



Common Misconceptions in POE protection

Focus on SPD designs, to protect POE installations.



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Common Misconceptions in POE protection

Focus on SPDs, to protect POE installations.

Keith Herrington; Project & Application Manager, Citel

28 Years in SPDs

- 25 Years in R&D (ABB Furse)
- 3 Years in Marketing (Citel)

IEC SC37A member of WG5, WG4 and WG3 committees, plus equivalent CENELEC.

Chair of BSi PEL/37 – Surge Arrestors



Title and Content Layout with List

- Presentation scope
- Ethernet & POE
- Typical circuits
- Misconceptions
- Challenges
- Conclusion

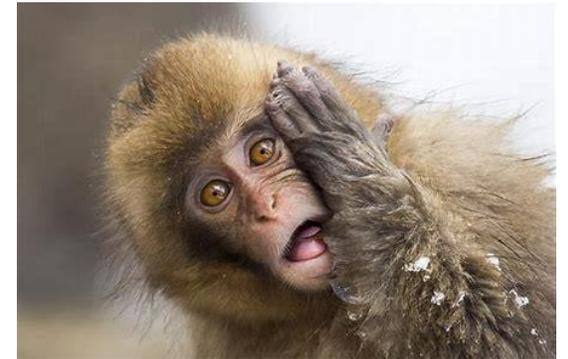
Presentation Scope

The focus of this presentation is on the designs of SPDs to protect of POE installations.

After a brief introduction to Ethernet and how POE power is applied, we look at how some circuit designs have missed the mark for protecting POE, and actually *reduced* the protection to the Ethernet datalines.

My viewpoint is based upon an R&D background of designing solutions for ABB Furse, mostly for UL497b applications. Since 2023 I am more focussed on applications, and realise there are challenges to be met!

I am hoping to learn back from you also, about US applications & standards...





Ethernet – what is it?

Ethernet – what is it?

Ethernet has become an industry standard for communicating data and is commonplace in our workplaces and homes; connecting modems, computers, servers, CCTV and appliances.

Ethernet is a low voltage signalling system, typically <3V. Early systems used 4 wires (2 pairs) with newer systems using all 8 wires (4 pairs) of ‘structured cabling’ using RJ45 connectors.

4 wires (2 pairs)

10BASE-T and 100BASE-T

8 wires (4 pairs)

1000BASE-T (1GBASE-T) / 2.5GBASE-T / 5GBASE-T / 10GBASE-T and beyond...

POE – what is it?

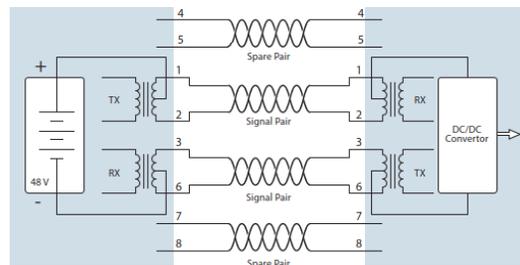
POE – what is it?

POE is a method of passing power over data cables, so existing cables can be used to quickly deploy POE within an installation. Power is injected, transmitted, then extracted using Ethernet transformers.

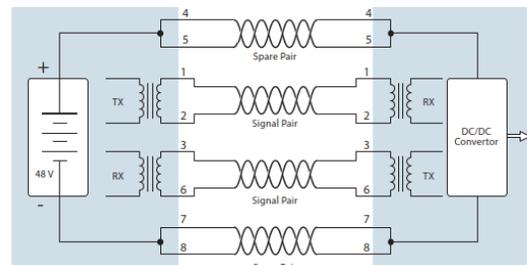
How is power applied?

4-wire (2 pair) systems used 4 of the 8 wires, given options for power transfer.

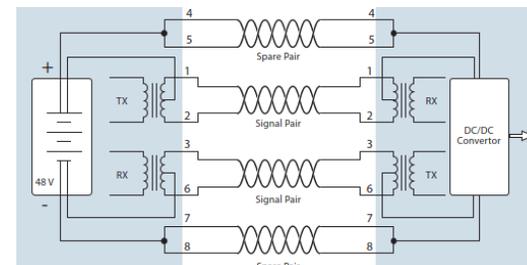
Mode A used a center tapping on Ethernet transformers to inject power, often called ‘phantom’ power. Mode B used the ‘spare’ 4 wires. At this point it was prohibited to use both modes A+B for high power.



Cat-5 PoE Mode A



Cat-5 PoE Mode B



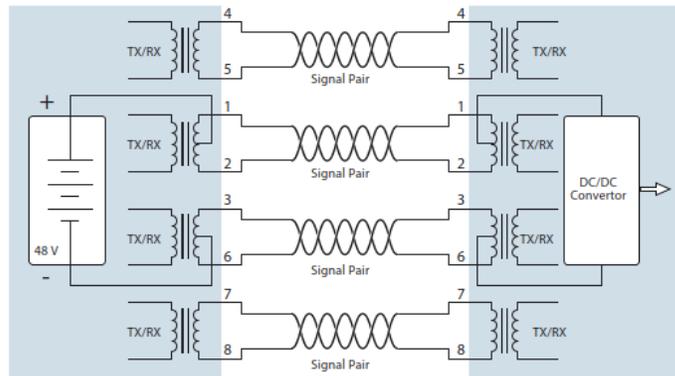
Cat-5 PoE Modes A+B (prohibited)

POE – what is it?

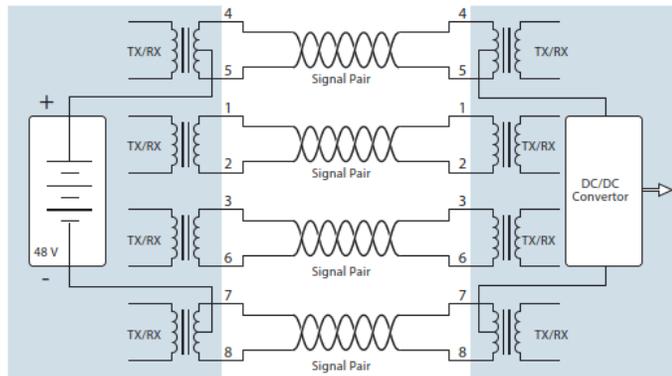
How is power applied?

The need for higher speeds pushed applications to use all 8 wires for data transfer, which has been called 4-PAIR-POE, often abbreviated to 4PPOE.

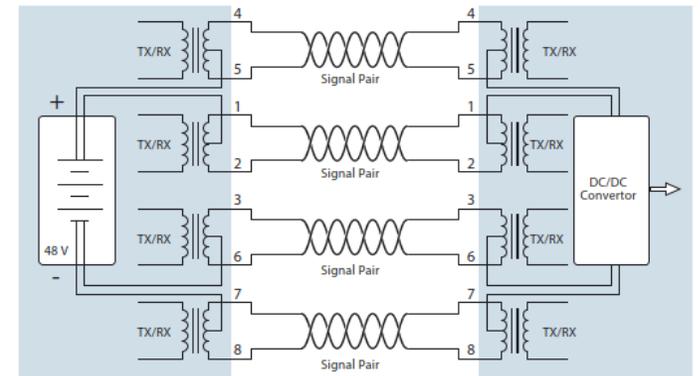
With 4PPOE there are no longer any 'spare' connections, so we use the 'phantom' power method.



4PPOE Mode A



4PPOE Mode B



4PPoE Modes A+B



POE – what is it?

POE – what is 4PPOE?

4PPOE is stating power can be transmitted over 4 pairs.

POE, POE+ and POE++

Over time, Powered Devices (PDs) needing more power were developed. For example, CCTV cameras with Point, Tilt and Zoom functions (PTZ) use a lot more power than static cameras.

POE, according to IEEE 802.3 af (2003), can deliver 12.95W (Type 1), to a PD.

POE+, according to IEEE 802.3 at (2009), can deliver 25.5W (Type 2), to a PD.

POE++, according to IEEE 802.3 bt (2018), can deliver 51W (Type 3) and 71.3W (Type 4), to a PD.

The act of automatic ‘negotiation’ between connected devices allows the system to configure power levels correctly, to avoid over-powering basic POE applications.



POE – market size

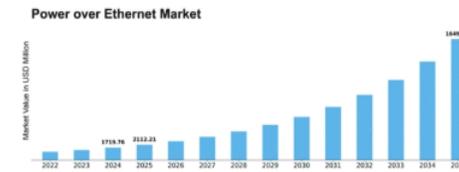
Power over Ethernet Market Summary

As per MRFR analysis, the Power over Ethernet Market Size was estimated at 1719.76 USD Million in 2024. The Power over Ethernet industry is projected to grow from 2112.21 in 2025 to 16498.23 by 2035, exhibiting a compound annual growth rate (CAGR) of 22.82 during the forecast period 2025 - 2035.

The Power over Ethernet Market is experiencing robust growth driven by technological advancements and increasing demand for energy-efficient solutions.

- The integration of Power over Ethernet with smart technologies is re-shaping various industries, particularly in North America.
- Energy efficiency remains a focal point, with significant advancements in standards and protocols enhancing system performance.
- Surveillance systems dominate the market, while lighting solutions are emerging as the fastest-growing segment, particularly in Asia-Pacific.
- The rising demand for IoT devices and growth in smart building initiatives are key drivers propelling the market forward.

Power over Ethernet Market



CAGR | 22.82%

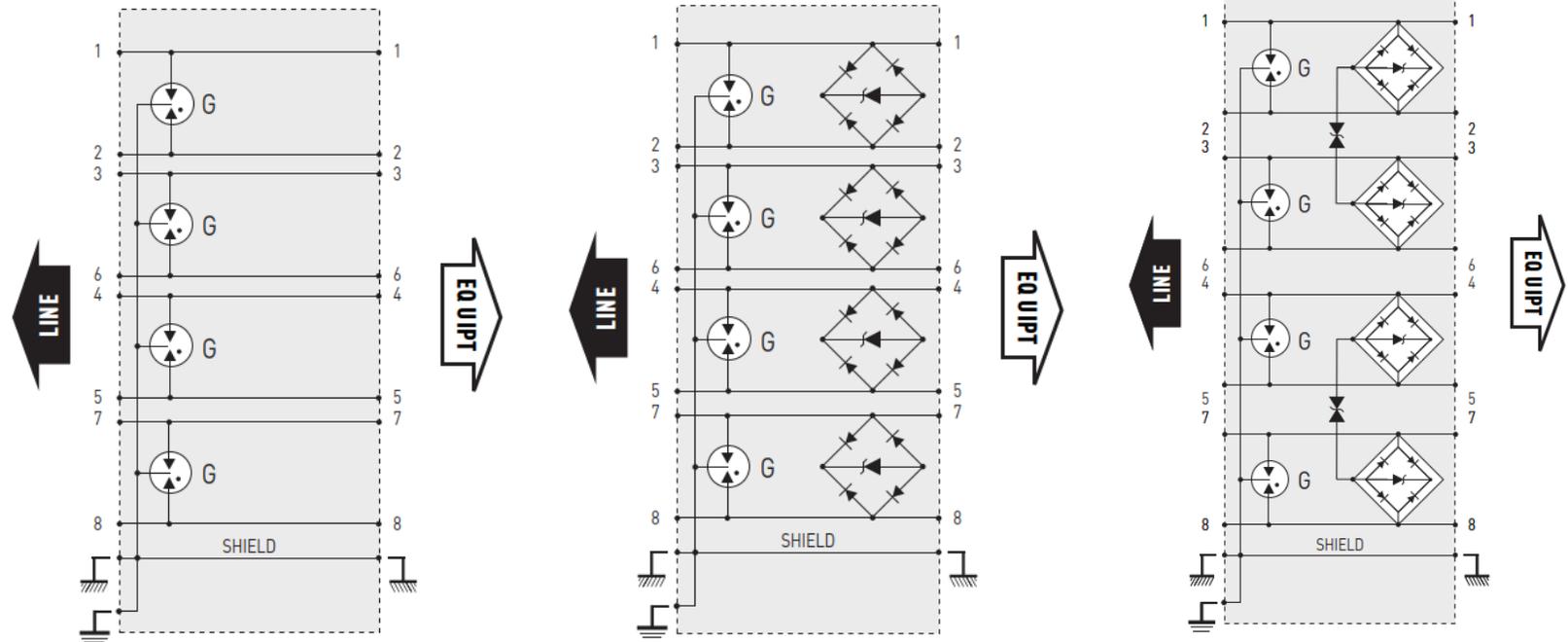
POE – Power levels

	Type 1	Type 2	Type 3	Type 4
Name	PoE	PoE+	PoE++ UPoE	High Power PoE
PoE Standard	IEEE 802.3af	IEEE 802.3at	IEEE 802.3bt	IEEE 802.3bt
Max. Power Per Port	15.4W	30W	60W	100W
Power to PD	12.95W	25.5W	51W	71.3W
Twisted Pair Used	2-Pair	2-Pair	2 or 4-Pair	4-Pair
Voltage (Operation)	44-57V	50-57V	50-57V	52-57V
Voltage (to Device)	37-57V	42.5-57V	42.5-57V	41.1 to 57V

Ethernet / POE – typical circuits

These are typical circuits used by SPD manufacturers:

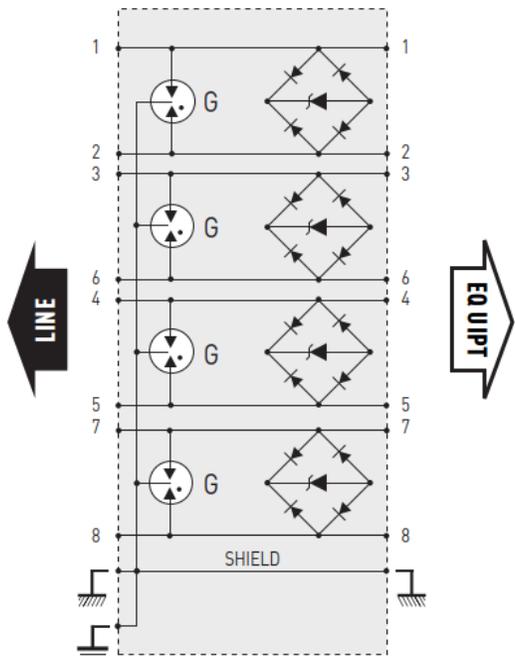
- GDT only
- GDT plus TVS (dataline)
- GDT plus TVS (dataline and POE)



Misconception #1

How to (not) protect POE feeds

For Ethernet protection, the TVS diode typically employed is 3.3V. When POE was introduced, and due to a misunderstanding of how power was applied, some designers simply changed the TVS to 58V.



Ethernet protection only [TVS diode of 3.3V]		
Data	CM	~ 700 V
	DM	~ 10 V
POE	CM	~ 700 V
	DM	~ 1200 V

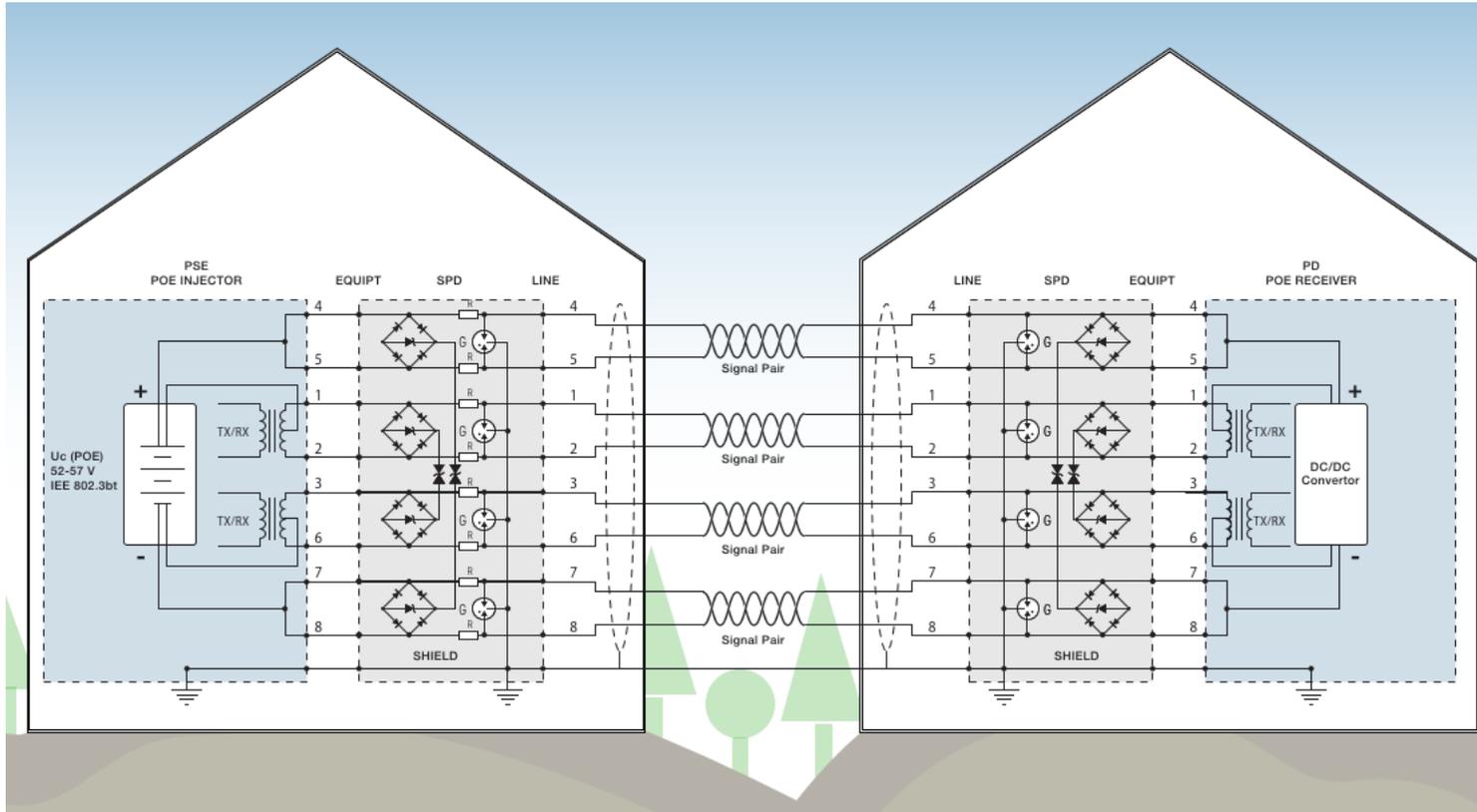
Ethernet protection, plus POE [TVS diode of 58V]		
Data	CM	~ 700 V
	DM	~ 80 V
POE	CM	~ 700 V
	DM	~ 1200 V

➡ POE protection did not change (still just GDT activation)

➡ Dataline protection was worse, protection levels increased from ~10V to ~80V

Misconception #2

That POE SPDs are not backwards compatible



The SPD on the left is a 'traditional' type with a coordinating resistor between primary/secondary stages, allowing for high surge ratings in CM and DM modes.

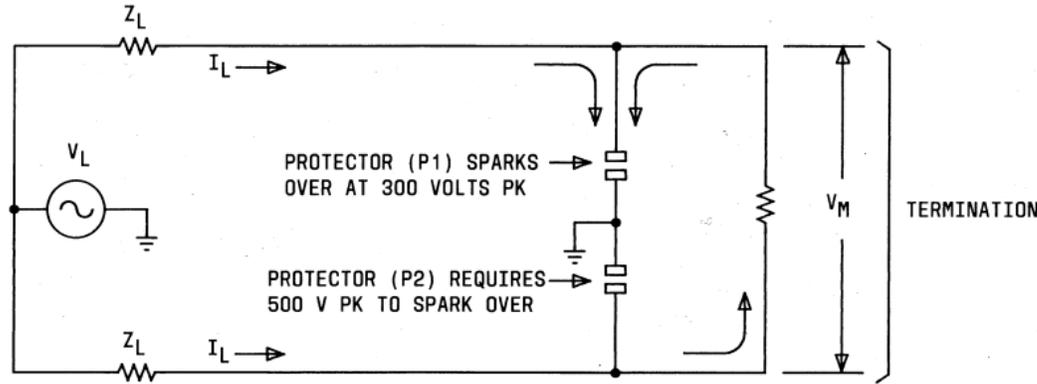
However, the resistor can block 'mode B' POE power if the resistance is too high, typically 5-10 ohms.

With speeds above 1G, most designers remove the resistors, accepting that metallic surge ratings are significantly lowered. [500A 8/20 versus 10kA 8/20]

But...this *does* allow for backwards usage, and the right SPD can be used for all POE powering methods

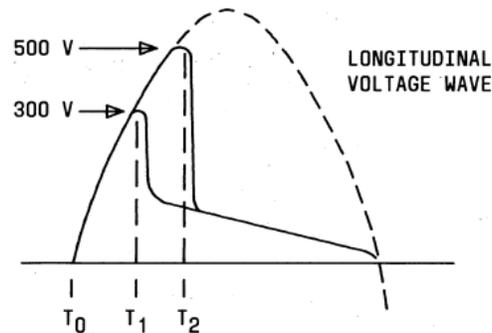
Misconception #3

That all GDTs cause conversion of CM to DM surges



It is true that conversion can happen in certain cases:

- When a pair of 2-electrode GDTs are used, each per line to earth.
- 3-electrode GDT that has separate gas chambers



NOTES:

1. METALLIC VOLTAGE (V_M) ACROSS TERMINATION VARIES FROM ABOUT 275 TO 475 VOLTS PK FOR THE PERIOD T_2-T_1 .
2. SPARKOVER VALUES SHOWN ARE POSSIBLE VALUES FOR BLOCKS WHICH HAVE EXPERIENCED SOME SERVICE DUTY.



Misconception #3

That all GDTs cause conversion of CM to DM surges

The use of common-chamber 3-electrode GDTs reduces/eliminates the occurrence, and is checked by ITU-T K.12, to ensure that any condition does not last beyond 200 ns.

7.4 Transverse voltage

The transverse voltage for a 3-electrode gas discharge tube is the difference in the discharge voltages between terminals a and b of the gaps assigned to the two conductors of the circuit during the passage of discharge current. For a 3-electrode gas discharge tube, the difference in time between the sparkover of the first and second gap shall not exceed 200 ns.

Ethernet / POE – ‘essential’ protection (GDTs)

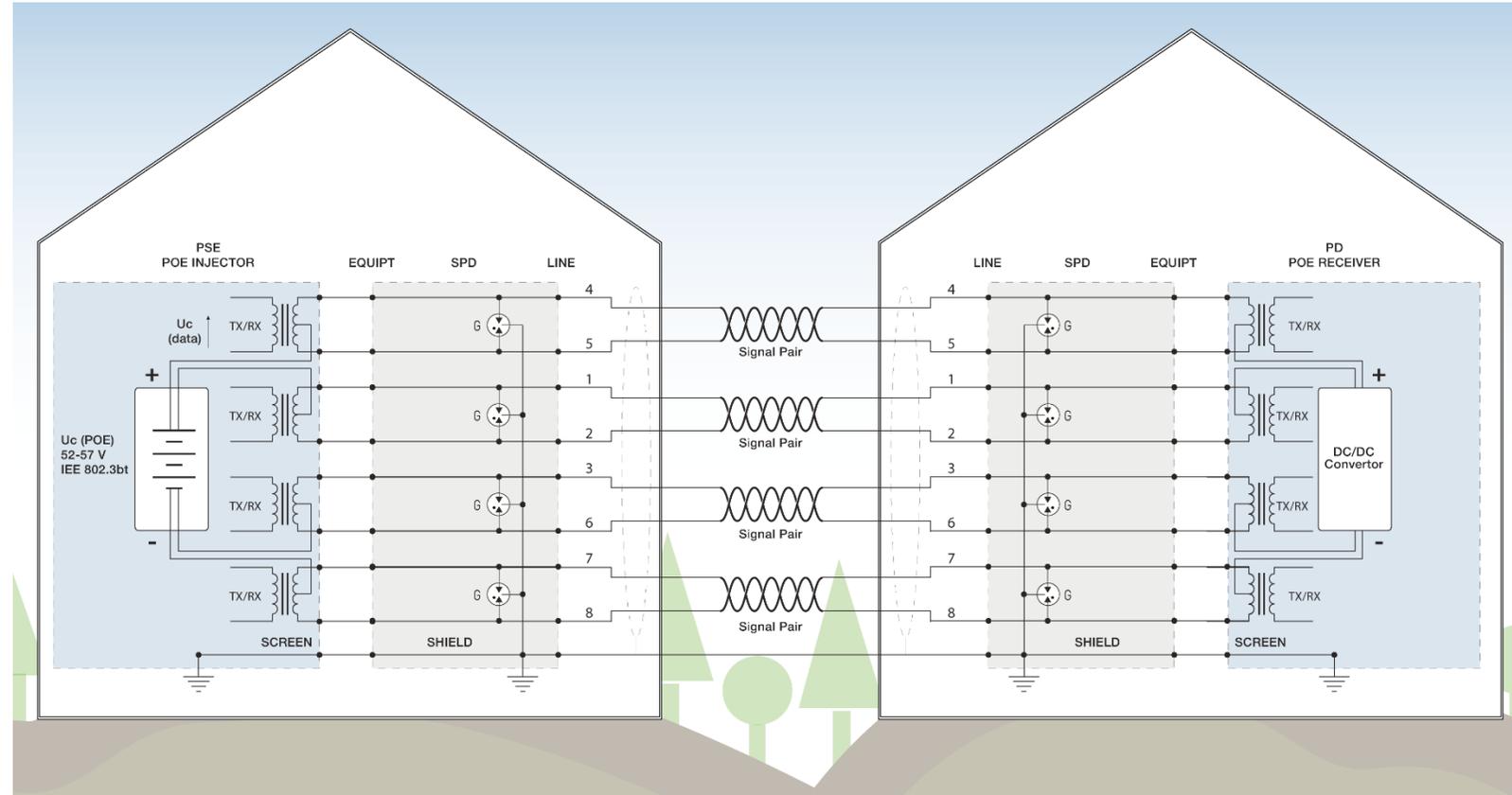
Protection offered (per mode):

Data

- CM ~ 700 V 10kA 8/20
2kA 10/350
- DM ~ 1200 V 10kA 8/20
2kA 10/350

POE

- CM ~ 700 V 10kA 8/20
2kA 10/350
- DM ~ 1200 V 10kA 8/20
2kA 10/350



Ethernet / POE – plus TVS diodes

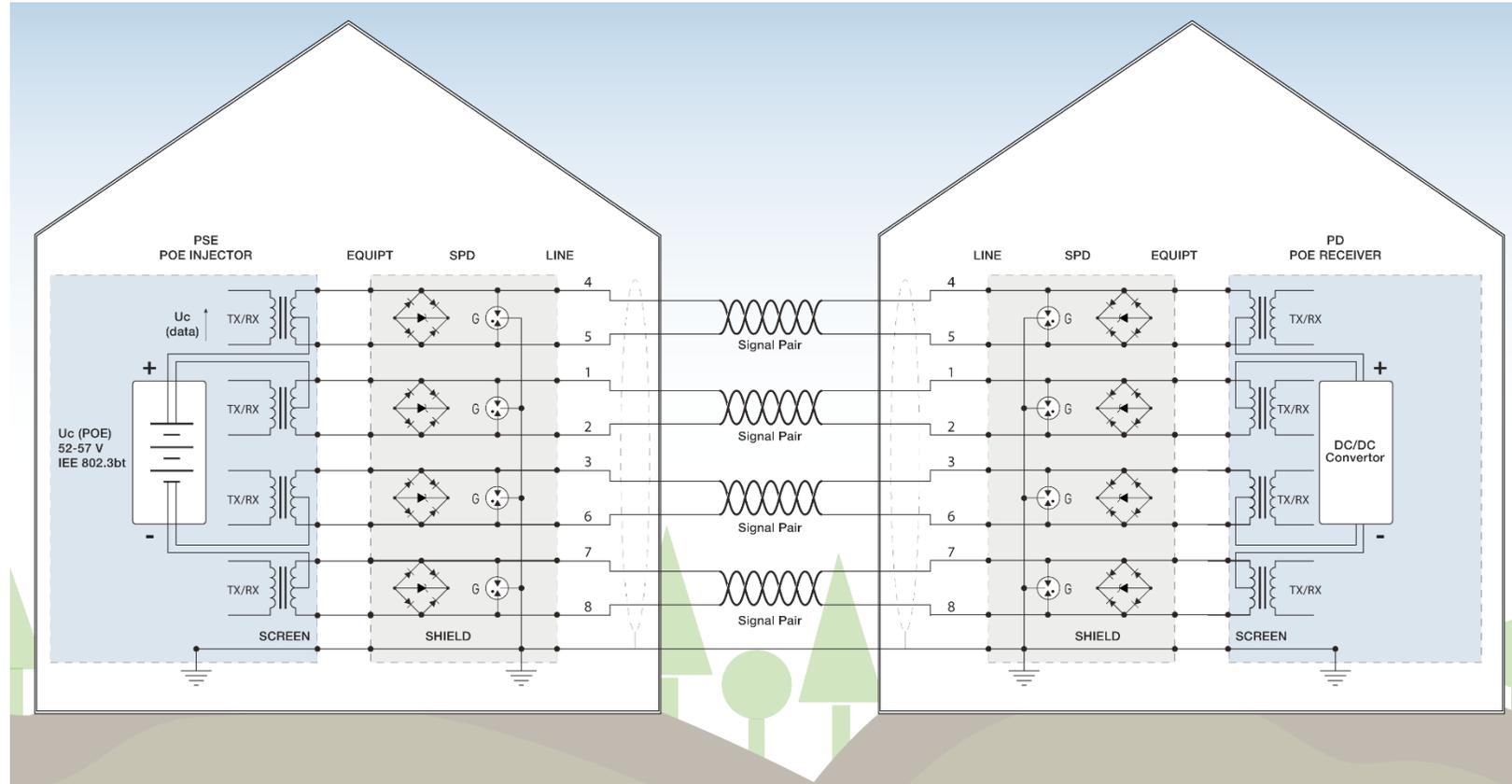
Protection offered (per mode):

Data

- CM ~ 700 V 10kA 8/20
2kA 10/350
- DM ~ 10 V 150A/500A 8/20

POE

- CM ~ 700 V 10kA 8/20
2kA 10/350
- DM ~ 1200 V 10kA 8/20
2kA 10/350



Ethernet / POE – plus POE TVS diodes

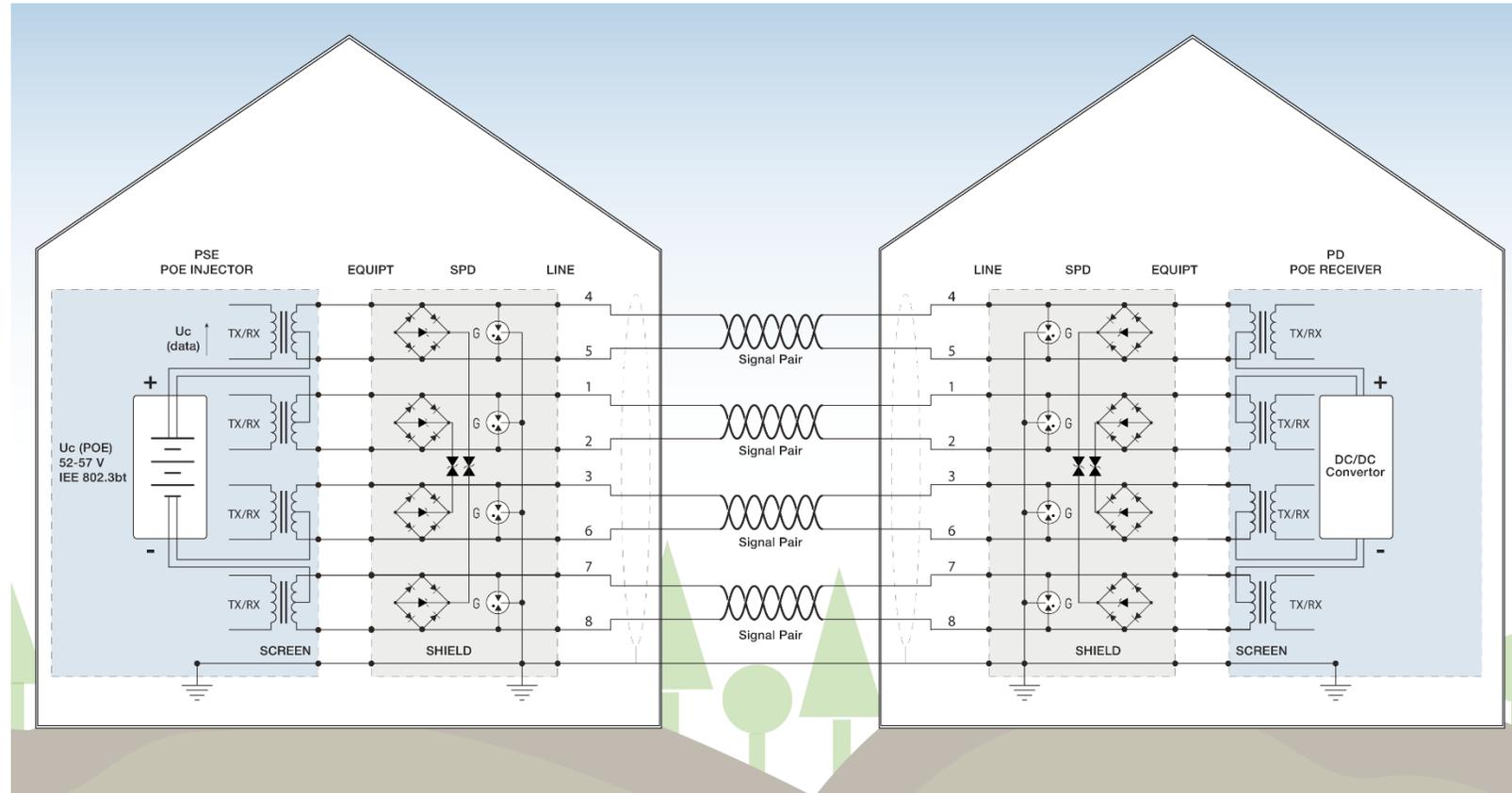
Protection offered (per mode):

Data

- CM ~ 700 V 10kA 8/20
2kA 10/350
- DM ~ 10 V 150A/500A 8/20

POE

- CM ~ 700 V 10kA 8/20
2kA 10/350
- DM ~ 80 V 150A/300A 8/20





Ethernet / POE – superior ‘low’ protection levels

The IEEE Emerald book states that ‘...*most solid state devices cannot tolerate more than twice their maximum working voltages...*’, and so designers may choose to achieve the lowest possible protection levels (VPR).

- The use of 3.3V ethernet protection circuits delivers protection levels ~10V
- TVS for POE protection (max=57V) delivers protection levels ~80V
- Ethernet transformers can withstand ~1500V surges (Ardley, 2015), assuming ‘essential’ SPD circuits based purely on primary GDTs are fitted (VPR ~ 1200V or lower).



Ethernet / POE – challenges for protection

There are various challenges, towards creating the ideal protection concepts:

Grounding

Whilst grounding is quite common, when systems cannot be grounded what technologies can be employed to survive surges? A combination of isolation & protection? (Ardley, 2015)

Port Types

With GR1089 having 15 port types, this makes ‘blanket’ POE protection impossible. From an outside view it makes it far more complex to offer protection solutions.

Surge Waveforms

We have so many types to consider, can we simplify and *standardize* better?

10/1000 μ s, 10/360 μ s, 10/350 μ s, 10/700 μ s, 2/10 μ s, 1.2/50 μ s, 8/20 μ s



Ethernet / POE – challenges for protection

There are various challenges, towards creating the ideal protection concepts:

Metallic protection

Given the modern approach within SPD designs to eliminate the inline resistance to help achieve the high speeds above 1G, have manufacturers weakened their protection too much with regards the metallic surge ratings within their SPDs?

Protection to UL497 / UL497a

Given the need for overcurrent protection, something needs to be added back into the line to do this – a resettable PTC / TBU solution or perhaps just fusing?



Conclusions

A misunderstanding about how POE is applied has led to SPD designs that expose the Ethernet data lines, offering little protection for POE sources/loads.

- ➔ Protect the Ethernet data line, in Longitudinal (CM) and Metallic (DM) modes.
- ➔ Protect the POE power feed, in Longitudinal (CM) and Metallic (DM) modes

Metallic (DM) / protection is becoming critical (Wiese, 2014)

- ➔ Low VPR is possible; to 10G+, that meets Intra/Inter building levels to GR1089.

There is a concern about GDTs converting Longitudinal (CM) surges to Metallic (DM).

- ➔ Any conversion is limited by the use of common-chamber 3-electrode GDT's, and through testing within ITU-T K.12 / GR1089.

It is possible to design and implement SPDs with very low protection levels (VPR), in line with IEEE Emerald book guidance on solid state systems.



References

Do I need to show all the past paper references I have made reference to?

ATIS-PEG-2015 Tim Ardley

Protecting POE PSE against Lightning & Power Fault, in internal & OSP type environments.

ATIS-PEG-2014 Jim Wiese

Ethernet Protection – Latest Standards Work update.

Littelfuse: [Ehttps://studylib.net/doc/18235402/telcordia-gr-1089--issue-6-calls-for-new-protection-andtheernet](https://studylib.net/doc/18235402/telcordia-gr-1089--issue-6-calls-for-new-protection-andtheernet) Port Protection & Testing

Telcordia GR-1089, Issue 6 Calls for New Protection and Testing of Ethernet Ports

Market Research Futures: <https://www.marketresearchfuture.com/reports/power-over-ethernet-market-2091>



Questions?

