# Next-Generation PoE: IEEE® 802.3bt White Paper

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## FUTURE-PROOFING POWER over ETHERNET (PoE)

Since the ratification of the first PoE standard in 2003, PoE use has increased dramatically and made headway into new applications. PoE provides huge benefits in relation to ease of installation, saving CAPEX and OPEX costs, and providing a unified and safe power standard for worldwide use.

The main limiting factor affecting PoE use in new applications is the amount of available power. While 15.4W at the power source is sufficient for most IP phones and 802.11a/b/g access points, it is not enough for IP video phones, 802.11n, and pan-tilt-zoom (PTZ) IP cameras. For that reason, the Institute of Electrical and Electronic Engineers, or IEEE, released IEEE 802.3at-in 2009, specifying 30W at the PoE source.

Today there is a demand for even higher power to support additional devices connected to the Ethernet network, such as PTZ security cameras, kiosks, POS terminals, thin client, 802.11ac and 802.11ax access points, small cells, and connected LED lighting, all of which can benefit from PoE.

The new IEEE 802.3bt standard increases the maximum PoE power available mainly by utilizing all four pairs of the structured wiring. IEEE 802.3bt extends the power classification information exchanged during initial negotiation to allow meaningful power management capability, enabling support of multiple PoE classes, while also being backward compatible. These enhancements solve the challenge of higher power and more efficient PoE delivery systems.

IEEE 802.3bt Call for Interest (CFI) activity started in early 2013, and the ratification of the standard took place in September 2018. The new standard addresses the existing market needs and is considered a major catalyst to PoE market growth as it facilitates the expansion of PoE use cases by pushing the power limit of Power Sourcing Equipment (PSEs) and Powered Devices (PDs) to 90W and 71.3W respectively.

## PRE-IEEE 802.3bt PoE STANDARDS

The IEEE 802.3 Ethernet Working Group has worked on standardizing the delivery of PoE cables since 1999. As one of the leading forces in this activity, Microsemi actively participated and contributed to the first and second PoE CFI in the 802.3 Working Group, and since then, in the standardization of 802.3af-2003, 802.3at-2009, and the 802.3bt Task Force.

The IEEE 802.3af-2003 PoE standard provided up to 15.4W of output power to each device over two pairs of Category 5e (Cat5e) cables. The IEEE 802.3at-2009 standard, also known as PoE+, introduced the “Type 2” PSE/PD capable of supporting 30W output power and 25.5W load power. The latter is mainly an extension of the first standard.

The HDBaseT Alliance standardizes the HDBaseT protocol, which allows extending HDMI links up to 100m over Cat5e or better cables. In 2011, the HDBaseT Alliance created the Power over HDBaseT (PoH) standard that extends the maximum power deliverable to 95W over four pairs.

The following table summarizes the pre-IEEE 802.3bt standards:

**TABLE 1: PRE-IEEE 802.3bt STANDARDS**

| Type | Standard | PSE Minimum Input Power | PD Minimum Input Power Ensured | Cable Category | Cable Length | Power Over |
|---|---|---|---|---|---|---|
| Type 1 | IEEE® 802.3af | 15.4W | 12.95W | Cat5e | 100m | 2 pairs |
| Type 2 | IEEE® 802.3at | 30W | 25.5W | Cat5e | 100m | 2 pairs |
| PoH | PoH | 95W | 72W-95W [1] | Cat5e/6 | 100m | 4 pairs |

**Note 1:** Extended power capability allows PD input power to reach up to 95W if channel length is known.

## WHAT'S NEW IN IEEE 802.3bt

- Introduces Type 3 and Type 4 PSEs/ PDs
- Supporting two PD constructions: Single-Signature PD and Dual-Signature PD
- Working over four pairs
- Additional classes—class 5 to class 8—and improved mutual identification process
- Automatic class functionality
- Extended power capability if channel length is known
- Low standby power support
- 10G-BASE-T with PoE

The following table shows the PoE capabilities on ratification of the IEEE 802.3bt standard.

**TABLE 2: PoE CAPABILITIES ON RATIFICATION**

| Type | Standard | PSE Minimum Output Power | PD Minimum Input Power | Cable Category | Cable Length | Power Over |
|---|---|---|---|---|---|---|
| Type 1 | IEEE® 802.3af | 15.4W | 12.95W | Cat5e | 100m | 2 pairs |
| Type 2 | IEEE® 802.3at | 30W | 25.5W | Cat5e | 100m | 2 pairs |
| Type 3 | IEEE® 802.3bt | 60W | 51W-60W [1] | Cat5e | 100m | 2 or 4 pairs class 0-4<br>4 pairs class 5-6 |
| Type 4 | IEEE® 802.3bt | 90W | 71W-90W [1] | Cat5e | 100m | 4 pairs class 7-8 |

**Note 1:** Extended power capability allows PD input power to reach up to 60W for Type 3 and up to 90W for Type 4 if channel length is known.

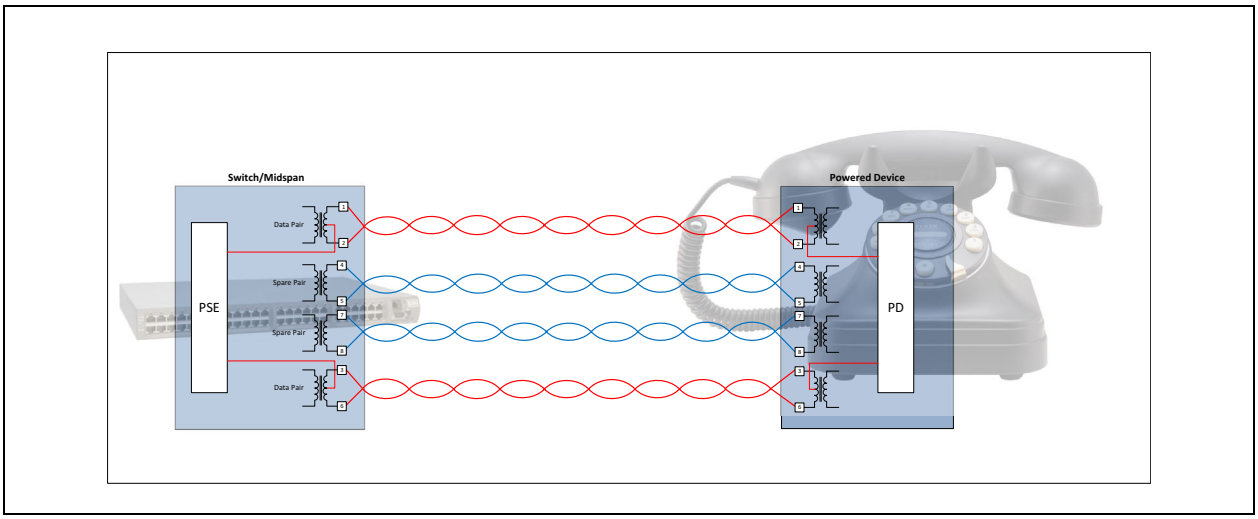
### Maximum Power Per Port

One of the objectives of this standard is to comply with the limited power source and Safety Extra Low Voltage (SELV) requirements as defined in ISO/IEC 60950. However, this compliance means that power cannot exceed 100W per port. Despite this power ceiling, 100W per port is still sufficient for applications previously unsupportable under the prior IEEE standards, expanding the potential number of PoE ports deployments.

## Implementing Power Over Four Pairs

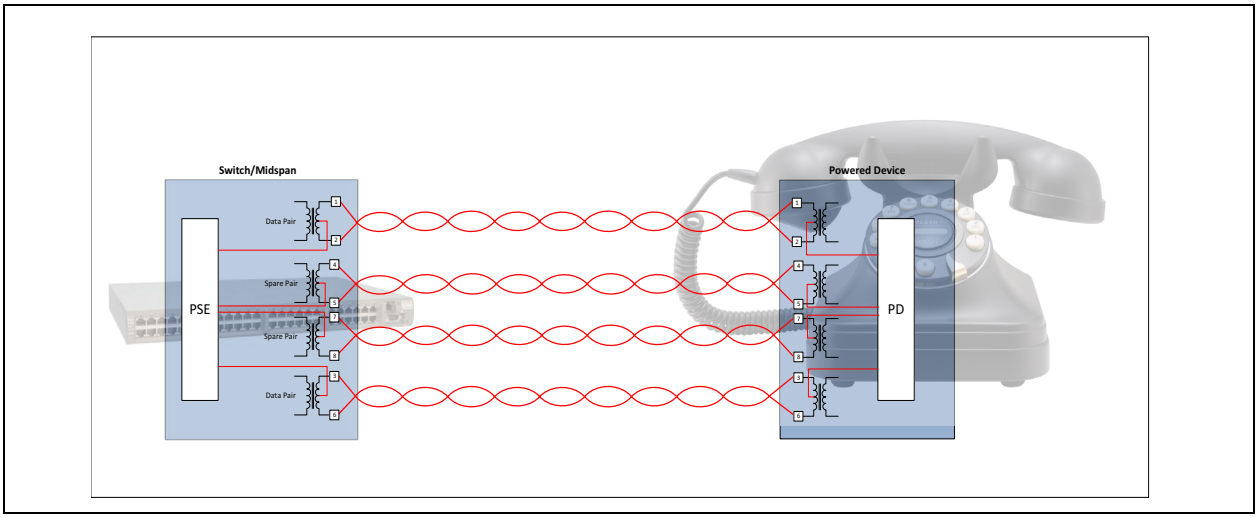
The following illustration (Figure 1) shows a two-pair power connection, with power delivered on the red pair only, while data can be delivered over all four pairs. While the illustration shows power delivery over wires 1, 2, 3, and 6, power can alternatively be delivered over wires 4, 5, 6, and 7as both options are valid alternatives in the IEEE 802.3 standard.

**FIGURE 1: DATA DELIVERY OVER TWO PAIRS**




The next illustration (Figure 2) shows a four-pair power connection where power is delivered over all 8 wires.

**FIGURE 2: DATA DELIVERY OVER FOUR PAIRS**



The standard distinguishes between two types of four pair PDs: Single-Signature PD and Dual-Signature PD. General implementation of each alternative is shown in the following illustrations Figure 3 and Figure 4.

**FIGURE 3: SINGLE-SIGNATURE PD**

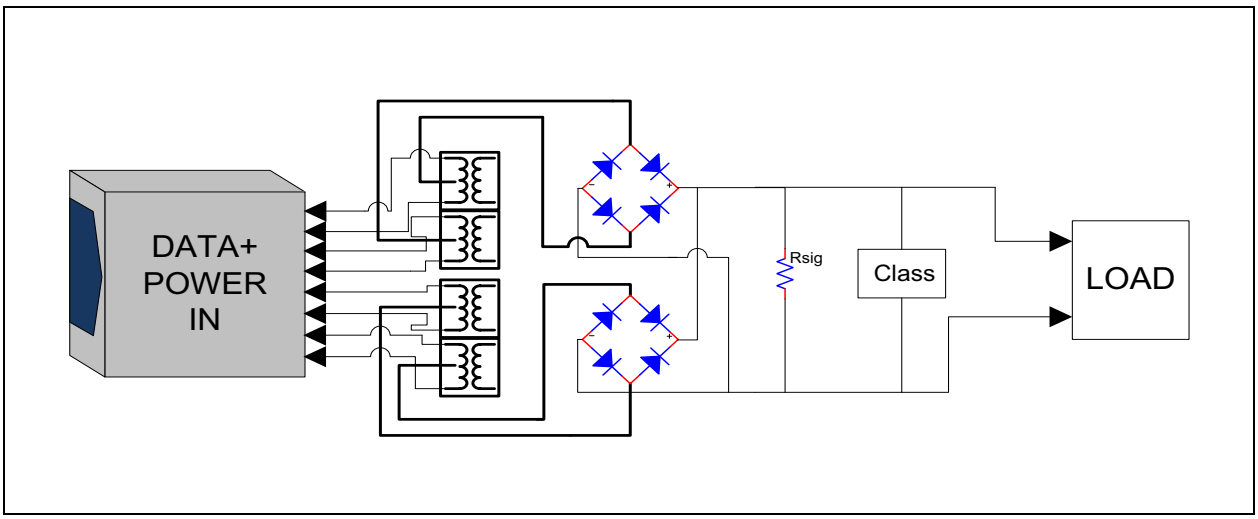
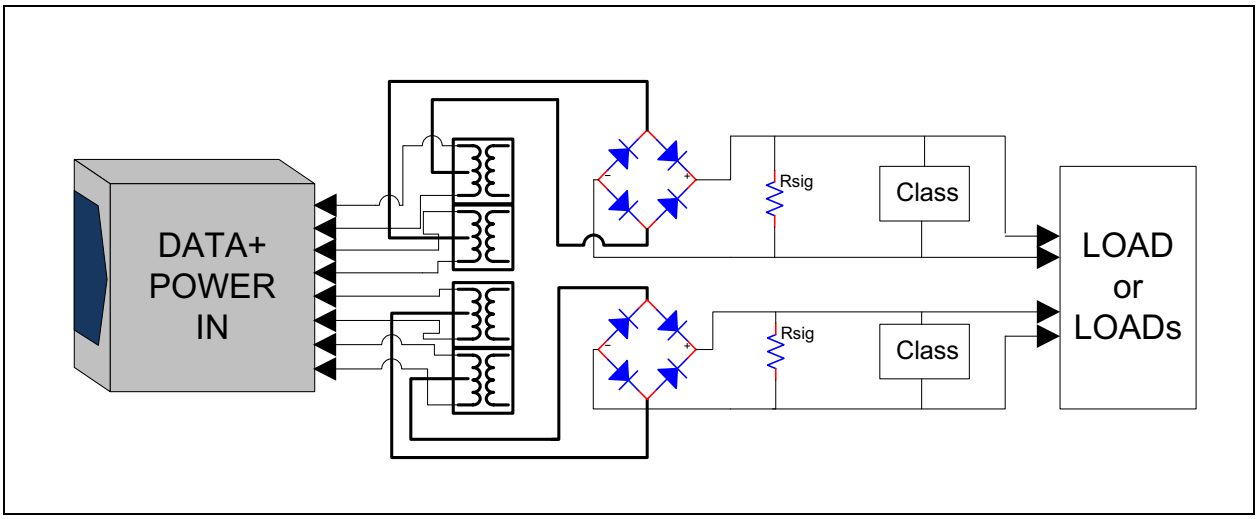



**FIGURE 4: DUAL-SIGNATURE PD**




An IEEE 802.3bt PSE will identify the PD type and set the power accordingly. According to the application nature, Single-Signature PD or Dual-Signature PD can be implemented. Supporting both architectures is ideal, as it allows more applications to be powered by PoE. Dual-Signature PDs allow supporting two independent loads, each with different power class; e.g. in a surveillance camera built with Dual-Signature PD, one pair may be connected to the camera and the other pair may be connected to the heater.

## Updated Classification Table

**TABLE 3: CLASSIFICATION TABLE**

| PD Requested Class | Number of PSE Class Events | Assigned Class | P_Class | P_Class_2P | PD Input Power (Pairset) | PD Input Power (Min) |
|---|---|---|---|---|---|---|
| **PSE Connected to a Single-Signature PD** | | | | | | |
| 1 | 1 | 1 | 4W | — | — | 3.84W |
| 2 | 1 | 2 | 6.7W | — | — | 6.49W |
| 0,3 to 8 | 1 | 3 | 14W | — | — | 13W |
| 4 to 8 | 2 or 3 | 4 | 30W | — | — | 25.5W |
| 5 | 4 | 5 | 45W | — | — | 40W |
| 6 to 8 | 4 | 6 | 60W | — | — | 51W |
| 7 | 5 | 7 | 75W | — | — | 62W |
| 8 | 5 | 8 | 90W | — | — | 71.3W |
| **PSE Connected to a Dual-Signature PD (Classification Per Pairset)** | | | | | | |
| 1 | 1, 2 or 3 | 1 | — | 4W | 3.84W | 7.68W |
| 2 | 1, 2 or 3 | 2 | — | 6.7W | 6.49W | 12.98W |
| 3 | 1, 2 or 3 | 3 | — | 14W | 13W | 26W |
| 4 or 5 | 1 | 3 | — | 14W | 14W | 26W |
| 4 or 5 | 2 or 3 | 4 | — | 30W | 25.5W | 51W |
| 5 | 4 | 5 | — | 45W | 35.6W | 71.2W |

## Type 3 and Type 4

As previously mentioned, two additional PSEs and PDs were defined, Type 3 and Type 4. The new types have unique properties that do not exist in Type 1 and Type 2. Additionally, some differences exist between Type 3 and Type 4. The following table summarizes the main features and differences between the four types.

**TABLE 4: SUMMARY OF TYPES 1-4**

| Capability | Type 1/Type 2 | Type 3 | Type 4 |
|---|---|---|---|
| $V_{PSE}$ (MIN) | 44V/50V | 50V | 52V |
| PSE Polarity | Flexible | Flexible | Fixed |
| 4P Capable | NO | Class 0-4: Optional<br>Class 5-6 Mandatory | Mandatory |
| Extended Power | NO | YES | YES |
| Auto Class | NO | YES | YES |
| Low MPS | NO | YES | YES |
| $P_{PSE}$ (MAX) | 15W/30W | 60W | 90W-99W |
| PD Minimum Input Power | 12.95W/25.5W | 51W [1] | 71W [1] |
| Supported PSE Classes | Class 0-4 | Class 1-6 | Class 8 |
| Supported PD Classes | Class 0-4 | Class 1-6 | Class 7-8 |

**Note 1:** Extended power capability allows PD input power to reach up to 60W for Type 3 and up to 90W for Type 4 if channel length is known.

The new standard introduces an “assigned class” to the PSE system, based on an auto-negotiation between the PSE and PD. The PSE system’s assigned class is determined as the lower power between the PSE available power and the PD requested power. For example, if a PD requests Class 8, but the PSE can support Class 6 only, the assigned class for the overall PSE system will be Class 6.

### Maintain Power Signature (MPS)

Deploying large numbers of PDs leads to considerable standby power. In the IEEE 802.3af/at standards, minimum power signature of 10 mA was required to keep the port alive. While the IEEE 802.3af/at allows a PD to operate with a minimum on time of 75 ms and a maximum off time of 250 ms duty cycle, it also has to satisfy the AC MPS requirement. This required such PD to show DC resistance below 26.3 KΩ, which resulted in an overall power consumption of 210 mW when operating with a 54V power supply. This power is multiplied by the number of ports in the system, which results in significant wasted power. For example, in LED lighting applications that use PoE, it is critical to reduce the standby power due to the large number of ports in a typical application. Also, while the light is off, the port should stay on and consume as little as possible. To improve this parameter, the IEEE 802.3bt removes the AC MPS requirement and allows class 5-8 PDs to draw 16 mA with a minimum on time of 7 ms and maximum off time of 310 ms duty cycle which results in less than 20 mW consumed to keep the port alive. This is 10 times better than existing solutions.

### Auto Class

Type 3 and Type 4 PSEs may choose to implement an extension of Physical Layer classification known as auto class. The purpose of auto class is to allow the PSE to determine the actual maximum power drawn by the connected PD and the actual cable length used. PSEs implementing auto class will measure the power consumption of the connected PD throughout a defined period; during this time the PD will consume the maximum power it will ever require. PSEs can set the maximum power output based on the power drawn during auto class plus margin.

### Extended Power

The af and at standards define the minimum power that the PSE should source and the maximum power that the PD should expect to receive. There is some amount of power that is budgeted for dissipation on the cables in the worst-case scenario of 100m cables. Following that approach means that for a PSE sourcing 90W output, the PD should expect only 71W while 19W are budgeted for 100m cable power loss. However, is that always the case? What if the PSE and the PD are in close proximity? If the actual cable power loss is much lower, can we free up this power for the system use? The idea of the extended power feature is to allow the PD (or the PSE) to use the maximum available power based on the cable's true total resistance. Once the PD measures the cable resistance, it can calculate the power that will be lost on the cable and benefit from a higher power consumption. Note that this feature was first introduced and implemented as part of the PoH standard and is now supported as an optional feature for Type 3 and Type 4 PSE and PD.

### Backward Compatibility

Although new features have been added, higher power is supported and some algorithms changed to ensure interoperability. The idea is that the system will work with legacy Type 1 and Type 2 devices. It should work automatically, as long as the PSE is capable (in terms of power) of supporting the PD and both are standard compliant. Should the PD require higher power (IEEE 802.3bt PD) and the PSE cannot support it (IEEE 802.3af/at PSE), the PD will either remain off or it will turn on and consume only the power available from the PSE.

For the latest information, see http://www.microsemi.com/designsupport/poe-and-poh-technology#resource.

## IEEE 802.3bt: ENABLING NEW APPLICATIONS

Support for higher power with PoE opens more opportunities. It enables new markets and widens PoE's scope to existing markets that require higher power in applications such as:

- Smart buildings with enterprise IoT (connected LED lighting)
- Safe cities (PTZ cameras)
- Kiosks
- Point of Sale (POS) terminals
- Thin clients
- Access points
- Small cells

## SUMMARY

The new IEEE 802.3bt standard enables delivery of 90W over four pairs of Cat5e cables and above. Such PoE level is expected to be the maximum level defined, as higher levels may not be safe for the existing cabling and connectors deployed in today's infrastructures. The standard will replace all existing pre-standard solutions that deliver 60W/75W/95W today, such as UPoE or 4PPoE.

Microchip is an innovator and thought leader in PoE technology and a major contributor to 802.3af, 802.3at, 802.3bt IEEE standards. Microchip is committed to providing PoE ICs and PoE Systems that comply with the new IEEE 802.3bt standard.

For more information about PoE Systems, or to find the solution to power your application, see http://www.microsemi.com/products/poe-systems/poe-systems.
For more information about PoE PSE ICs, or to find the solution to power your application, see http://www.microsemi.com/product-directory/power-over-ethernet/850-poe-pse-manager.
For more information about PoE PD ICs, or to find the solution to power your application, see http://www.microsemi.com/product-directory/power-over-ethernet/847-poe-pd-front-end-wpwm-controller.

## REVISION HISTORY

**TABLE 5: REVISION HISTORY**

| Date | Section/Figure/Entry | Correction |
|---|---|---|
| 2016 | Document | Microsemi initial document release |
| March 2019 | Document | • Converted to Microchip format and assigned document number DS00002992A<br>• Changes made to reflect Microchip's editing standards<br>• Included Microchip back matter |

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