IEEE 802.3 PoE Specifications

Power over Ethernet is a technology that has been guided by three generations of IEEE 802.3 specifications.

- Originally, 802.3af (802.3 clause 33) defined PD's that draw up to 13 watts from four wire pairs and PSE's the furnish at least 15.4 watts on two of those four wire pairs.
- 802.3at (also 802.3 clause 33) upgraded and replaced 802.3af in order to add PD's that draw up to 25.5 watts from four wire pairs and PSE's that furnish 30 watts on two of those wire pairs.
- 802.3bt (802.3 clause 145) defined PD's that draw up to 71.3 watts from four wire pairs and PSE's that furnish up to 90 watts on those same four wire pairs.

PoE specifications overcome all of the effects of delivering power across at least 100M of cable

One key role of the 802.3 PoE specifications is to enable the power source and the power consumer to be separated by up to 100 meters of cabling and associated network connections. Because of this feature, PSE's and PD's may be fully tested "locally" at their respective interfaces without the need to insert long lengths of cabling and associated impairment modeling.

In PoE, backward compatibility depends on PD's accepting what PSE's have to offer

The 802.3at and the 802.3bt specifications were very carefully composed to promote backward compatibilities so that older PD's would work with newer PSE's and older PSE's could work with newer PD's.

- All three generations of PoE specifications included classification mechanisms whereby a PSE could determine the desired power demand from a PD.
- The 802.3at and 802.3bt specifications added classification mechanisms whereby a PD could determine the power that the PSE could provide when initially powering the PD.
- Any interoperable (802.3at or 802.3bt) PD requiring more than 13 watts must be sensitive to the power allocated initially via classification and must be designed to not draw more than that level of power.
- Any interoperable (802.3at or 802.3bt) PD requiring more than 13 watts must support the ability to communicate to the PSE, via PoE LLDP, the maximum PD power demand with resolution of 0.1 watt.
- PSE's that furnish more than 13 watts have the right to withhold PD requested power until the PD communicates its power demand via LLDP to the PSE.

When a PD is initially allocated less than its power demand, it is considered to be **power demoted**. *Backward compatibility in PoE depends on PD's handling power demotion properly*.

On the PSE side, 802.3 PoE specifications enable wide ranging design variation including highly variable tolerance of non-compliant PD behaviors

Unlike many other 802.3 LAN physical layer specifications, 802.3 PoE specifications enable very wide latitude in the design features of a PSE in order to promote innovation and flexibility. This factor is extremely significant because it means that *non-conformant PD's may interoperate successfully with some PSE's but not with all PSE's*.

What 802.3 Compliant PSE's Expect of PD's

Given the above summary of 802.3 PoE specifications, it is useful to summarize basic expectations of specification conforming PSE's when powering PD's:

PD's will never over-draw allocated power

PD's that draw more than 13 watts must be sensitive to the power allocated by the PSE during PD classification. If a PD draws more than the power allocated by the PSE, it may enter a rapid cycle of powering and overload shutdowns that could continue indefinitely. To an end user, this can be highly confusing behavior and will often be interpreted as a problem with the PSE.

Under the 802.3bt standard, there are at least 6 possible scenarios of PD power demotion

- A **class 4** PD could be demoted to **class 3**
- A **class 5** PD and a **Class 6** PD could be demoted to **class 3** or to **class 4**
- A **class 7** PD and a **Class 8** PD could be demoted to **class 3**, to **class 4**, or to **class 6**

(Note: This does not consider powering of dual signature PD's defined by 802.3bt.)

PD's drawing more than 13W will communicate their precise power demand over PoE LLDP

The 802.3at and 802.3bt standards do not require PSE's to support PoE LLDP, however, they do require PD's operating with class 4 power or higher to support PoE LLDP. Large system PSE's supporting 24, 48, or more ports must carefully allocate a limited power supply resource to many PD's. The PD classification process allows the PSE to assess PD power demand with approximate granularity of 15 watts. PoE LLDP allows the PSE to allocate power with granularity of 0.1 watt. This can greatly extend the economic efficiency of a system PSE while also adding valuable information to a network manager.

802.3 Compliant PD Controllers: Where They Help (*and Where They Can't Help*)

Manufacturers of integrated PD controllers and PD interface modules may claim that their solutions have been fully tested for 802.3 specification conformance and they even may produce the test data to prove that. So there's no doubt that deploying a specification compliant PD controller will help with specification conformance and PSE-PD interoperability.

PD controllers only impact a subset of PD specification conformance properties

PD controllers are essential to managing the PD detection and classification processes. That means assuring detection signatures are present or removed as required, classification signatures are communicated with proper values and timing, and initial power allocations from the PSE are properly assessed. PD controllers may also play a role in inrush current limiting and MPS load management. While all of this is useful, it is not the full picture of PD specification conformance.

The 'heavy lifting' required to interoperate with all PSE's in all connection environments is outside the role of a PD controller

Many of the features of a PD that could lead to common interoperability problems are well outside the context of a PD controller:

- Handling all forms of power demotion without overloading a PSE
- Drawing average power levels that are within the PD advertised and assigned classification
- Drawing peak power levels and transient durations that are within the PD advertised and assigned classification
- Uniformly drawing power from any two powered wire pairs
- Properly balancing power draw between wire pairs when powered from four wire pairs
- Conveying, using proper PoE LLDP protocol, an accurate level of average power demand with 0.1 watt granularity
- Depending upon PD controller features, assuring that inrush currents don't overload the PSE at start-up

Verifying PD's with PSE's – The Limitations

With the ready availability of commercial PSE's including low cost PSE injectors, a strong temptation exists to utilize these products to test Powered Devices. Coupled with a long spool of cable, a PSE provides a "real world" interface to a PD.

As an "interop" test strategy, this approach overlooks the wide-ranging design flexibility allowed to IEEE 802.3bt and 802.3at PSE's. This attribute of the PoE standard has translated into a vast proliferation of PSE designs and configurations with widely varying tolerances of many critical PD traits. *PD's that interoperate with one or a few PSE's may fail to properly interoperate with hundreds of other specification compliant PSE's and cabling networks*.

PD Behavior	PDA-604 Test Coverage	Commercial PSE Coverage
PD Power-Ups to Minimum / Maximum Voltages	✓	✗
Ethernet LAN Link-Up / Auto-Neg / Rate Control	✓	?
ALT-A, ALT-B, & 4-Pair Powering	✓	✗
MDI & MDI-X Powering Permutations	✓	✗
Detection Resistance – Single & Multi- Cycle	✓	?
Detection Resistance vs Voltage*	✓	✗
Detection Capacitance – Single & Multi-Cycle	✓	✗
Connection Check/Signature Validation	✓	?
Classification Signature (per Pairset)	✓	?
Classification Signature Per Class Event	✓	✗
Classification Signature vs Voltage*	✓	✗
Mark Loading	✓	✗
Inrush Loading (per PSE Type-1, 2, 3, and 4)	✓	✗
Inrush Limiting (per PSE Type-1, 2, 3, and 4)	✓	✗
Type-2/3/4 Power Delay	✓	✗
Turn-On Voltage	✓	✗
Turn-Off Voltage	✓	✗
Average Power Consumption (per Class Grant)	✓	✗
Instantaneous Peak Power Load (per Class Grant)	✓	✗
Windowed Peak Power Load (per Class Grant)	✓	✗
Classification Integrity	✓	✗
MPS – Level (per PSE Type 1, 2, 3, and 4)	✓	?
MPS – Duty Cycle (per PSE Type 1, 2, 3, and 4)	✓	?
Load Power over Voltage	✓	✗
LLDP Message Formatting	✓	?
LLDP Allocation Response Time	✓	✗
LLDP Requested Power Integrity	✓	✗

Table 1: PDA-604A versus Commercial PSE Coverage

The reality is that PSE's are not test instruments. A PSE cannot test critical characteristics of a PD that are vital to interoperability over all PoE networks. Even the most sophisticated PSE's that offer management reporting of PD classification and power draw offer no insight regarding how the PSE produces those parameters or what they might really mean.

Table 1 illustrates a variety of PD performance parameters that are critical to the broad interoperability of a PD and the respective test coverage that can be expected from a commercial PSE relative to a PDA-604A.

EA PoE Certification: A Program to Assure Interoperability

The Ethernet Alliance introduced a PoE Logo Certification program in 2017 and then extended that program (Gen 2) to cover 802.3bt PSE's and PD's in 2021. The program includes published PSE and PD testing regimes and qualification criteria. Many of the topics discussed earlier in this application note are addressed in the PD testing.

EA Certified 2.0™

PD and PSE manufacturers can obtain PoE logo certification to demonstrate interoperability of their PD's

Logo Certification provides PD manufacturers the ability to apply an industry logo on their products and literature that conveys that their PD will interoperate correctly with any PSE that similarly displays the same EA PoE certification logo. PoE Certification assures that the model of PD carrying the logo has been subjected to a rigorous set of tests to assure that interoperability.

EA Program offers self-certification options utilizing fully automated testing with the Sifos PDA-600 while also offering alternative 3rd party lab certification testing.

Like many other hardware certification programs, the EA PoE Logo Certification program has set up outside labs to perform testing and generate reports. Unlike other hardware certification programs, the EA program has also certified test equipment so that PD designers and manufacturers may conduct all certification testing in-house and then submit reports.

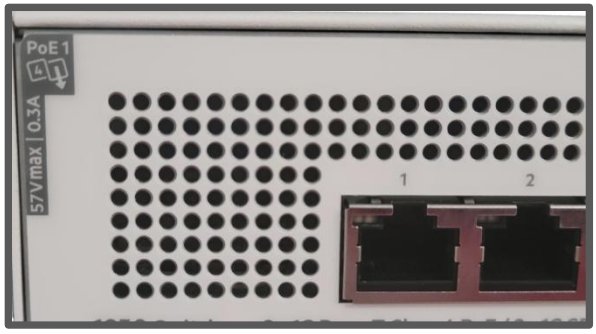

Figure1: EA Certified PSE (Class 4 Capable)

The approved PD test equipment includes the Sifos **PDA-602B** and **PDA-604A** Powered Device Analyzers and associated software. Using these solutions, testing for Gen 1 (802.3at) and Gen 2 (802.3bt) EA certification is entirely automated and is designed to produce test reports that may be submitted to the EA for logo certification.