802.3da
Consequences of Being Grounded
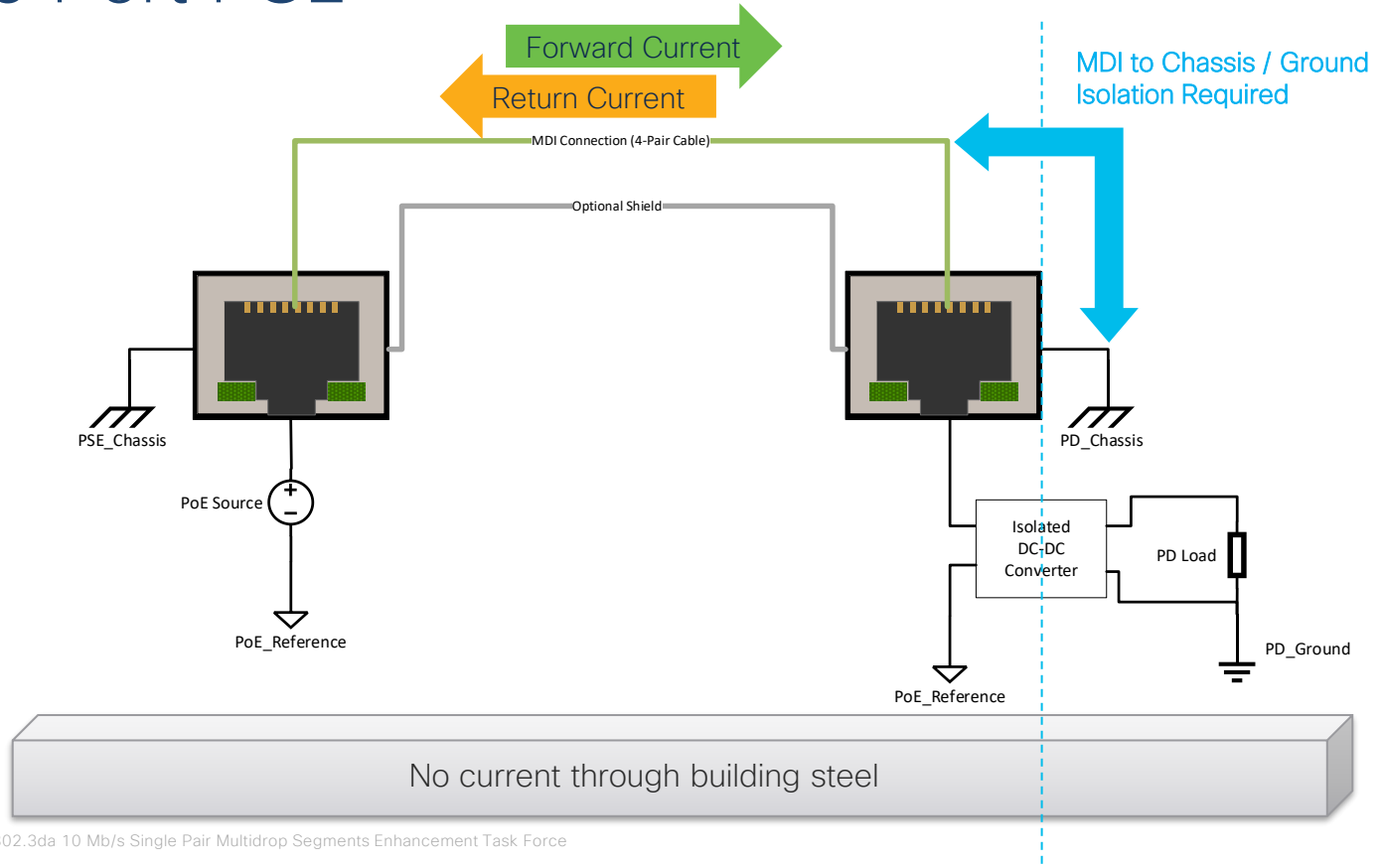## Isolation Requirement Implications on System Voltage

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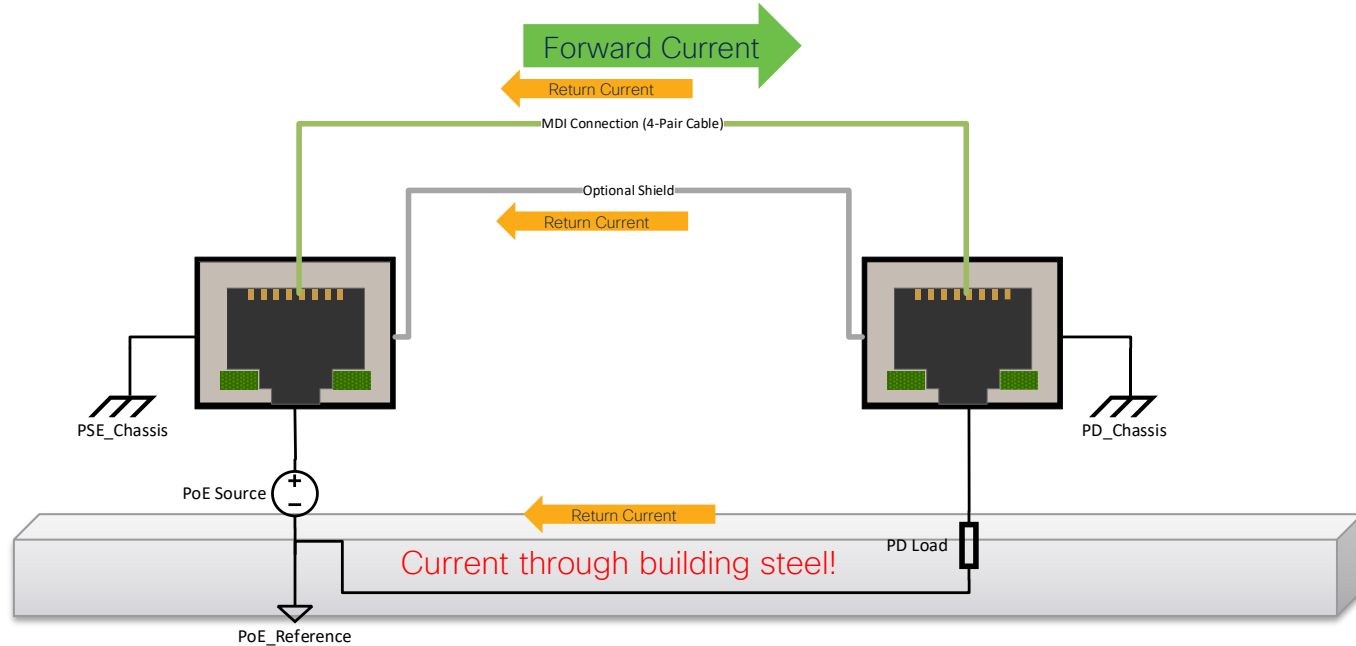2022-10-24

Motivating Problem

Single Port PSE

Forward Current

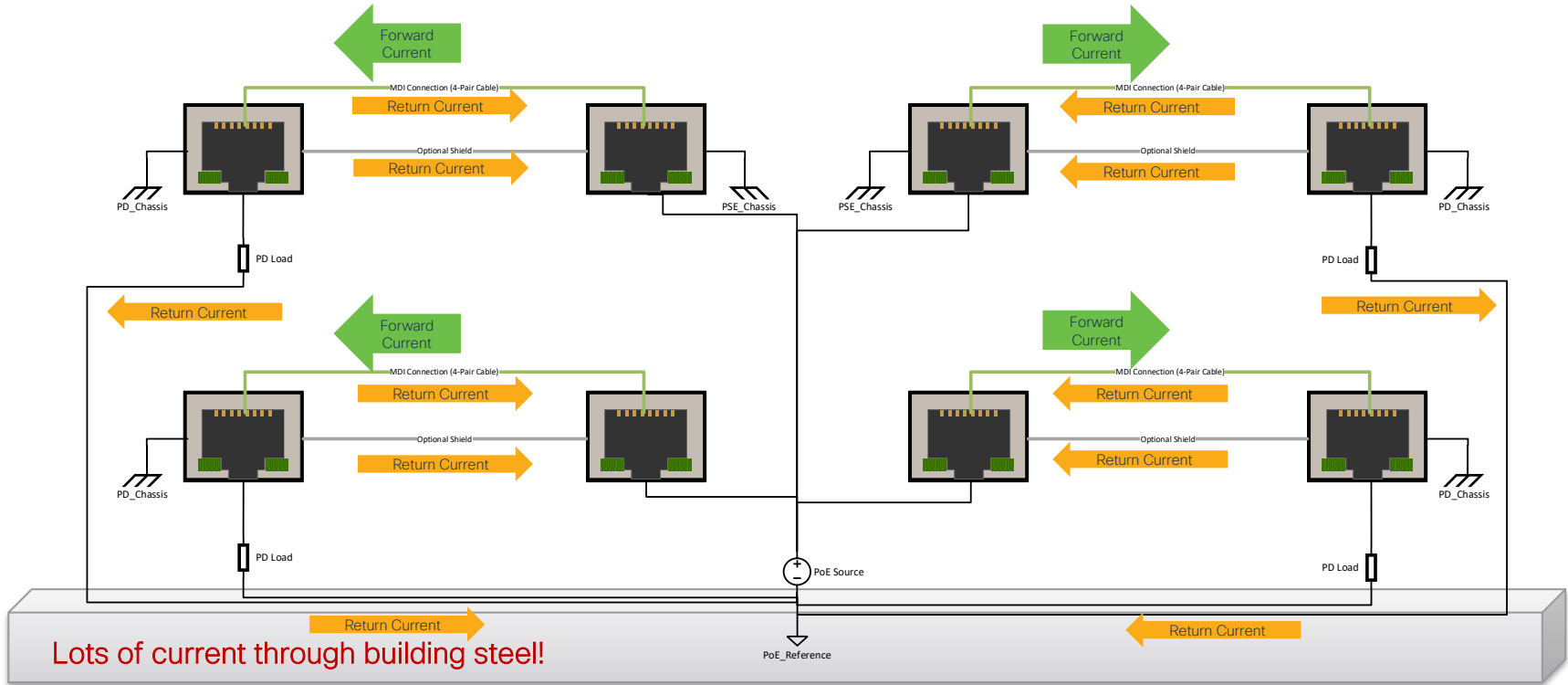Return Current

MDI Connection (4-Pair Cable)

MDI to Chassis / Ground Isolation Required

Optional Shield

PSE_Chassis

PoE Source

PoE_Reference

PD_Chassis

Isolated DC-DC Converter

PD Load

PoE_Reference

PD_Ground

No current through building steel

Single Port PSE Without Isolation

Forward Current

Return Current

MDI Connection (4-Pair Cable)

Optional Shield

Return Current

PSE_Chassis

PD_Chassis

PoE Source

Return Current

PD Load

Current through building steel!

PoE_Reference

Multi-Port PSE

Multi-Port PSE Without Isolation

Forward Current

MDI Connection (4-Pair Cable)

Return Current

Optional Shield

Return Current

PD_Chassis

PSE_Chassis

PSE_Chassis

PD_Chassis

PD Load

Return Current

Forward Current

MDI Connection (4-Pair Cable)

Return Current

Optional Shield

Return Current

PD_Chassis

Forward Current

MDI Connection (4-Pair Cable)

Return Current

Optional Shield

Return Current

PD_Chassis

PD Load

Forward Current

MDI Connection (4-Pair Cable)

Return Current

Optional Shield

Return Current

PD_Chassis

PD Load

Return Current

PoE Source

PoE_Reference

PD Load

Return Current

Return Current

Lots of current through building steel!

Key Take Aways and Questions

Key Observation

- Isolation is required at long distances

- Isolation requires a DC–DC converter

- If a converter is required anyway, why not **transmit the highest allowed voltage** and buck/boost voltage at PD to meet design requirements?
  - Multi–port PSEs will be specialized and have a dedicated power supply for which the rail voltage can be any voltage that meets Class 2 limits
  - PDs would certainly be smaller and simpler without isolation, but this adds **significant risk** to the powering network
  - Focusing on isolation for I/O only can help ease impact.
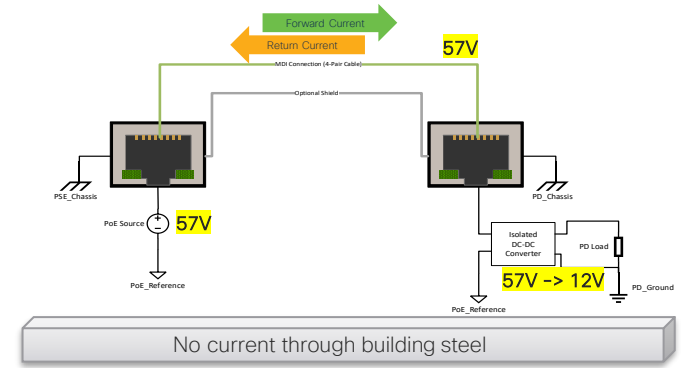
Minimal Isolation Example
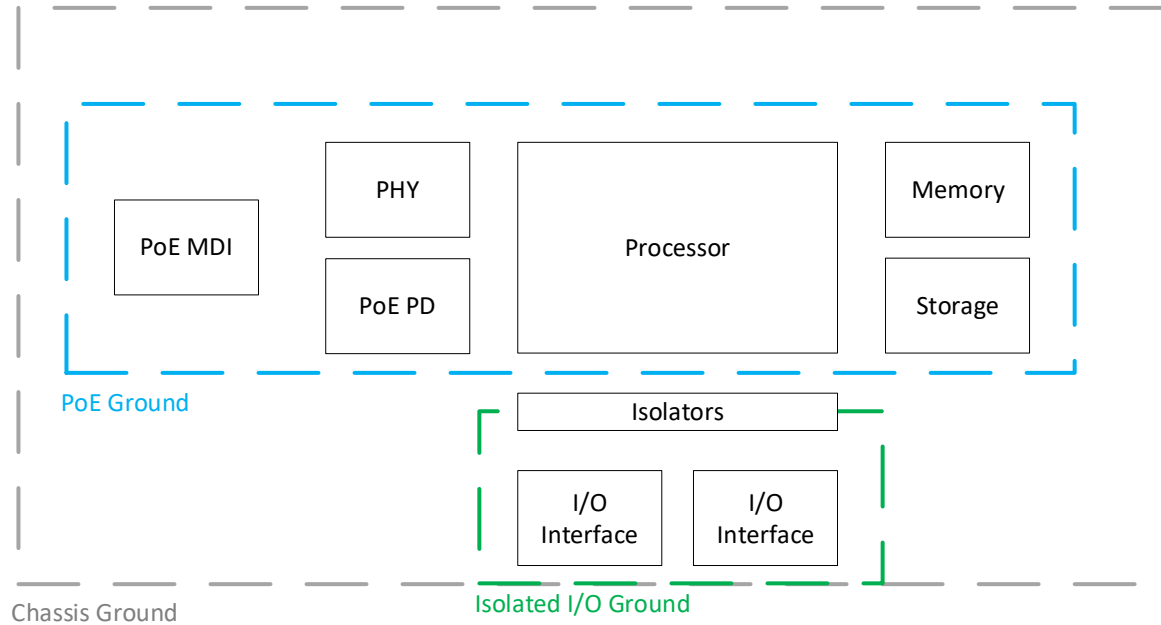
Questions for Discussion

- Should there be different requirements for data-only SPMD networks?

  - Isolation is far easier to maintain with data-only, which cuts both ways

- How small would a network need to be to allow non-isolated loads?

  - Obviously two devices on the same circuit board would not need isolation, but they also wouldn't need SPMD

  - A few meters is probably still OK

  - How about 50 meters?

  - Should requirements differ for multi-port and single-port PSEs?

  - Does multi-drop nature of network make a more complex per-output isolation scheme on the PSE sensible?

Hall of Pedantry

Overview of PoDL Isolation Requirements

104.6.1 Isolation

In order to prevent the formation of a ground loop, a PD shall provide at least 1 MΩ dc isolation **between all accessible external conductors, including frame ground (if any), and all MDI leads**, when measured using a 5 V ± 20% source voltage. Any equipment that can be **connected to a PD through a non-MDI connector that is not isolated from the MDI leads must provide isolation between all accessible external conductors, including frame ground (if any), and the non-MDI connector**, so as not to negate the dc isolation provided by the PD.

Compliance with requirements of 104.8.1 may require greater isolation, particularly in applications outside of automotive or other contained systems. (Added by 802.3dd-2022)

Overview of Common 802.3 Isolation Requirements (802.3cr Annex J)

J.1 Electrical isolation

Electrical isolation shall withstand at least one of the following electrical strength tests:

a) 1500 V rms at 50 Hz to 60 Hz. This test voltage amplitude is raised from zero to the prescribed voltage and held at that value for 60 s.

b) 2250 V dc. This test voltage is raised from zero to the prescribed voltage and held at that value for 60 s.

c) A sequence of ten 2400 V impulses of alternating polarity, applied at intervals of not less than 1 s.

The shape of the impulses is 1.2/50 (1.2 µs virtual front time, 50 µs virtual time to half value), such as one produced by a 1.2/50-8/20 combination wave generator, as defined in ITU-T Recommendation K.44.

NOTE 1—If the MDI is also a Clause 33 or Clause 145 PI then see 33.4.1 or 145.4.1 for specific requirements associated with option c).

There shall be no insulation breakdown during the test. Insulation breakdown is considered to have occurred when the current that flows as a result of the application of the test voltage rapidly increases in an uncontrolled manner; that is, the insulation does not restrict the flow of the current. Corona discharge is not regarded as insulation breakdown. The resistance after the test shall be at least 2 MΩ, measured at 500 V dc.

NOTE 2—IEEE Std 802.3-2018 and previous revisions provided references to various editions of the IEC 60950-1 standard for guidance in performing the isolation test for options a) and b). IEC 60950-1 has been withdrawn. References to IEC standards are not essential to performing the isolation test specified in J.1. No technical change is implied by the removal of these references.

Overview of Clause 145 PoE Isolation Requirements

145.4.1 Electrical isolation

PDs and PSEs shall provide isolation **between all accessible external conductors, including frame ground (if any), and all MDI leads including those not used by the PD or PSE.** Any equipment that can be **connected to a PSE or PD through a non-MDI connector that is not isolated from the MDI leads needs to provide isolation between all accessible external conductors, including frame ground (if any), and the non-MDI connector.**

External accessibility to conductors is specified in Section 5.4.10.1 b) of IEC 62368-1:2018.

This electrical isolation shall meet the isolation requirements as specified in J.1 with electrical strength test c) details being replaced by: "An impulse test consisting of a 1500 V, 10/700 waveform, applied 10 times, with a 60 s interval between pulses. The shape of the impulses is 10/700 (10 µs virtual front time, 700 µs virtual time to half value), as defined in ITU-T Recommendation K.44."

Conductive link segments that have differing isolation and grounding requirements shall have those requirements provided by the port-to-port isolation of network interface devices (NID).

In a multiport system, the implementer should maintain DC isolation through the termination circuitry to eliminate cross-port leakage currents. See 145.2.10.4.

Dual-signature PDs shall have less than or equal to 10 µA of current between any negative conductor of Mode A and any negative conductor of Mode B when VPD, as defined in 145.1.3, is less than VOff_PD min, as defined in Table 145–29, on either Mode. See Table 79–6f.

Thanks!