

Bridging Functional Insulation Implications and system consequences

802.3 Isolation Ad Hoc Meeting
Bridging Functional Insulation Contribution
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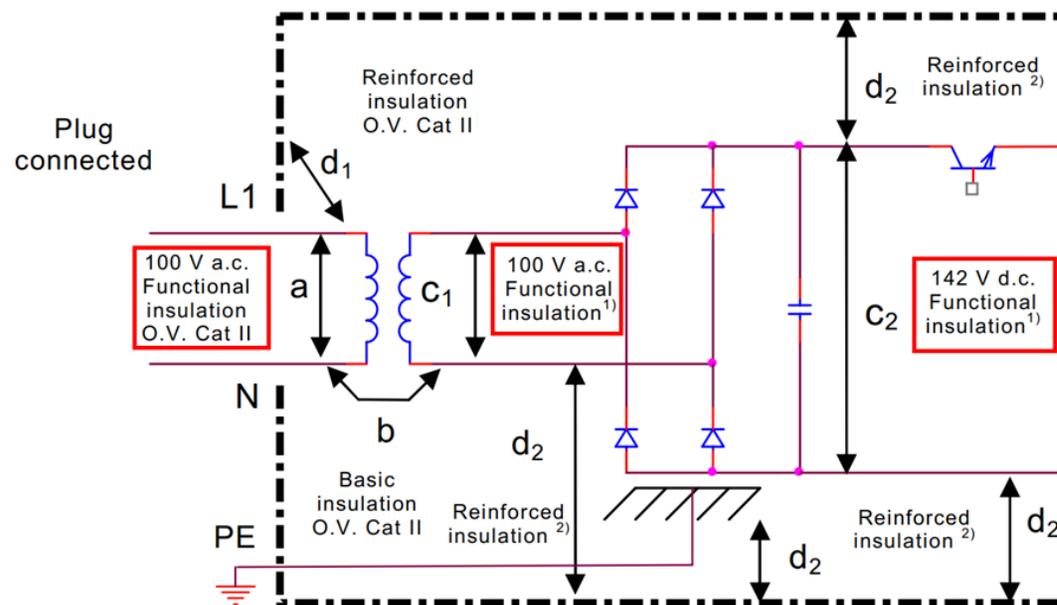
Bridging Functional Insulation Contribution

Introduction

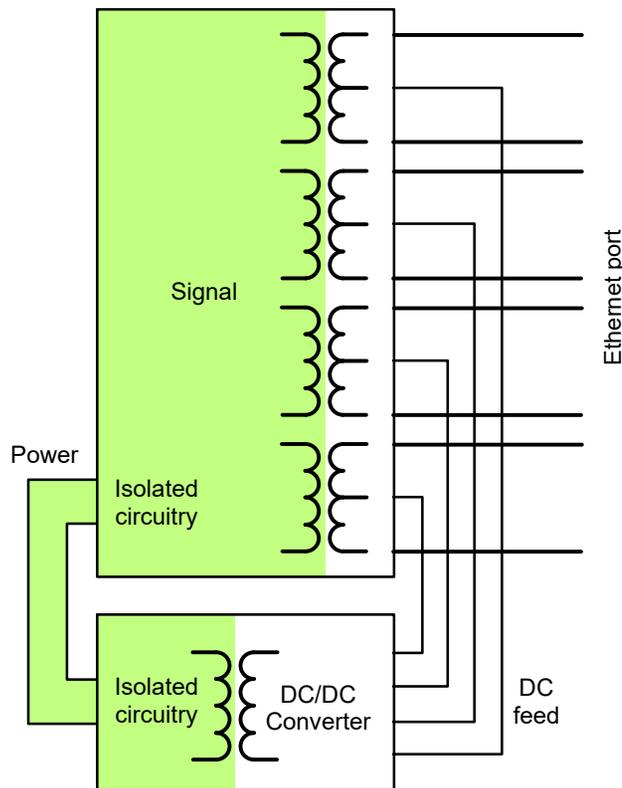
- IEC TR 60664-2-1 Ed. 2.0: *Insulation coordination for equipment within low-voltage systems - Part 2-1: Application guide - Explanation of the application of the IEC 60664 series, dimensioning examples and dielectric testing* has functional insulation bridging examples
- Reference PoE designs from several manufactures and actual products bridge the functional insulation barrier
- This is particularly relevant for PoE equipment mounted outside the building such as Access Points and Cameras.
- The recent Protection Engineers Group 2018 Conference had a presentation called “*Lightning Protection for PoE Powered Ethernet Radio Systems*” that illustrated the resulting lightning currents flowing in the Ethernet cabling.
- This contribution discusses the consequences of bridging and mitigating actions

Functional Insulation Example

- IEC TR 60664-2-1 only considers the functional insulation case of conductors at different AC or DC potentials.

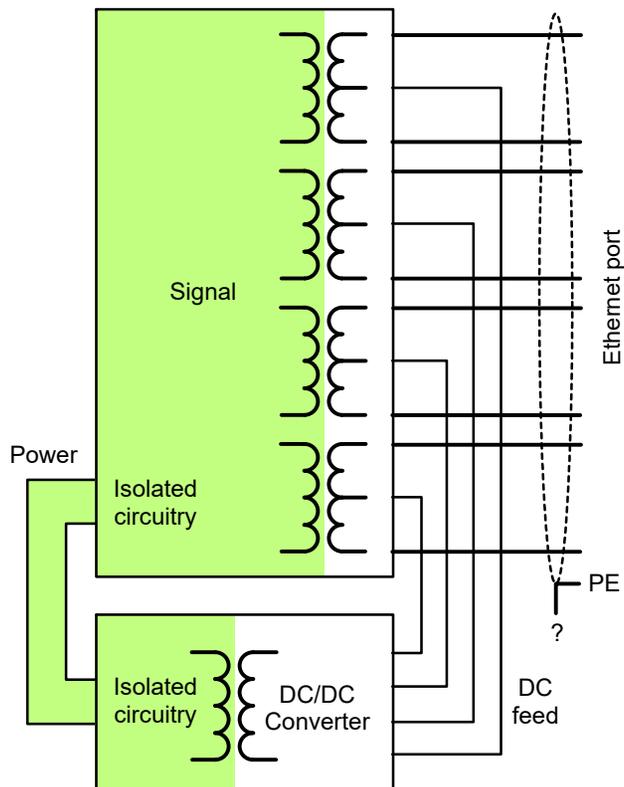


Functional Insulation Ethernet



- **Ethernet and PoE functional insulation is rather special because it involves isolating transformers as part of the functional insulation barrier**
 - Before PoE the isolation barrier was signal and powering source. An AC mains powering source required a safety insulation barrier
 - IEEE PoE uses non-hazardous voltages and the DC/DC converter can use a functional insulation barrier
 - PoE PDs, with a single (Ethernet) port and in a reinforced insulation enclosure, do not need a DC/DC converter insulation barrier, provided there is not a protective earth PE connection.

Functional Insulation — Ethernet screened (shielded) cable



- It is highly recommended the external Ethernet runs use screened cable. Application examples are remote access points (APs) and PoE cameras.
 - The internal PSE or a PoE injector is likely to connect the cable screen to PE.
 - The screened cable brings the PE to the remote PD.
 - What does the screen/PE get routed to at the PD?
 - The remote PoE PD may route the screen to a PE or functional earth terminal on the PD.
 - Further, the isolated circuitry may be bridged to the screen/PE terminals in both the remote equipment and a separate PoE injector, see next slide.

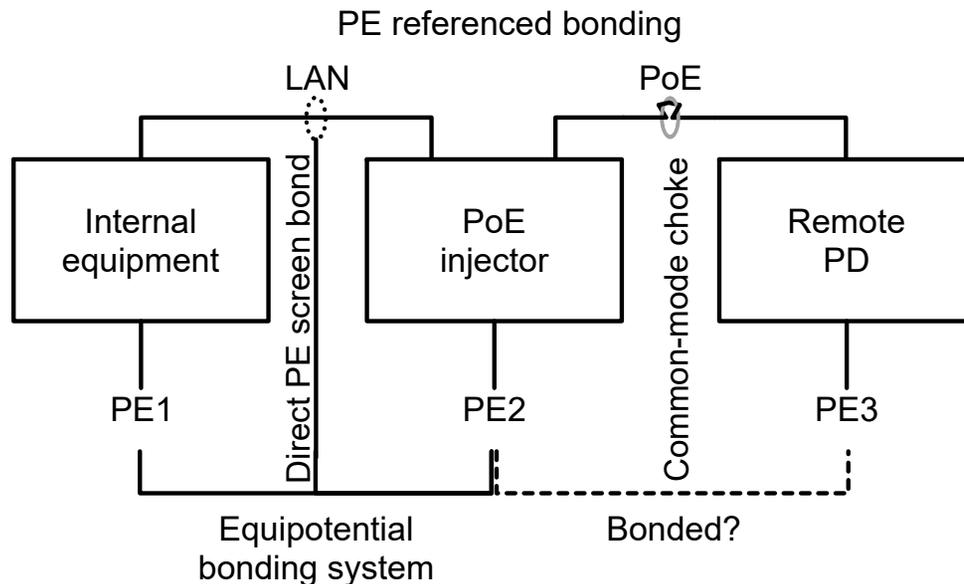
Functional Insulation — PE connections everywhere



- The left remote AP connects the screen to the PE terminal and via a diode bridge the “isolated” circuitry (weather proof cover removed). Note the use of a functional earth symbol  and not the PE symbol 
- The right PoE injector connects the mains PE terminal to the LAN and PoE connector screens. The injector power source is also connected to PE

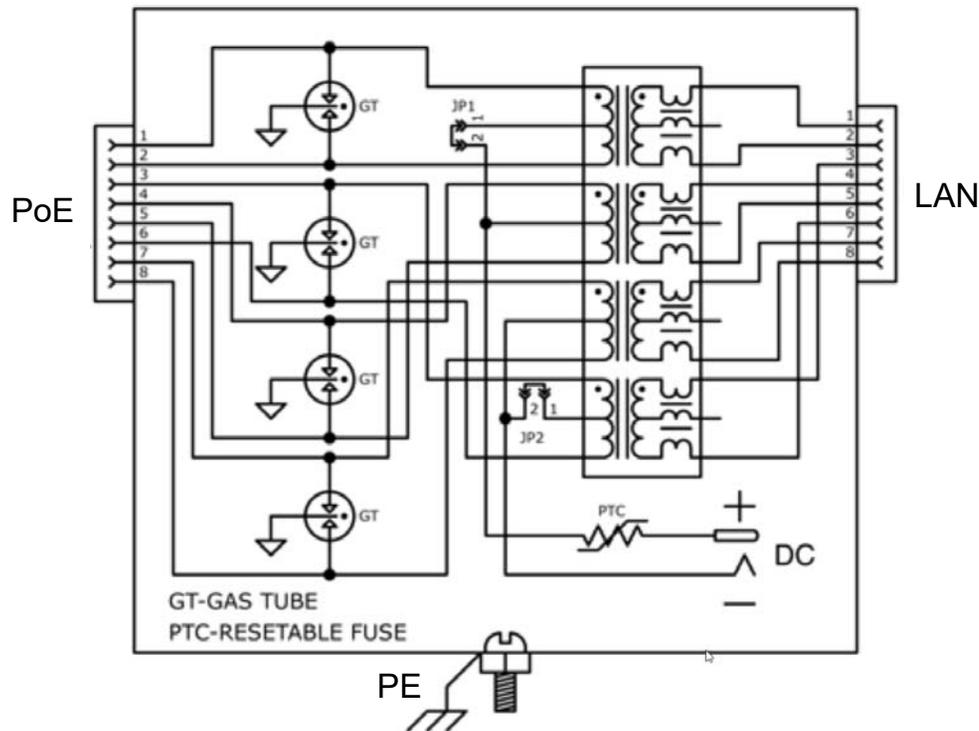


PE current routing



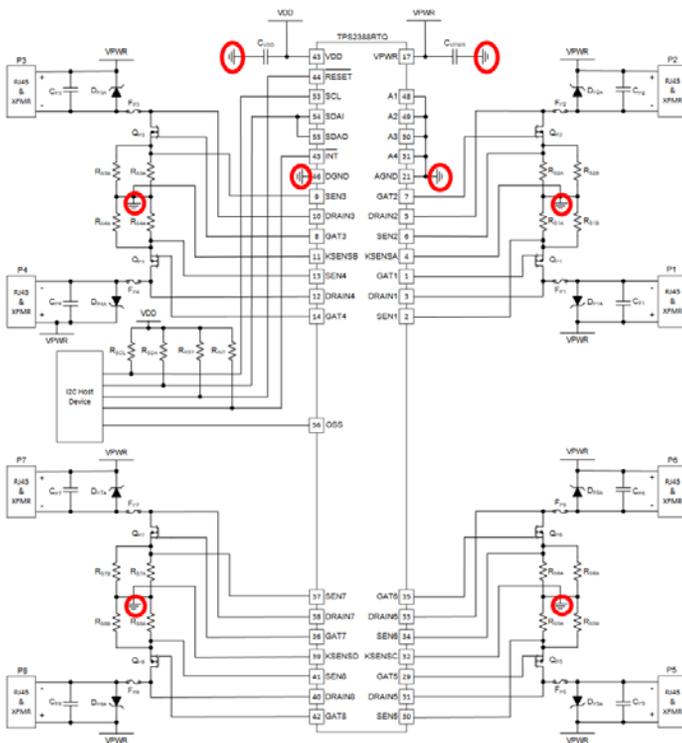
- Lightning surge currents have several circulation paths.
- If an earth potential rise occurs at PE3, a surge current will flow through the PoE connection.
- A series common-mode choke can reduce the PoE cable surge current
- At the PoE injector some current will flow into PE2 and the rest to the LAN connection.
- A direct screen to PE bond can bypass some of the LAN cable surge current
- At the Internal equipment the current will flow to PE1 and possibly to other connected equipment.

2018 PEG conference paper protected PoE injector



- Uses 90 V gas discharge tubes (GDTs)
 - PoE port will fail the IEEE 802.3 500 V insulation resistance test
 - Do not give the best lightning limiting voltage — a 150 V to 200 V type GDT is less.
 - Likely to be hazardous if power line contact occurs.
- Connects the PoE to PE in common-mode surge operation.
- No differential-mode surge protection.

PSE situation



- The use of the earth symbol  (circled) implies that the PSE powering is connected to the PE system.
 - A better symbol would be functional equipotential bonding  (Chassis in vacuum tube days)
- A common power supply to all ports has led to an incoming surge to one PoE port exiting via another PoE port. This has caused field failures.
 - Full description and some fixes given in [*Power Over Ethernet \(PoE\) Part 2 - Protecting PoE Against Intra-Building and OSP Environments*](#) by Tim Ardley, 2015 PEG Conference

Closing comments

- Some PD and PSE designs offered do not maintain the functional isolation barrier
- If shunt voltage limiting protection is used it needs to have a limiting threshold above 500 V to pass the IEEE 802.3 500 V insulation resistance test.
 - A useful by-product of this is that an AC mains power contact test is not required.
 - For products that fail the 500 V insulation test the ITU-T is set to require an AC mains power contact test.
- To reduce the conducted surge currents in the LAN and PoE cables & ports, PE bonding arrangements should be thought through, possible use of direct screen to PE bonding, application of toroidal core in-line common mode chokes considered and PSE PoE inter-port surge resistance understood.
- Surging ports without removing protection is required for ITU-T compliance and allowed in IEC TR 60664-2-1 Ed. 2.0: *Insulation coordination for equipment within low-voltage systems - Part 2-1: Application guide - Explanation of the application of the IEC 60664 series, dimensioning examples and dielectric testing.*