White Paper

Next-Generation PoE: IEEE 802.3bt

Future-proofing Power over Ethernet

Since the ratification of the first Power over Ethernet (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 CAPX 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 15.4 W 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 IEEE802.3at-in 2009, specifying 30 W 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 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. Currently, work is in progress and ratification of the new standard is expected in the second half of 2017.

Existing PoE Standard

The IEEE 802.3 Ethernet Working Group has worked on standardizing the delivery of power over Ethernet (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 15.4 W 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 30 W output power and 25.5 W 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 100 m over Cat5e or better cables. In 2011, the HDBaseT Alliance created the Power over HDBaseT (PoH) standard that extends the maximum power deliverable to 95 W over four pairs.

The following table summarizes the available standards (IEEE 802.3 and PoH):

Table 1 Available Standards

Type	Standard	PSE minimum input power	PD minimum input power guaranteed	Cable category	Cable length	Power over
Type 1	IEEE802.3af	15.4 W	12.95 W	Cat5e	100 m	2 pairs
Type 2	IEEE802.3at	30 W	25.5 W	Cat5e	100 m	2 pairs
PoH	PoH	95 W	72 W–95 W[1]	Cat5e/6	100 m	4 pairs

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

However, the power supported by the IEEE standards is insufficient and, based on market needs, there are already pre-standard products supporting 60 W and 95 W (PoH) over four pairs.

What's New in IEEE802.3bt

- Introduces Type 3 and Type 4 power sourcing equipment (PSE)/powered devices (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 awaiting ratification of the IEEE802.3bt standard.

Table 2 PoE Capabilities Awaiting Ratification

Type	Standard	PSE minimum output power	PD minimum input power	Cable category	Cable length	Power over
Type 1	IEEE802.3af	15.4 W	12.95 W	Cat5e	100 m	2 pairs
Type 2	IEEE802.3at	30 W	25.5 W	Cat5e	100 m	2 pairs
Type 3	IEEE802.3bt	60 W	51 W–60 W[1]	Cat5e	100 m	2 pairs class 0–4 4 pairs class 0–4 4 pairs class 5–6
Type 4	IEEE802.3bt	90 W	71 W–90 W[1]	Cat5e	100 m	4 pairs class 7–8

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

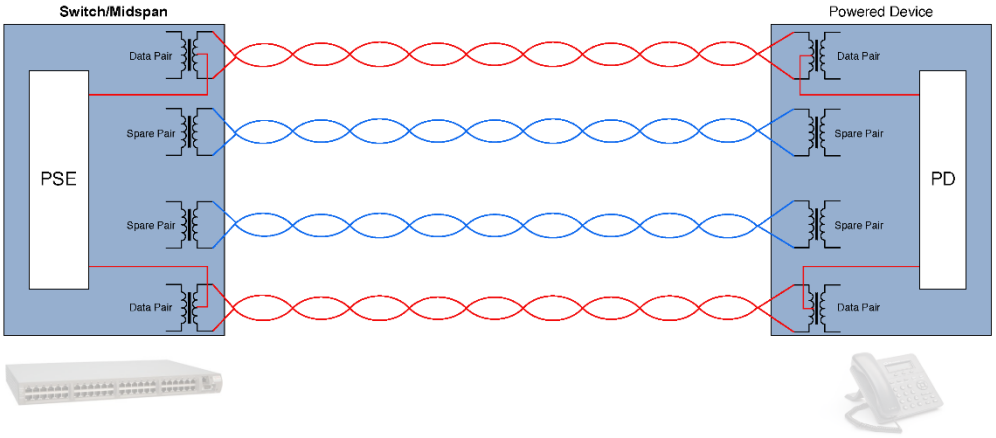
Maximum Power per Port

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 100 W per port. Despite this power ceiling, 100 W per port is still sufficient for applications previously unsupportable under the prior standard, expanding the potential number of PoE ports.

Implementing over Four Pairs

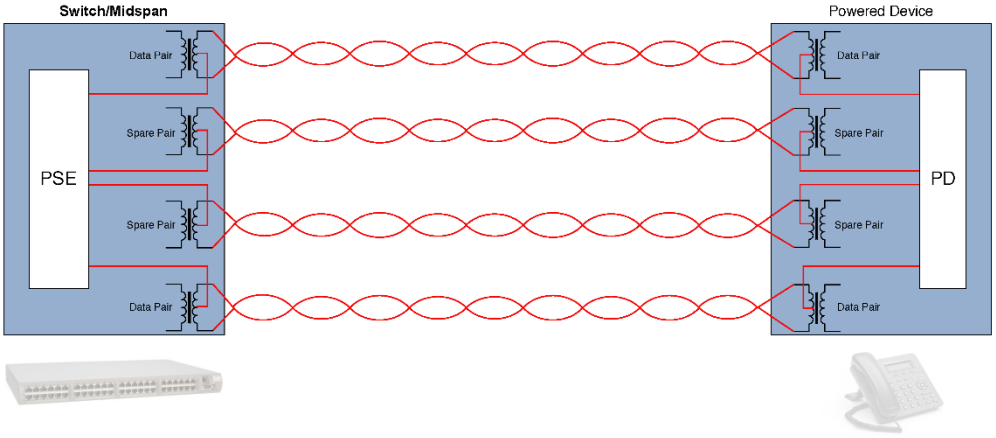
The following illustration shows a two pair connection, with only power delivered on the red pair, while data can be delivered over all four pairs. It also shows connections over wires 1, 2, 3, and 6. However, power can be delivered over wires 4, 5, 6, and 7 instead. Both options are valid alternatives in the IEEE802.3af/at standard.

Figure 1 Data Delivery over Two Pairs



The following illustration shows a four pair connection where power is delivered on all four pairs.

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 Single Signature PD

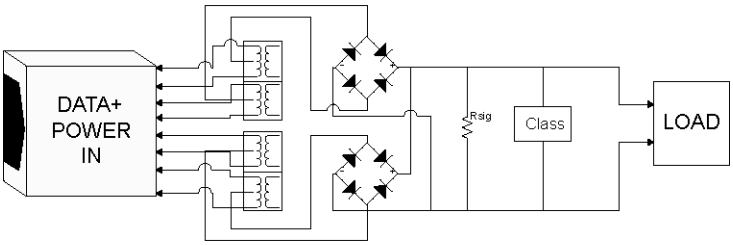
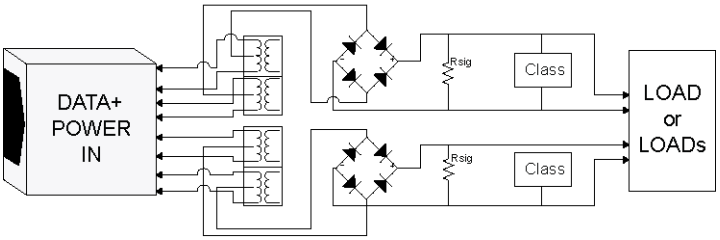


Figure 4 Dual Signature PD



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 PD enables the load to also work, where possible, with two pair PSEs; for example, 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

Classification is the process where the PSE detects the PD's power requirements by using Physical Layer Classification or LLDP (data protocol). The standard specifies mutual identification to address four pair operation. Additional classes were added as a result, and it is defined as follows:

Table 3 Classification Table

Class Number	PSE Output Power [W]	PD Input Power [W]	PD Type	Notes
0	15.4	12.95	1	IEEE802.3af
1	4	3.84	1	
2	7	6.49	1	
3	15.4	12.95	1	
4	30	25.5	2	IEEE802.3at
5	45	40	3	IEEE802.3bt
6	60	51	3	
7	75	62	4	
8	90	73	4	

Type 3 and Type 4

As previously discussed, 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)	44 V/50 V	50 V	52 V
PSE Polarity	Flexible	Flexible	Fixed
4P Capable	NO	Class 0–4: Optional Class 5–6: Mandatory	Mandatory
Extended Power	NO	YES	YES
Auto Class	NO	YES	YES
Low MPS	NO	YES	YES
P_{PSE} (MAX)	15 W/30 W	60 W	90 W–99 W
PD minimum input power	12.95 W/25.5 W	51 W[1]	71 W[1]
Supported PSE Classes	Class 0–4	Class 1–6	Class 8
Supported PD Classes	Class 0–4	Class 1–6	Class 7–8

1. Extended power capability allows PD input power to reach up to 60 W for Type 3 and up to 90 W 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 by the lowest common power denominator that both PSE and PD can support. 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 current standard, in order to keep the port alive, the minimum power signature required is 10 mA. It also allows a duty cycle of 20%. For example, keeping the port alive requires consumption/waste of 2 mA average. At a typical voltage of 50 V, this amounts to 100 mW. This power multiplied by the number of ports 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. In order to improve this parameter, the duty cycle was reduced to 1.875%, which results in less than 10 mW consumed to keep the port alive. This is 10 times better than existing solutions. Having said that, MPS is usually irrelevant for other applications such as small cells, wireless backhaul, WiFi access points, and security cameras, which do not have standby mode. These latter application types currently rely on products that support the PoH standard to get higher power.

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. PSEs implementing auto class will measure the power

consumption of the connected PD throughout a defined period of time; 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 current standard defines 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 "saved" for dissipation on the cables in the worst case scenario of 100 m cables. (The previous standard considered the worst case). Following that approach means that for a PSE sourcing 90 W output, the PD should expect only 71 W and 19 W are "saved" for dissipation on the cables in case the PD is deployed 100 m away from the PSE. However, is that always the case? What if the PSE and PD are in close proximity; if the cable losses are much lower, can we "save" less power?

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 claim the worst case reserve to be used by the PD. At worst, the power reserve will be the same as in current standard, but it can be also much lower. This feature is supported today by the PoH standard.

Backward Compatibility

Although new features were added, higher power is supported and some algorithms were 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 PSE), the PD will either remain off or it will turn on and consume only the power available from the PSE.

The table on PoE backward compatibility is updated every six weeks, after the IEEE802.3bt Task Force meetings take place. For the latest information, see http://www.microsemi.com/design-support/poe-and-poh-technology#resources.

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:

- Building management (connected LED lighting)
- Pan-tilt-zoom (PTZ) security cameras
- Kiosks
- Point of Sale (POS) terminals
- Thin clients
- Access points
- Small cells

Expected Timeline

The IEEE 802.3bt standard is expected to be ratified by 2017. From past experience, we expect to see "bt-ready" products available in the market prior to final ratification of the standard. New designs starting today already take into account, where possible, future compatibility with the standard.

Summary

The coming IEEE 802.3bt standard will enable delivery of 90 W over four pairs of Cat5e cables and above. This 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 new standard will replace all existing pre-standard solutions that deliver 60 W/75 W/95 W today, such as UPoE or 4PPoE.

Microsemi is an innovator and thought leader in PoE technology and a major source of 802.3af, 802.3at, 802.3bt, and HDBaseT standards. Microsemi is committed to providing PoE ICs and PoE Systems that will comply with the new IEEE802.3bt 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-w-pwm-controller.

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