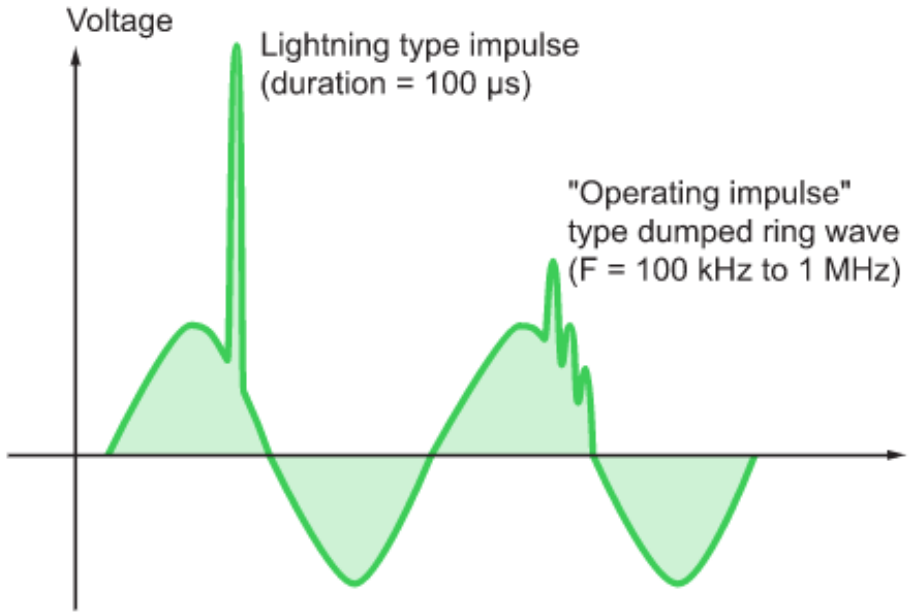


Hazard	Fault Type	GFCI	AFCI	FMPS
Shock	Line-to-Earth	✓	✓	✓
	Line-to-Line	✗	✗	✓
Fire	Series Arc	✗	✓	✓
	Parallel Arc	✗	✓	✓
	Line-to-Line Resistive	✗	✗	✓
	Series Resistive	✗	✗	✓

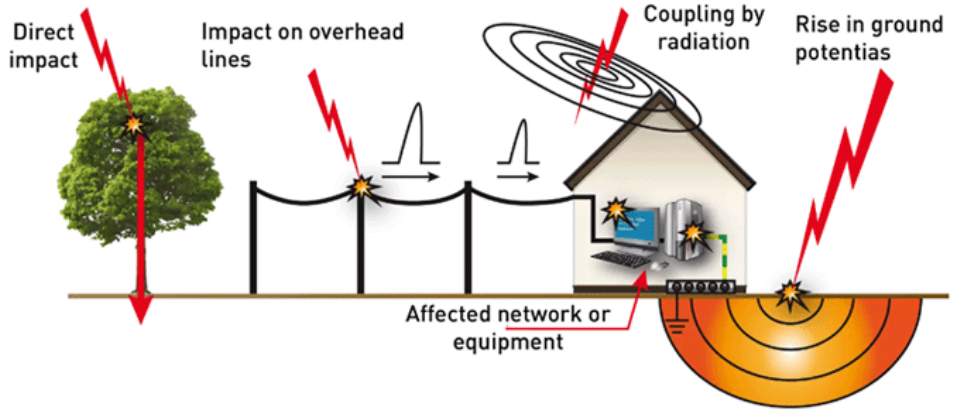
Surge Protection???

What is a “Surge”?

- A very short, very intense burst of energy, with a duration significantly less than a cycle, and an amplitude significantly above the normal circuit amplitude.
- *aka* “Transient Voltages” or “Transients”

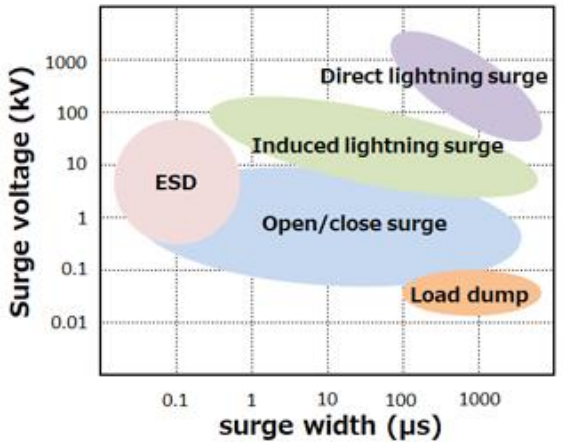


Lightning Surges



- Direct Impact – Direct Strike
- Indirect
  - Impact on overhead lines
  - Rise in ground potential
  - Coupling by radiation

Industrial Surges



- Starting motors or transformers
- Neon and sodium light starters
- Switching power networks
- Switch “bounce” in an inductive circuit
- Operation of fuses and circuit-breakers
- Falling power lines

Impacts of Surges

- Shock Hazards
- Fire Hazards
- Degraded Performance
- Equipment Destruction
- Downtime
- Repair/replacement costs

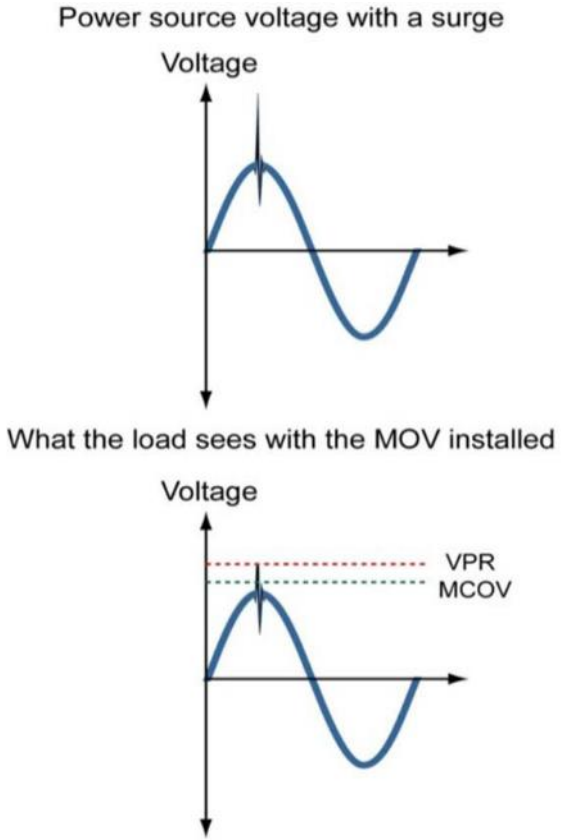
When Do You Need SPD in FMP?

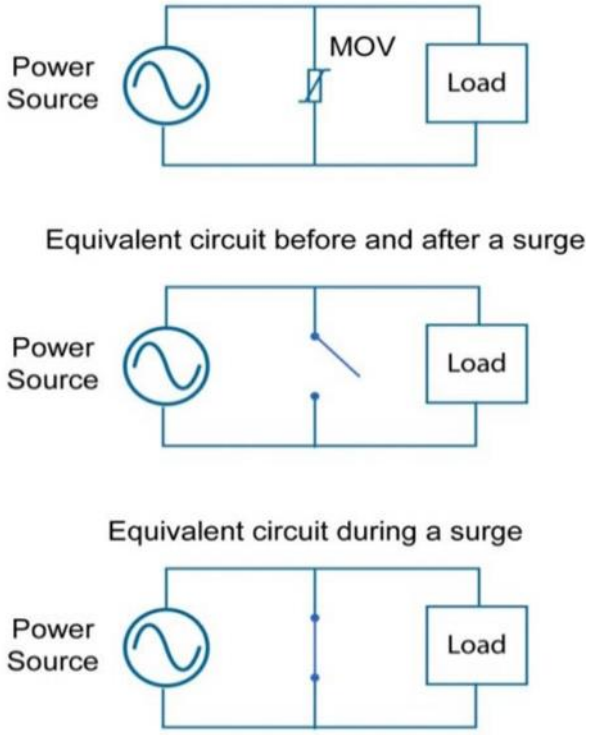
- If any part of the FMPS is outdoors: FMP TX, FMP RX, or the cable between them
- TX and RX ground are not “continuous building steel”

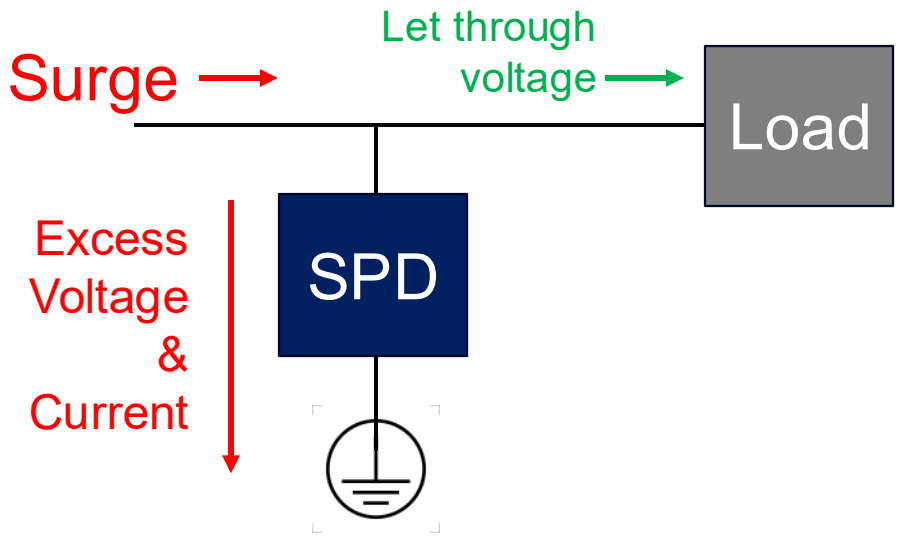
Why Do You Need SPD in FMP?

- Ensures operational continuity and personnel safety.
- Protects your investment – SPD’s protect the equipment ***and the cable***!

How SPD's Work

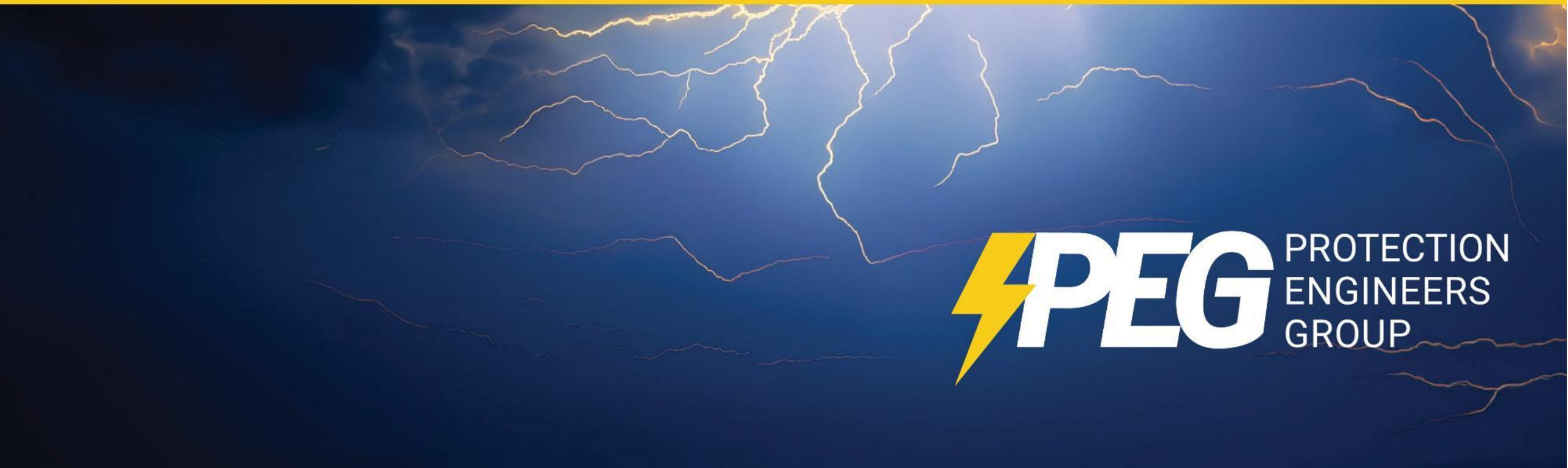






Surge Capacity
= Voltage & Current rating

THEORY VS PRACTICE



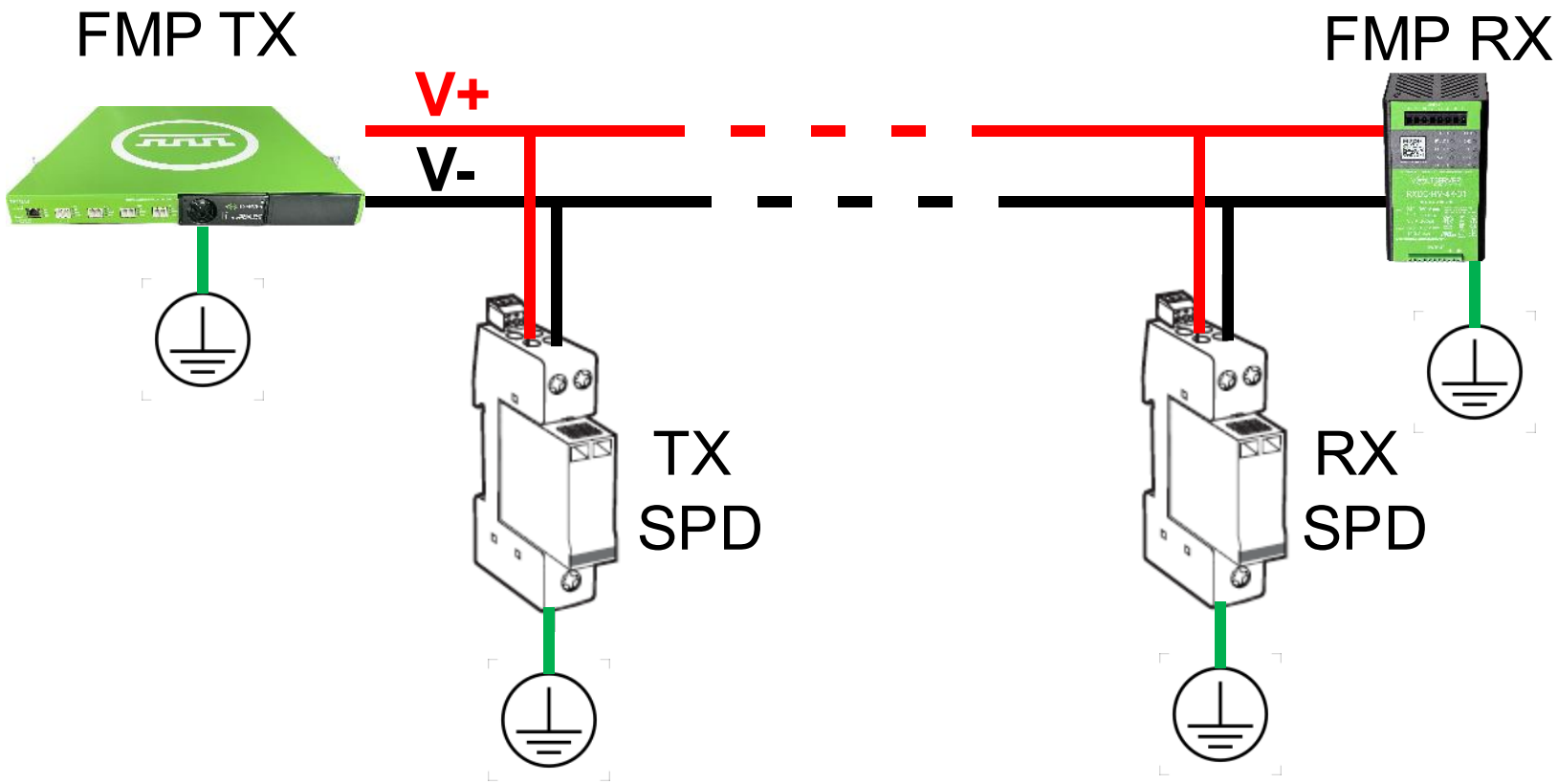
SPD Requirements & Installation

NEC 2023 Article 285:
Premises wiring systems <1kV

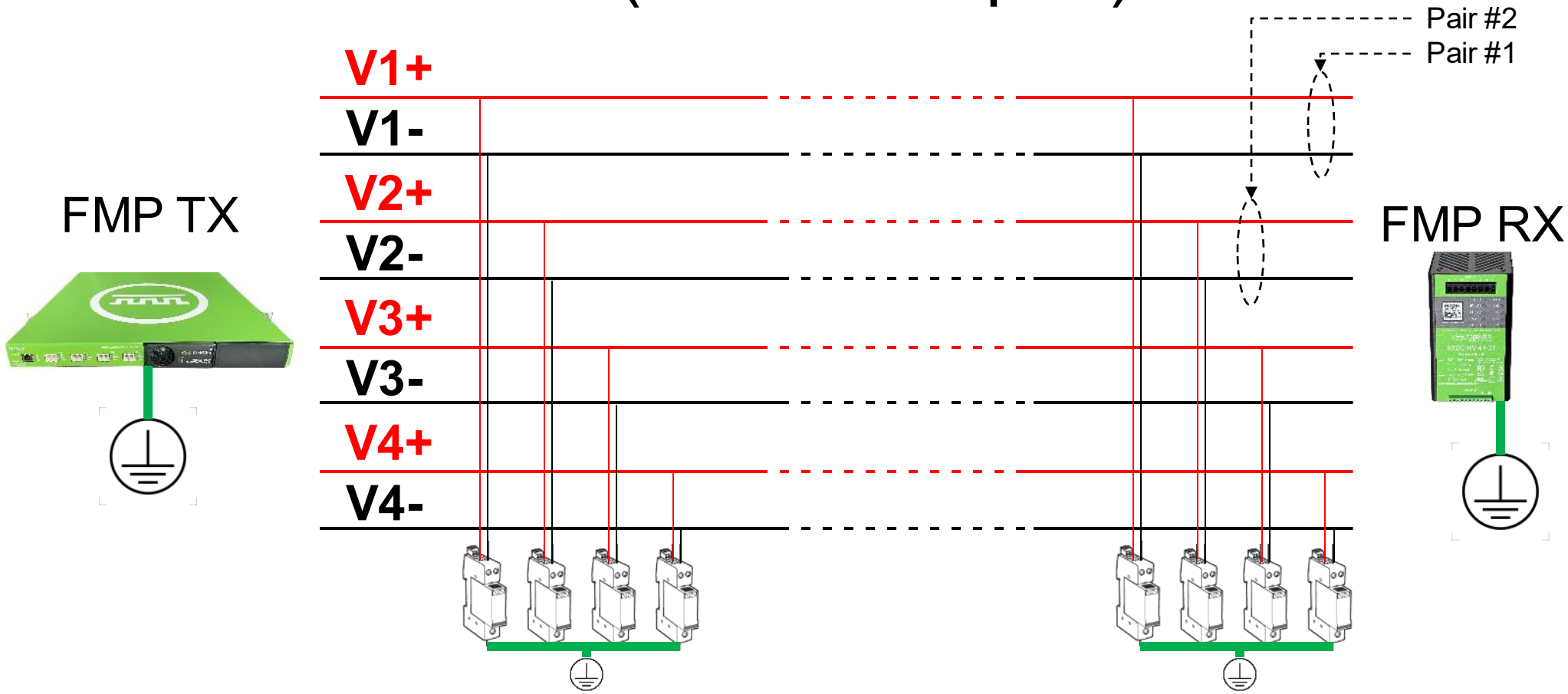
UL 1449: North American safety standard for SPDs

SPD is required when:

- *TX or RX is outdoors*
- *Any portion of the cable is run outdoors*
- *TX and RX are on separate ground planes (i.e. between buildings)*



Each DE channel (conductor pair) needs SPD



Importance of Grounding and Bonding

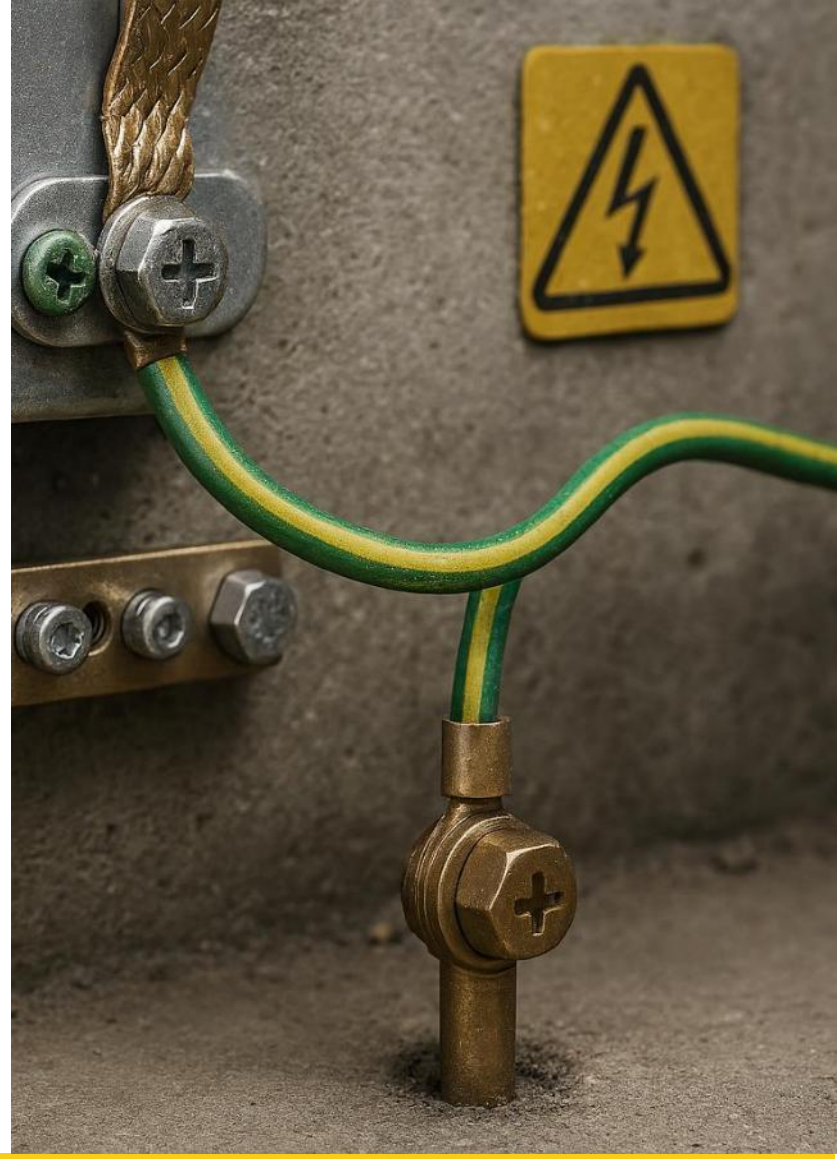
Electrical Safety via Grounding

Grounding provides a low-resistance path to earth, preventing overvoltages and enabling fault currents to dissipate safely.

Role of Proper Bonding

Equipotential bonding reduces potential differences and prevents hazardous voltage buildup between conductive parts.

The effectiveness of the SPD to provide protection is primarily determined by the quality of the local ground connections.

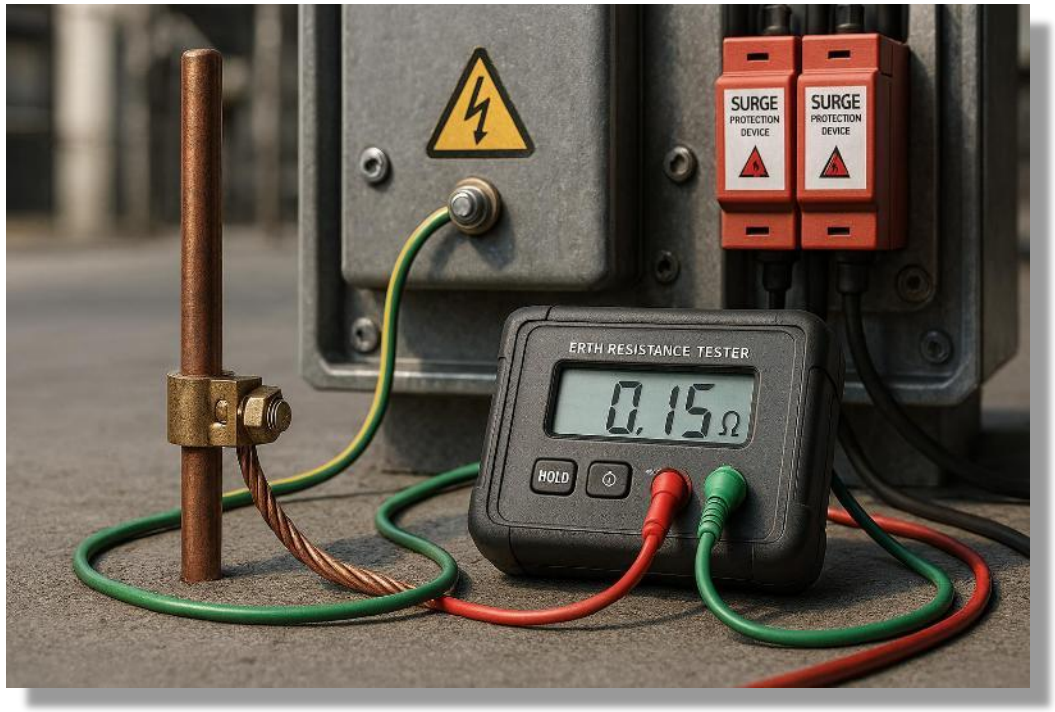


Grounding Resistance Verification

Application	Maximum Earth Ground Resistance
NEC minimum (single rod)	**25 Ω max**
FMP / Telecom equipment	**5 Ω max**
Sensitive / Mission-critical electronics	**3 Ω max**
Substations / lightning protection	**1 Ω max**

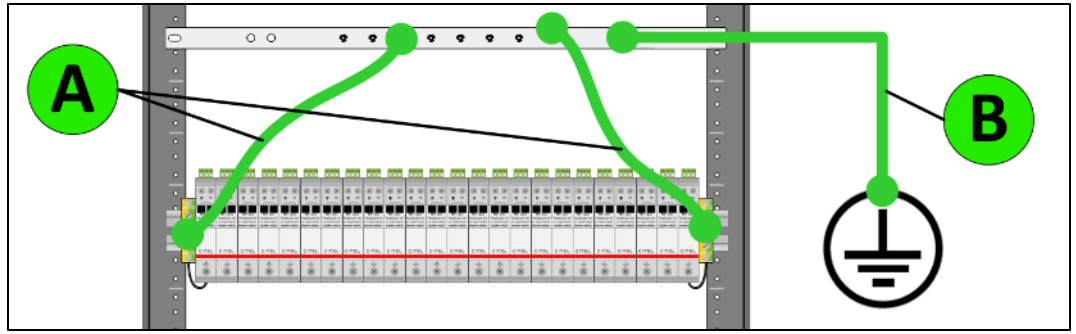
25 Ω for code compliance only!

25 Ω = 💩

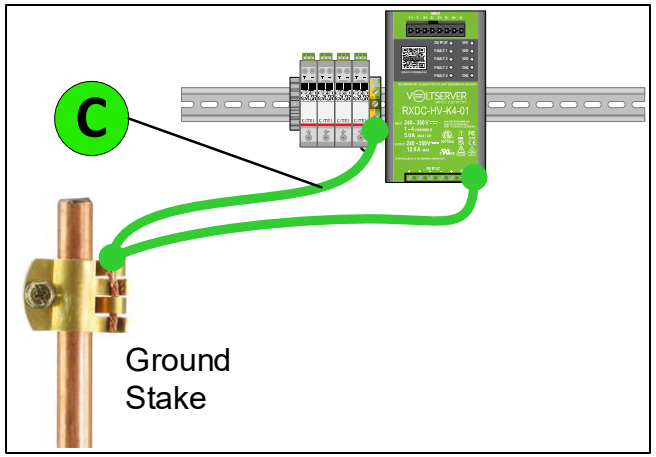


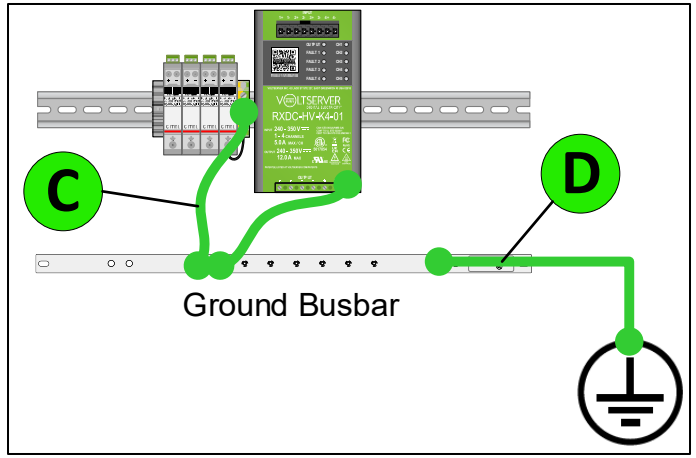
SPD Grounding Requirements

@ FMP TX



@ FMP RX





A

- If < 8 feet → 2 x 6 AWG
- If > 8 feet → 2 x 4 AWG

B

- Indoors: 1/0 AWG
- Outdoors < 20ft → 4 AWG
- Outdoors > 20ft → 1/0 AWG

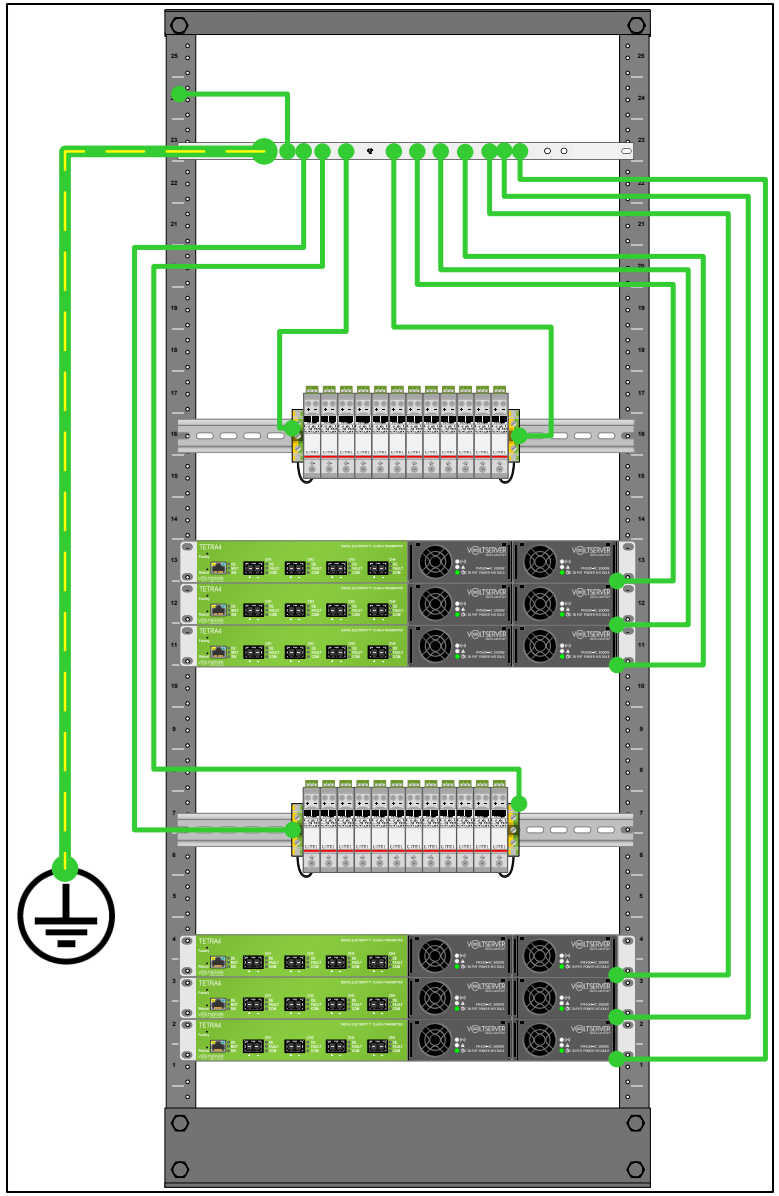
C

- If < 8 feet → 1 x 6 AWG
- If > 8 feet → 1 x 4 AWG

D

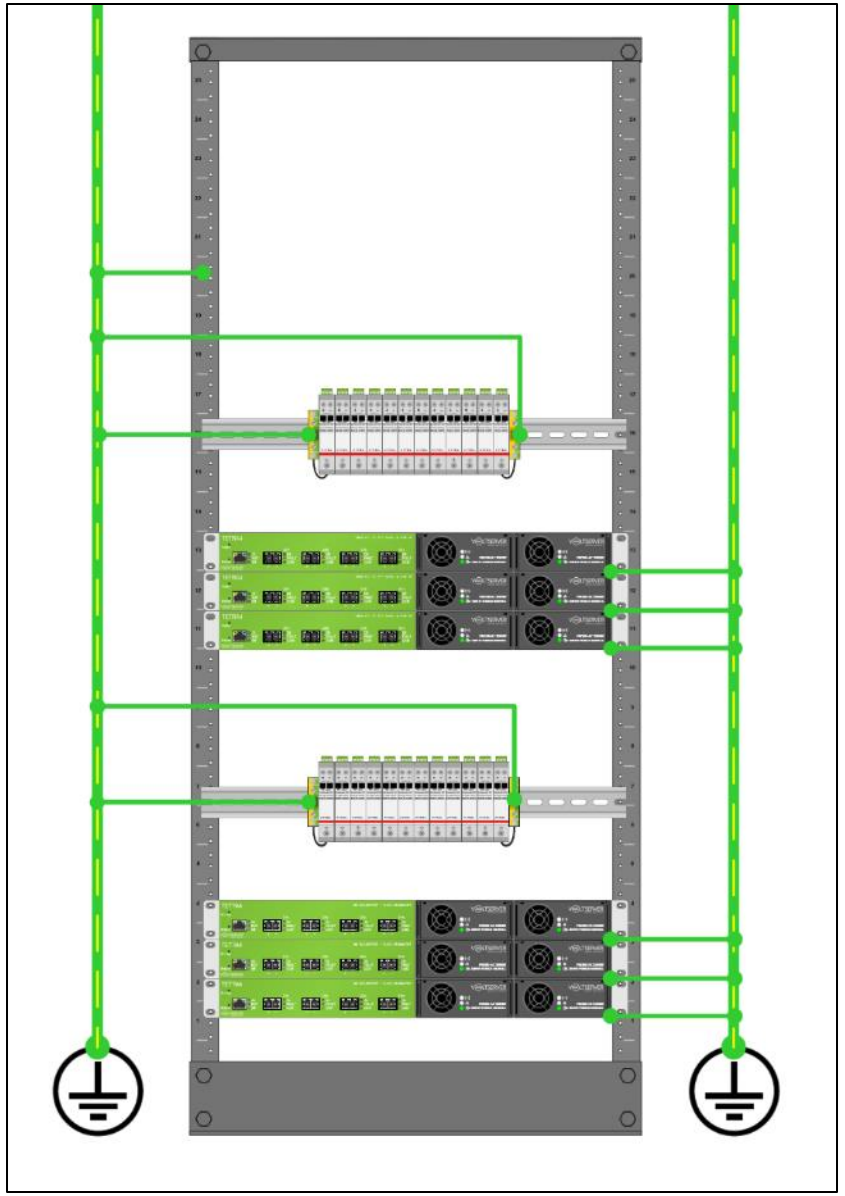
- If < 8 feet → 1 x 6 AWG
- If > 8 feet → 1 x 4 AWG
- If > 20 feet → 1x 1/0 AWG

Top of Rack Ground Busbar



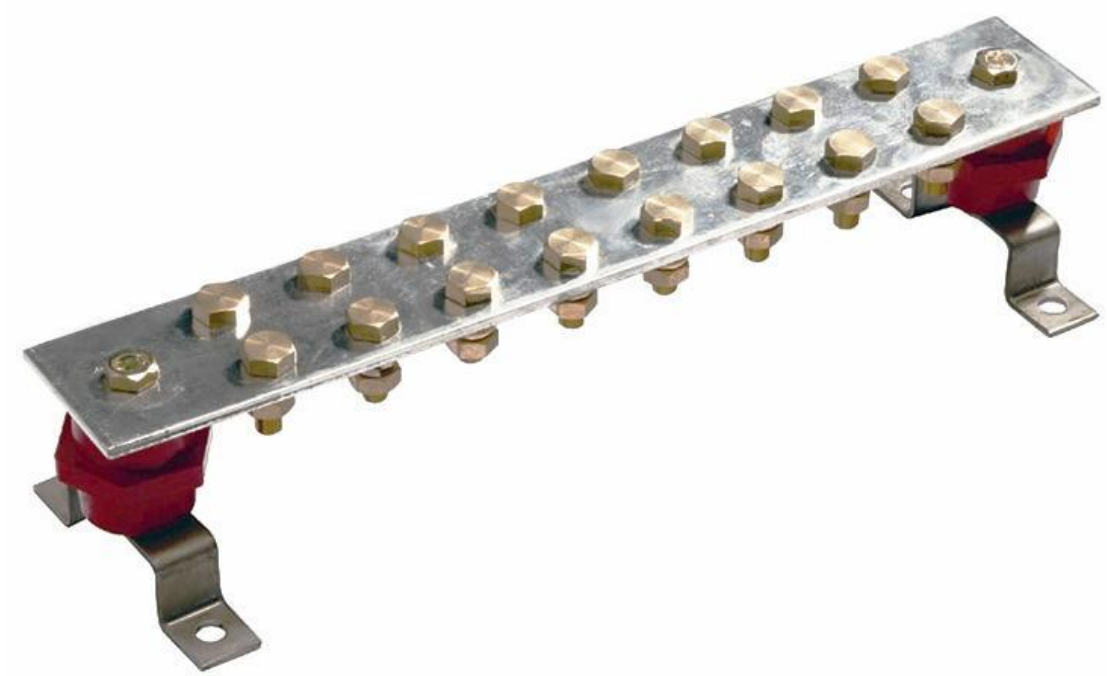
Star-shaped equipotential bonding

Isolated Grounds



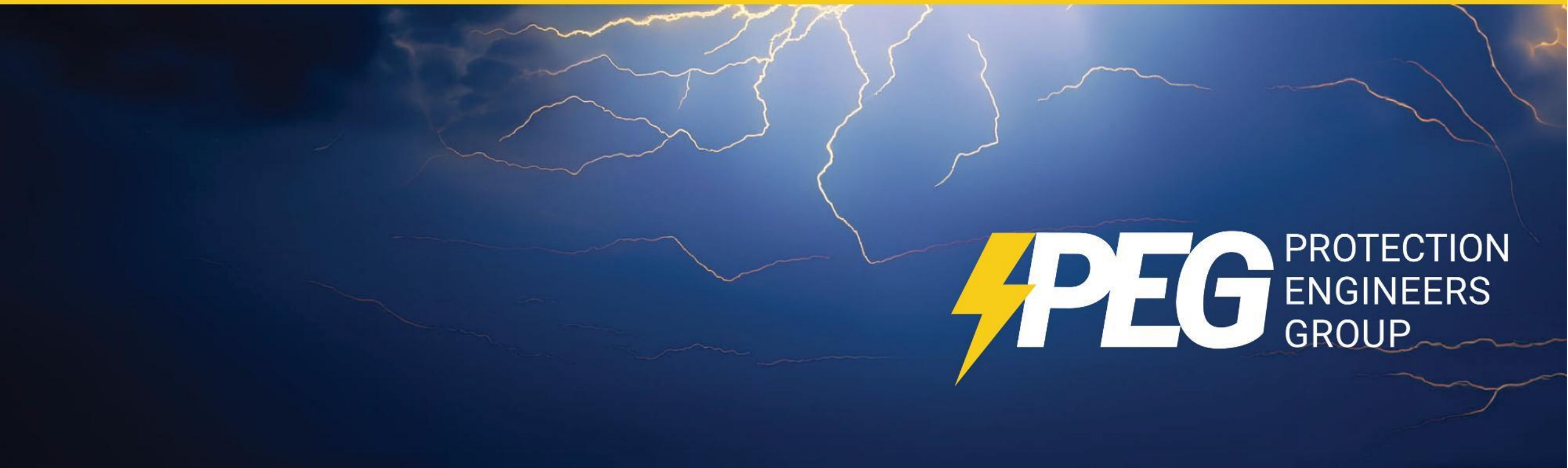
Mesh-shaped equipotential bonding

Don’t forget your Isolators!



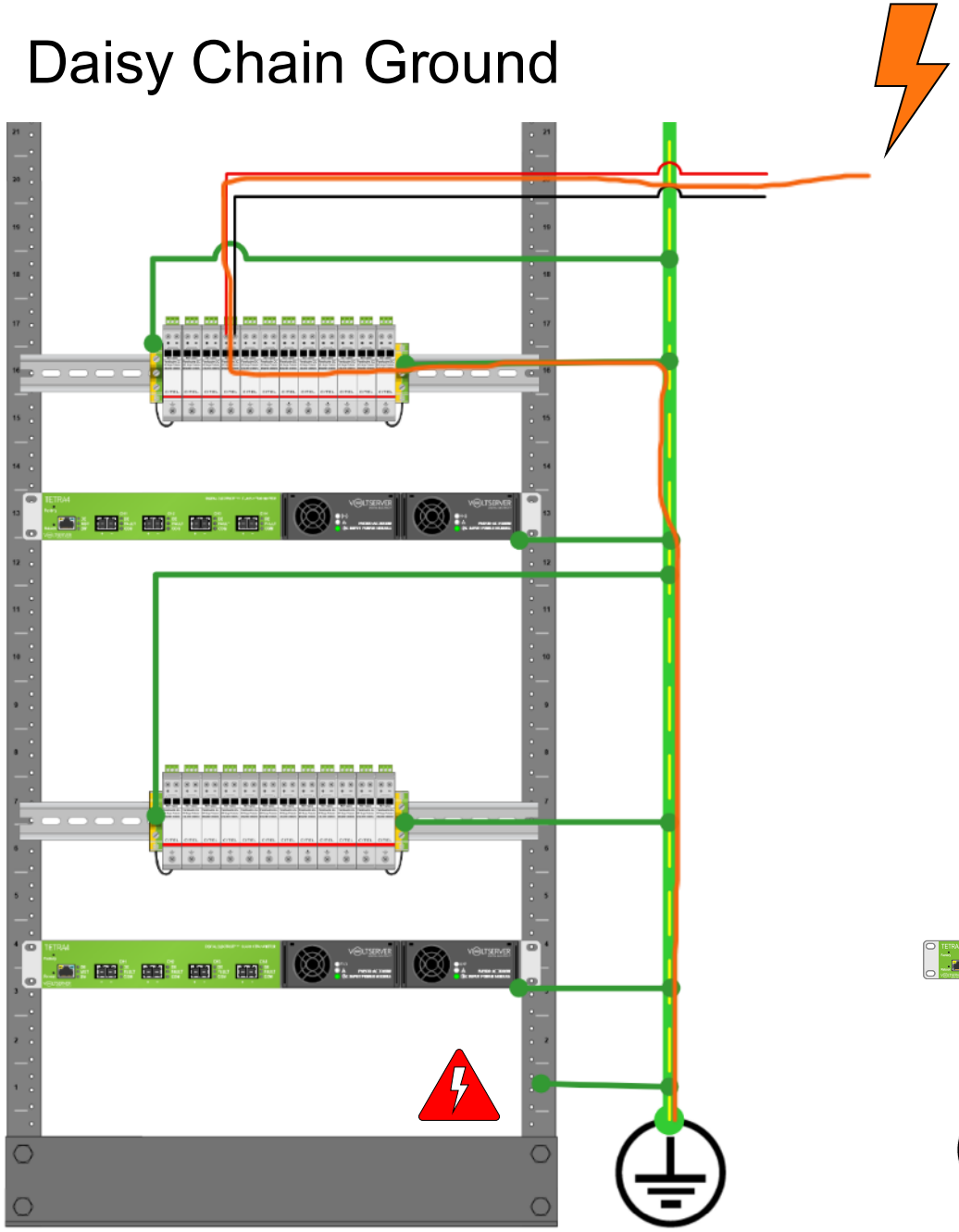
Common Installation Errors

Nothing is foolproof to a sufficiently talented fool…



No!

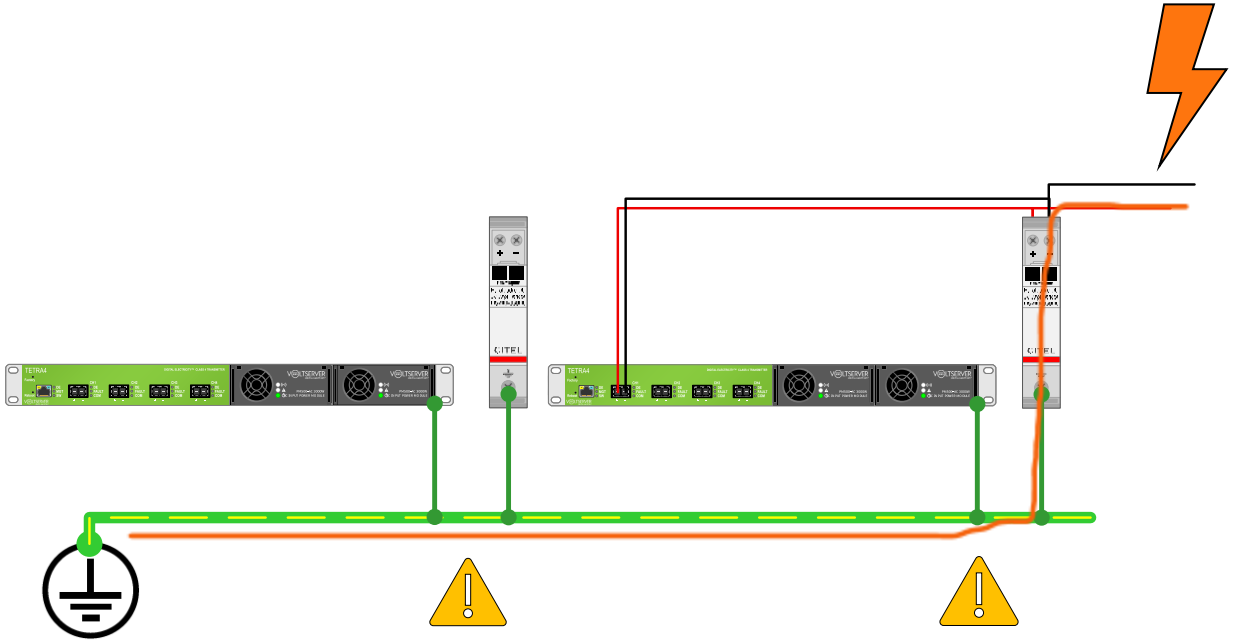
Daisy Chain Ground



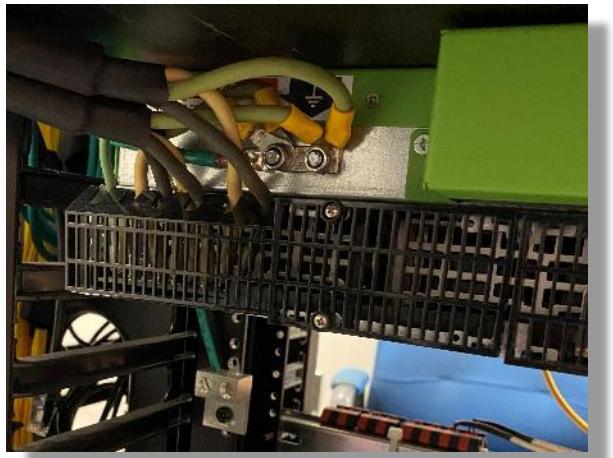
Surge path to ground

Rise in ground potential

Rack energized by surge



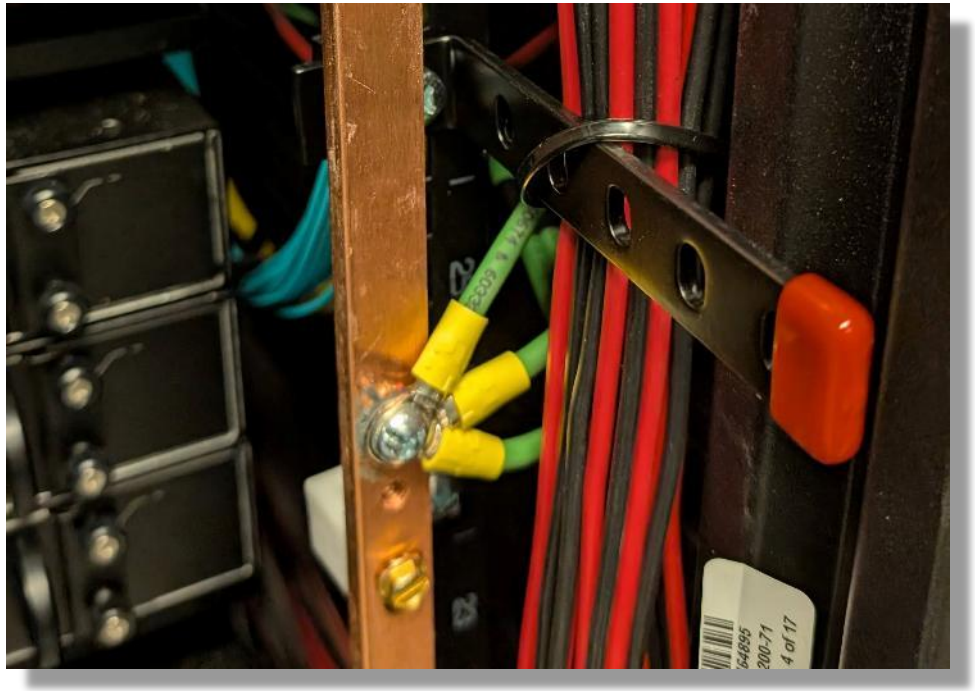
Using the Rack as Ground

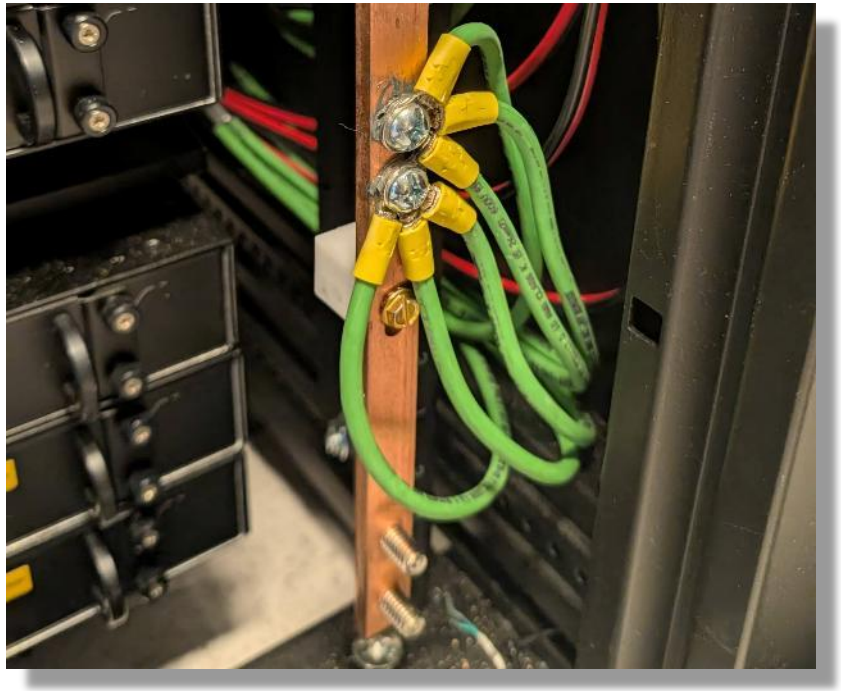


Unreliable connections

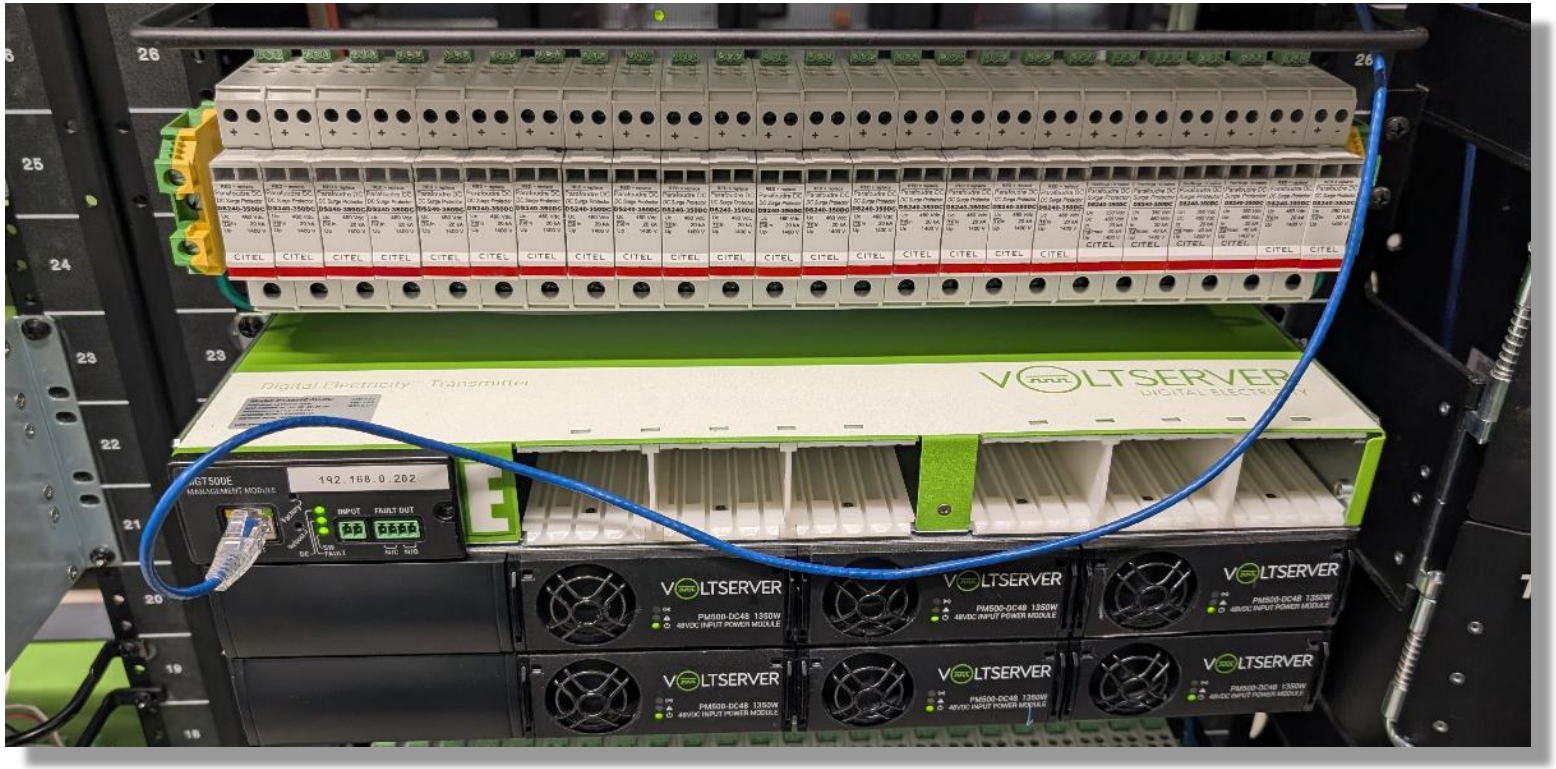
Vinyl screw → No electrical connection

Overloading Ground Studs





Assuming SPD DIN rail is EGND



Lack of SPD Awareness & Monitoring

- Surge events occurs
- SPD Fails Open as intended
- SPD not replaced
- Next surge event causes equipment failures
- Customers believe TX/RX faulty

FMP Best Practices

Do!

- Ground FMP TX and FMP RX
- Connect both sides of the SPD assembly to ground
- Use a top of rack bus bar with individual home run grounds to each piece of equipment

  OR

- Isolate equipment ground from the SPD's surge path to ground

Do Not!

- Use the DIN rail as the SPD ground
- Use the rack as ground
- Daisy chain grounds
- Use indoor cable for outdoor applications

Routine Inspection and Maintenance

Visual Inspections

Conduct periodic visual inspections to identify wear or damage in surge protection and grounding components.

Ensure the SPD are not tripped. SPD Fail Open.

Grounding Resistance Verification

Verify grounding resistance values to maintain proper system grounding and reduce failure risk.

Documentation and Maintenance Scheduling

Maintain thorough documentation and schedule regular maintenance to improve system reliability and safety compliance.

Questions?

THANK YOU!

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