PoE AND ITS IMPACT ON CABLING AND CONNECTIVITY

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Introduction

Safely supplying low voltage power over twisted pair communication cabling has existed since the earliest forms of cabled communication. In earlier days automated central offices supplied ring voltages of 30V + 15V via 1 or 2 pairs to residential or business land line telephones. More recently we progressed from data signaling voltages of 5V or less, to PoE power piggybacking over the same twisted 4 pair structured cabling in almost all commercial building communication cabling infrastructure.

A common definition of PoE.

"Power over Ethernet or PoE technology is a method & system to safely deliver DC electrical power, along with data, to remote devices over standard data-com cabling on an Ethernet network."

The Goal of Power over Ethernet (PoE) is to provide a low voltage delivery technology & method that can efficiently power an end device from a central location (telecom closet, communication cabinet) using the same transmission path/cabling and at the same time as the Ethernet data transmissions. PoE powering eliminates the need to run or utilize separate cabling or AC outlets for purpose of powering end devices (example: eliminates the need for an AC outlet to power IP phone sets or wireless access points).

What standards bodies have impacted PoE?

The PoE application, and the cabling it is likely to be run on, are primarily impacted by 2 separate standards organizations. The IEEE which governs and defines all Ethernet (802.3) applications (which includes PoE) and the EIA/TIA or ISO/IEC through commercial cabling standards (SCS structured cabling systems) along with subsequent related standards defining structured communication cabling design, installation and testing guidelines.

While the PoE application will typically be run over structured cabling defined by TIA & ISO/IEC, the PoE standard is controlled entirely by IEEE. The IEEE has and continues to solicit input from the cabling standards bodies regarding cabling recommendations and to initiate liaison discussions on joint technology topics and concerns. Several corporate members belong to both standards bodies acting as liaisons.

The TIA and ISO/IEC define & own the dominant version of structured communication cabling design, installation and testing guidelines. These standards (TIA568C and ISO/IEC11801) have been embraced and followed in the Americas and internationally since the late 1990s. The TIA and ISO/IEC organizations now consider the power impact of PoE when assembling or updating cabling standards and practices

The first Power over Ethernet (PoE) standard (IEEE 802.3af) was introduced in 2003. 802.3af targeted applications that were already served by twisted pair copper cabling. An early targeted application for PoE was IP telephony. This and subsequent IEEE PoE applications were designed for deployment over 4 pair cabling via both the building or campus infrastructure (TIA-568 & ISO/IEC11801) structured cabling, as well as application specific 4 pair cabling infrastructure.

What are the key elements of PoE as defined by IEEE?

There are two main elements that comprise the PoE standard, each with defined characteristics and roles as part of 802.3af and 802.3at. These elements include the Powered Device (PD) which is the device being powered, existing examples include IP telephones and wireless access points, and the Power Sourcing Equipment (PSE) which supplies the power for the end device, existing examples include PoE enabled switches.

Figure 1

Power-Supplying Equipment (PSE)

As the name indicates, the PSE is the source of power for the attached powered devices. It is also tasked with identifying when power should be made available to a channel. PSEs can also be responsible for budgeting power amounts available to PDs based on demand requirements.
Usually located at the originating end:

- Figure1: Endpoint PSE, typically supplied by the switch

OR

- Figure 2: Mid-Span PSE adding power between the 2 ends of a data circuit

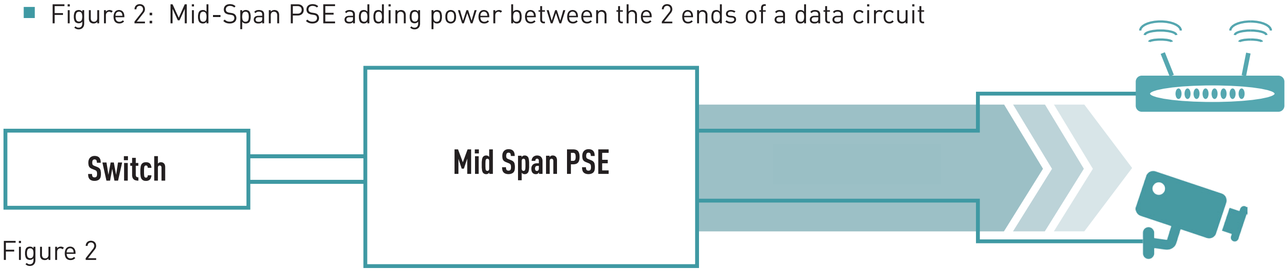


Figure 2

Powered Devices (PD's) are end devices that negotiate & accept power from the PSE. These network devices (PDs) may be powered, as well as communicate via the LAN receiving power & data from a LAN switch (endpoint PSE) or using an inline powering alternative (Mid-span PSE) where data comes from the switch but power is introduced mid-span between the switch and PD.

The Two Currently Approved IEEE Standards for POE:

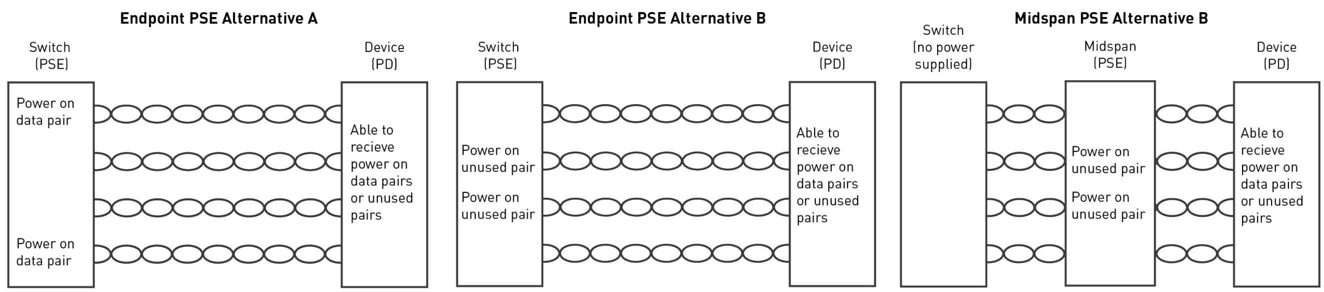
IEEE 802.3af PoE

- Ratified in 2003
- Providing 15.4W at the PSE, with min of 12.95W available to the PD

IEEE 802.3at PoE+

- Ratified in 2009
- Providing 34.2W at the PSE, with min of 25.5W available to the PD

The IEEE 802.3af PoE standard first defined the requirements for PoE supplying up to 15.4 W of DC power to each device without affecting the data rate (10/100/1000 Mbps) of Ethernet networks running on 100 OHM 4 pair balanced cabling. Power was supplied on 2 of the cablings 4 pairs. You may have heard references to Alternative A and Alternative B regarding which 2 pairs are being used to provide a power path. Alternative A refers to providing power on the same pairs as the 10BaseT or 100BaseTX data signal (pairs 2 & 3, RJ45 positions 1,2,3,6). Alternative B refers to the supply of power on the unused 10BaseT and 100BaseTX pairs (pairs 1 & 4, RJ45 positions 4,5,7,8). From a cabling perspective the choice of Alternative A or Alternative B is not of much importance. Please note that all 4 pairs are used for 1000BaseT so power will always be supplied on data pairs. MidSpans only operate on alternative B. 802.3af PDs can operate with either powering alternative.



IEEE Standards for Higher Power PoE in Development

Proposed IEEE 802.3bt PoE Type 3

- Currently in Working Group
- 60W at PSE
- With 49 watts at the PD, Doubling IEEE 802.3at
- Utilizing all 4 wire pairs
- Projected to be Ratified by IEEE in 2017

Proposed IEEE 802.3bt PoE Type 4

- Currently in Working Group
- 100W at PSE
- Max current 1000 mA , with 96 watts at the PD
- Utilizing all 4 wire pairs
- Projected to be Ratified by IEEE in 2017

In addition to the IEEE standards listed previously, there are other standards for supplying power HDBaseT/PoH and proprietary methods. An example of this is Cisco UPoE, which can vary from the aforementioned information.

Why is PoE a safe method to deliver power?

The IEEE approved model for PoE is safe for the following reasons:

- The technical foundation is built around the NEC (National Electric Code) thresholds for low voltage cabling similar to what had been used for years for phone systems.
- Power is only supplied by the PSE onto cabling that has a valid PD connected onto the end following an authorization negotiation. When a PD is removed or channel continuity is interrupted, power is no longer supplied to that cable channel.

When is PoE power on the cabling?

Power is only supplied by the PSE onto cabling that has a valid PD connected onto the end. To accomplish this, each PoE supported port of a PSE will poll each cabling channel it is connected to.

- First, the PSE applies a very low trace detection voltage onto the attached cabling.
- A valid PD that wants power acknowledges this detection voltage with a specific signature response to the PSE. Along with a valid PoE signature, PDs may optionally present a classification signature (how much wattage the device is requesting)
- After completion of signature negotiation process, power is supplied by the PSE as long as that PD is attached / connected and requesting power. When the PD is detached, power is no longer supplied and the PSE will begin the trace voltage polling again.
- If no valid signature detected, the PSE will not supply power to that line. If a PoE switch (PSE) does not receive a valid PD signature, that port will still send data even though power is not supplied.
- For Mid Span PSEs, if no valid signature is detected, the Mid Span will not supply power to that line but data will continue to pass through the Mid Span to support the end device.
- This design, controlled by the IEEE standards, ensures power is only supplied when an appropriate device is attached and requesting PoE power

What are some benefits of PoE power vs. alternative power?

A primary benefit of utilizing PoE is that it allows both data & power to be delivered by the same cabling to a powered device. As a result of this convergence, the following benefits are realized:

- An AC power outlet does not need to be cabled to the PD.
- Use of DC power supports the elimination of AC power and DC transformers at the device location, reducing power
  infrastructure requirements and losses from conversions.
- PoE power supplied from a central location (e.g. wiring closet),offers simplified and central control of power distribution by the Ethernet switching device.
- Centralized PoE offers the additional option of easily supporting end devices with UPS for backup power.
- For evolving applications PoE provides the communication path from an end device allowing more intelligence to be shared and communicated to a device.

Cabling requirements for IEEE PoE

The IEEE qualification process for PoE standards continues to be based largely on the TIA's 568 commercial cabling standards. This is to ensure TIA and ISO CAT 5e, CAT6 and later CAT6A, 100 meter cabling channels would support these PoE applications and targets. This cabling model was also used when IEEE calculated the anticipated attenuation of power over a maximum of 100 meters of cabling.

Example for maximum planned power attenuation:

- For the IEEE 802.3at standard, while the PSE will supply up to 34.2W of DC it is predicted/designed that at least 25.5W will be available at the powered device (PD) on channels up to 100 meters.

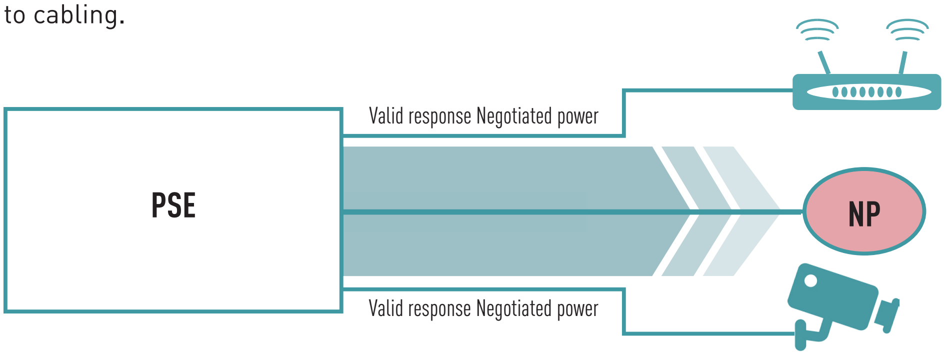
"Spark Gap"

IEEE approved PoE applications have been operating on TIA and ISO specified 4 pair structured cabling since 2002-2003. First IEEE 802.3af PoE supplied 15.4W at the PSE (Power Supplying Equipment), with min of 12.95W available to the PD (Powered Device). 802.3af PoE primarily serviced VOIP phones and single antenna Wireless Access Points (WAPs). In 2009 up to 30W became available from the PSE with a min of 25.5W delivered to the PD. This PoE+ version was introduced to the market as IEEE 802.3at to support devices with higher power requirements.

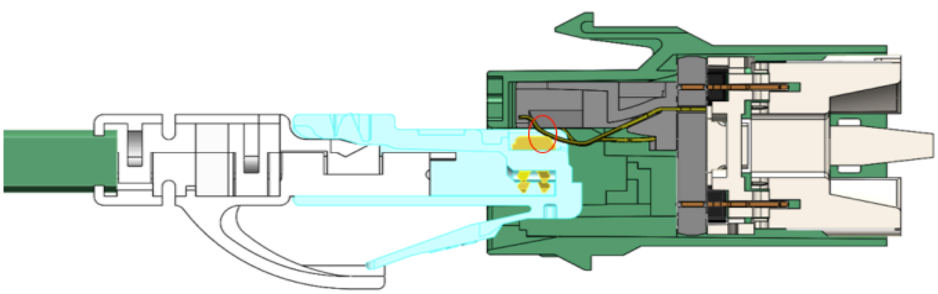
While PoE has been successfully deployed for over 13 years, one connectivity related concern that has recently received more attention is a condition identified as spark gap erosion. This condition can be caused by un-mating the plug jack connection under PoE load. This concern has gained more interest in anticipation of the proposed higher power versions of PoE on the horizon.

STANDARD	IEEE 802.3AF	IEEE 802.3AT	IEEE 802.3BT	
	PoE	PoE+	4-pairs PoE or 4PPoE	
Type	1	2	3	4
Status	Released	Released	Draft (2017)	
Maximum number of energized pairs	2	2	4	4
Maximum DC current per pair	350 mA	600 mA	960 mA	960 mA
Maximum power delivered by the Power Sourcing Equipment (PSE)	15.4 watt	30.0 Watt	60.0 Watt	99.9 Watt
Minimum required power at the Powered Device (PD)	12.95 Watt	25.5 Watt	51.0 Watt	71.0 Watt

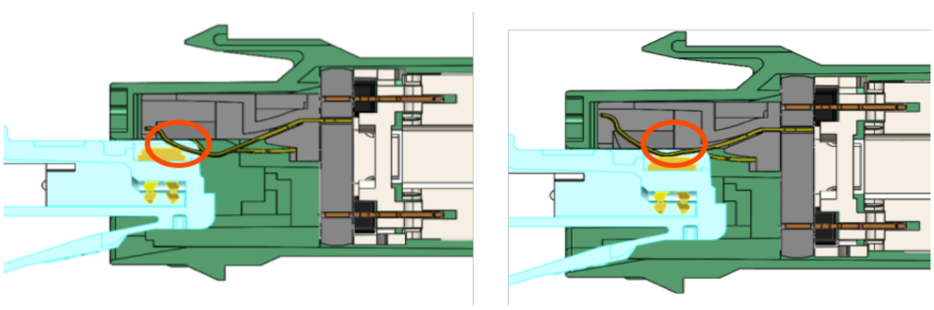
We discussed earlier the negotiation process that must happen between the power supplying equipment and the powered device before power can be supplied over the twisted pair cabling. This ensures PoE power is not on the cabling until after a circuit is completed and confirmed with a valid PD. Since PoE power is not yet on the cabling there is no opportunity for a spark to jump between plug and jack contacts when the channels are being connected together or when a PD is attached to cabling.



Disconnecting a powered PD from a cabling channel or unplugging an element of an active channel is a different situation. In this case un-mating a jack-plug connection while transmitting PoE power can produce the potential for a small arc between the plug and jack contacts. This all occurs internal to the mated plug/ jack and so safety concerns are eliminated from an end-user perspective. A concern that has been raised is the arcing could damage the plug and jack contacts (specifically the gold plating), and impact future data or power transmission capabilities of a connection. **The truth is arcing can cause eroding/ damage at the very last point of connection of the plug and jack.** Any arcing impact would take place on both the plated jack and plug contact surfaces at this final point of connection. Severe enough eroding of contact plating might cause some performance degradation over the life of the connection.



The concern about contact plating damage from arcing can be **successfully addressed by segregating any potential arcing to a location separate from the fully mated contact area of both the plug and jack.** This approach to the spark gap mitigation has been confirmed and has also been referenced in other position papers on this topic.



A jack contact design (Shown above, developed by Ortronics in 2002 for use initially on category 5e & 6 jack ports and later for category 6A) separates this last area of contact (where any arching might take place during disconnect) away from the fully mated position of the plug and jacks. This protects the 50 micro-inch gold plating area of the fully mated position ensuring a long / high quality contact connection for the life of these products. This is an effective way to protect against connection degradation that could compromise network performance or increased bit error rates.

Heat and Power Loss

Power loss and the resulting heat are also concerns that impact cabling, connectivity and installation. First, any power loss that occurs in the cabling system obviously impacts the amount of delivered power to the PD. But a second impact is this loss of power generates heat that can affect the data transmission abilities of the cabling.

From the start, the IEEE worked to anticipate the maximum amount of PoE power that could be loss based on worst case models of TIA 568 structured cabling channels. The first PoE standard, IEEE 802.3af identified a supply of 15.4W from the PSE (Power Supplying Equipment) while delivering a minimum of 12.95W to the PD (Powered Device) when delivered over a 100 meter channel. Power levels between 13- 15W would be available to PD at distances below 100 meters.

Later to support multi- band multi antenna WAPs and motorized (PZC) cameras, a PoE+ version was introduced as IEEE 802.3at supplying up to 30W from the PSE and a min of 25.5W delivered to the PD.

The first PoE standard, IEEE 802.3af utilized a maximum of 350 mA to supply its power level while IEEE 802.3at utilized a maximum of 600 mA to supply its power level.

The number of devices utilizing or looking to use PoE continues to increase. With that, the expectations for the application and the supporting infrastructure are also being elevated. Higher PoE power levels were pursued so new PoE devices that would require more power could be created. Below are some applications that began to surface with some of the following estimated power requirements.

- Digital Signage →30W
- Retail Point of sale devices 30-60W
- Multichannel Wireless APs →30W
- Pan, tilt and zoom (PTZ) cameras 30-60W
- Banking/financial IP turrets/ kiosk 45W
- Building management, air & access controls 40-50W
- Virtual desktop terminals 50W
- Healthcare Nurse call systems up to 50W

While some of the above applications are being addressed with proprietary approaches for delivering power and data, the IEEE has been working to introduce standards-based models for higher power versions of PoE.

New higher power PoE and the supporting infrastructure (including the cabling) must deliver higher power levels while also increasing the efficiency of power delivery. In addition to the need for higher power, devices such as IEEE 802.11ac WAPs will also exceed gigabit Ethernet speeds. This requires these new standards to accommodate high power PoE in tandem with higher speed Ethernet (such as 2.5GBASE-T, 5GBASE-T and 10GBASE-T).

Pending (higher power) IEEE PoE standards use all 4 pairs and are projected to be ratified in 2017. These include:

- A proposed IEEE 802.3bt PoE Type 3, providing 60W at the PSE, with a min of 49 watts available to the PD, (double the power of IEEE 802.3at).
- A proposed IEEE 802.3bt PoE Type 4 will provide 100W at the PSE, with up to 96 watts available at the PD.

Both of the proposed 802.3bt PoE standards are expected to increase the maximum DC current per circuit/pair to 960 mA. **The impact of this increased current capacity to support the higher powered devices will be discussed below in relation to connectivity and cabling.**

STANDARD	IEEE 802.3AF	IEEE 802.3AT	IEEE 802.3BT	
	PoE	PoE+	4-pairs PoE or 4PPoE	
Type	1	2	3	4
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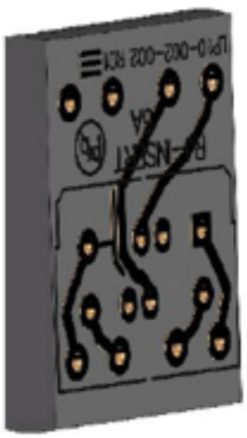
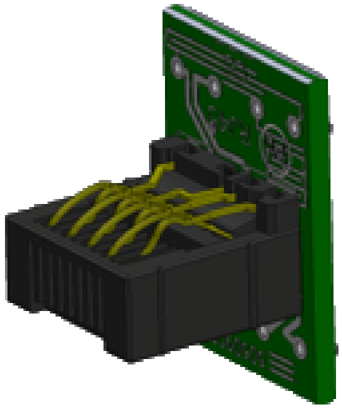
The Impact on Connectivity

Jacks and panels have little attenuation impact, because circuits within these parts are very short, still these connectors can still influence power throughput. Many of today's jacks and panel connectors utilize printed circuitry to control/cancel noise and elevate readable digital signal performance. This emphasis on the data transmission when designing printed circuit board (PCB) traces did not cause concerns when the initial lower power PoE standards were released. But PCB circuit paths (total surface area, trace widths and cross sectional content) can differ with each variation contributing to differences in current carrying capacities. Today we need to be more aware of these current carrying capacities. Connectivity that utilize printed circuit boards and designed to IEC 60512-99 recommendations are already designed to support 1 amp on each circuit path/trace. (Since a complete circuit is a loop, typically containing 2 traces, this requirement can sometimes be listed as 1 amp per pair.) A 1 amp design had been more than enough to support the max 350mA of 802.3af and the max 600mA of 802.3at. But with 960mA projected for 802.3bt types 3 & 4 we are getting quite close to the 1 amp capability and design protection recommended by the IEC. To ensure some level of margin, connectivity with PCBs would benefit from all circuit traces designed to handle more than 1 amp.

What to consider:

1. If connectivity does not comply with IEC 60512-99, that connectivity should not be described as able to support all levels of PoE.
2. By depending on the only standards body recommendation to date (IEC 60512-99), compliant connectivity might be very close to its design limits when supporting the pending high power PoE applications. To eliminate risk, look to connector manufacturers who are designing connectivity beyond a 1 amp capacity.
3. Connectivity designed or specified with 1.5 amp or greater offer larger power paths capacity and margin.





Higher PoE current levels can also have an impact on patch cords. The first impact relates to **attenuation (power lost).** The TIA already de-rates 24awg patch cords by a factor of 1.2 when compared to 24 awg solid conductor horizontal cable because:

- Stranded conductor is not as efficient a medium as solid conductor.
- The TIA wanted to budget for the anticipated use of stranded conductor patch cords in their Structured Cabling Systems (SCS) channel models.

When comparing other gauge patch cords, 26awg conductors lose (attenuate) 25% more power than 24awg stranded patch cords. 28awg conductors lose (attenuate) 37 % more power than 24awg stranded patch cords. So if 26awg or 28awg patch cords are used in longer channels, the actual PoE power available to a PD may be less than what was planned by the IEEE.

A second impact is the **heat generated** by the above increase in attenuated power caused by a smaller wire gauge size. This heat increase is not considered a safety issue, because cable designs can safely handle significant increases. However, the data transmission performance of the channel is more sensitive to heat rise, making this a potential performance issue when using smaller gauge cords in highly powered applications. The issue of increased heat with both cords and cables is further complicated when cords or cables are bundled which reduces the ability of cables in the center of bundles from dissipating any heat generated by attenuation.

TIA TSB-184 (Technical Service Bulletin) and TIA184A (currently in draft development) include guidelines for horizontal cable bundle sizes based on conductor gauge to minimize captured heat increases within cables while also recommending max heat increase limits for cables to ensure proper data transmission performance of cables. It is recommended that bundle sizes should be limited to ensure no more than a 15 degree C temperature increase from a targeted base of 45 degrees C.

At a time when many installation specifications have been looking for smaller cords and cables to address density, the trade off may be counter-productive relative to channel performance. This leads to considering a recommendation that 802.3BT type 3 & 4 or Cisco UPoE be supported with full size patch cords to reduce power loss and heat generation.

In summary

Power over Ethernet has been a mainstay of our commercial buildings since the early 2000s and has continued its adoption with support for newer applications and higher power throughput. The ability to send power and data over a single cable, without degrading the performance of that same cable, provides a huge benefit to specifics, contractors, building managers and even the end user. However as we see an increase to 100W of supplied power, additional considerations, such as the jack design, gauge of cabling and bundle sizes should be examined when deploying these higher-powered systems. There are several current and developing standards that can be referenced when looking for these recommendations, including IEC 60512-99 for the cabling components, as well as TIA TSB-148 for bundle recommendations to ensure proper performance of your PoE-based cabling infrastructure and systems.

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