Bridging Functional Insulation
Implications and system consequences

802.3 Isolation Ad Hoc Meeting
Bridging Functional Insulation Contribution
Created by Mick Maytum
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.
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.
• 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.*