High Power PoE
Updating Power over Ethernet Standards for More Power, Speed and Efficiency
High Power PoE

For the last ten years, Power over Ethernet (PoE) and PoE+ have provided organisations with a simple and convenient option for powering devices such as IP phones and low-power cameras. Now, as technology continues to evolve, the structured cabling infrastructure is being used to support an increasingly diverse and power hungry set of devices whose appetites exceed the current capabilities specified by today’s PoE+ standard. This paper provides updates on developments in the standards, expected deployment arenas and their respective applications. Further discussions on the impact to structured cabling, and insights to enable planning for future PoE and structured cabling deployments are provided. It is clear that the developing PoE ecosystem will continue to grow through new applications and will be better serviced by cabling with improved power delivery capabilities.

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The Evolution of PoE

PoE first emerged in 2003 with the IEEE 802.3af standard and was originally built around Category 3 and Category 5 specifications, to deliver approximately 13 watts to a powered device through 350mA of current with Ethernet speeds up to 100Mbps. The standard allowed for delivering power on two combinations of two pairs as two different alternatives – Mode A or Mode B (Figure 1). However, the standard did not permit power simultaneously over all four twisted pairs. In Mode A, pairs 1-2 and 3-6 have both power and data flowing over them while pairs 4-5 and 7-8 are unused. In Mode B, all pairs are utilized, but power and data are separated, with data being carried via pairs 1-2 and 3-6 and power using 4-5 and 7-8.

In 2009 major changes were made to PoE with the ratification of 802.3at. These included specifying Category 5 cabling as the minimum cable grade required to support the new PoE+ standard. With this ratification, 25.5 watts and 600mA of current could now be delivered to devices. As illustrated in Figure 2, all four pairs are utilized to transmit data in order to support 1000BASE-T transmission, but Mode A and Mode B power distribution remains consistent with the previous standard.

Figure 1: 802.3af delivers 12.95W and 10/100BASE-T

Figure 2: 802.3at delivers 25W and 1000BASE-T
Enhancements for Emerging Applications

In the intervening years since the last update, non-standardised solutions have been developed to address specific challenges. For example, some solutions may deliver continuous power without the IEEE specified handshake or perhaps require additional converters at the device. Others may deliver 50 watts over four pairs, maintain compatibility with 802.3at, and yet not be 802.3at standards-compliant due to the explicit exclusion of 4-pair power delivery. Finally, there are the proprietary solutions that deliver higher wattages but are not compatible with the current standardised equipment.

In March 2013, the IEEE held a Call for Interest focused on evaluating the need to develop a higher power standard. This need has been driven primarily by emerging applications that require power in excess of what is supported by today’s standards. The markets with identified needs span today’s infrastructures and include areas such as healthcare, retail, building management, IP turrets, thin clients, video conferencing, IP security cameras, and industrial networks. Figure 3 above depicts the overall potential market for high power PoE ports, with especially substantial growth in building management opportunities through 2018. Significant growth is also projected for industrial automation and thin clients.

Sources: VDC Research
IMS Research – Jenalea Howell
and other research reports
Gartner Forecasts, BT Turret, Cisco Partners

Figure 3: High Power PoE Applications
Setting the Stage for Next Generation Standards

As these opportunities expand, so do the expectations for standardisation, which center primarily on delivering as high a power output solution as can be managed. To do this will require increased system efficiencies to address the limitations and shortcomings of a DC power distribution system. Early generations of networking equipment lacked power reserves and were unable to provide the full 25 watts of power across all ports simultaneously, causing issues with large scale deployments. In future developments, this power supply limitation must be mitigated through greater power supply capacities and smarter equipment to ensure an adequate power supply for building management functions. The new standard must also service Ethernet devices such as 802.11ac wireless access points that will require additional power as well as faster network speeds.

To address this, the IEEE 802.3bt task force convened in January 2014 to begin the standardisation process. Comprised of electronic component and cabling manufacturers, the task force has the responsibility of specifying new levels of power delivery while assuring compatibility with previous generations of equipment. Standardisation is still underway, but it is possible to project the form that this technology will take. It is anticipated that higher power 2-pair solutions will be developed along with 4-pair delivery configurations as shown in Figure 4. The use of all four pairs in the cable for the highest levels of power delivery will increase efficiency by cutting the potential delivery losses in half.

With these parameters in mind, the standardisation bodies have a number of complex goals set before them. First, the standard must exhibit backward compatibility with the previous generations of the PoE standards, IEEE 802.3af and 802.3at. Additionally, the new standard must support 10GBASE-T operation with possible new speeds such as 2.5Gbps and 5Gbps to enable wireless access points that are aggregating the traffic of multiple users and multiple devices. Finally, this technology will need to utilize all four pairs simultaneously in order to maximize power distribution efficiencies.

An initial objective of delivering a minimum of 49 watts to the powered device was adopted in order to deem the project successful. However, the growing deliverable list has become quite diverse and complicated through the initial course of draft development. There are two primary active components as defined within the standard. The power sourcing equipment (PSE) represents the end span switches or mid-span injectors while the powered device (PD) represents the device at the opposite end such as a camera, thin client or building management device.

There are now 9 proposed classes for the PSE ranging from 4 watts to 90 watts, as illustrated in Table 1. Due to cabling losses, the minimum available power at the PD is slightly less. (Note: Class 0 and Class 3 are grouped together because they are required to deliver the same 13W to the powered device. Class 0 can be declared or used as a default state when the powered device does not indicate its classification. It is presumed that an undeclared device will need the maximum 13W.)

### Table 1: Power Sourcing Equipment Classifications

<table>
<thead>
<tr>
<th>Class</th>
<th>Min Power from PSE (Watts)</th>
<th>Min Guaranteed Available Power at PD (Watts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 and 3</td>
<td>15.4</td>
<td>13.0</td>
</tr>
<tr>
<td>1</td>
<td>4.0</td>
<td>3.84</td>
</tr>
<tr>
<td>2</td>
<td>7.0</td>
<td>6.49</td>
</tr>
<tr>
<td>4</td>
<td>30.0</td>
<td>25.5</td>
</tr>
<tr>
<td>5</td>
<td>45.0</td>
<td>40.0</td>
</tr>
<tr>
<td>6</td>
<td>60.0</td>
<td>51.0</td>
</tr>
<tr>
<td>7</td>
<td>75.0</td>
<td>62.0</td>
</tr>
<tr>
<td>8</td>
<td>90.0</td>
<td>71.3</td>
</tr>
</tbody>
</table>
In order to further maximize power delivery or energy conversation, the task force is considering the complexities of evaluating the cabling losses in each link. Specifically in the case of short links, the PSE may conserve and repurpose the power for other links, or allow a PD on a short link to reserve and utilize the unused power that is budgeted for a full 100-meter length deployment. These system design characteristics give added importance to the development of cabling specifically designed for use in multiple applications with the goal to improve overall system efficiencies. For the delivery of power and data, higher grades of cable will provide the best performance and efficiencies.

IEEE defines four types of powered device (PD) systems. Each varies in maximum power available at the PD – see table 2. Other parameters such as voltage range also differ between the types.

<table>
<thead>
<tr>
<th>Number of pairs needed</th>
<th>Maximum power output for PSE</th>
<th>Usable power budget for the end device (PD)</th>
<th>Norm</th>
<th>In effect since</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoE</td>
<td>2</td>
<td>15.4 Watts</td>
<td>12.95 Watts</td>
<td>IEEE 802.3af, Type 1</td>
</tr>
<tr>
<td>PoE+</td>
<td>2</td>
<td>30 Watts</td>
<td>25.50 Watts</td>
<td>IEEE 802.3at, Type 2</td>
</tr>
<tr>
<td>PoE++</td>
<td>4</td>
<td>60 Watts</td>
<td>49 Watts</td>
<td>IEEE 802.3bt, Type 3</td>
</tr>
<tr>
<td>PoE++</td>
<td>4</td>
<td>90 Watts</td>
<td>71 Watts</td>
<td>IEEE 802.3bt, Type 4</td>
</tr>
</tbody>
</table>

Class: Power sourcing equipment classification  
PSE: Power Sourcing Equipment = e.g. the (FTTO) access switch  
PD: Powered Device = e.g. VoIP-Telephones
Understanding the Power-Heat Relationship

While the IEEE standard is in development, several manufacturers and technical consortiums are working to establish the boundaries of technical feasibility. It has been demonstrated in a lab environment that it is possible to supply at least 60 watts over a 100-meter 10GBASE-T link. However, increasing power delivery increases current flow, resulting in an increase in heat generation within the cabling infrastructure. It is expected that this increased power delivery will significantly impact cable bundle temperatures, and the de-rating factors originally recommended in 2009 in the TIA TSB-184: Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling will need to be revised. As a result, the standards bodies of TIA, ISO and CENELEC are investigating the impact of delivering an average of 1 amp per pair within the cable and revising their recommendations.

In general, cable temperature rise with PoE deployment is a function of several factors:

1. **Gauge Size**: Larger copper conductor reduces the resistance and allows for easier current flow, generating less heat.

2. **Twist Rate per Inch**: Higher categories of cable generally have increased pair twist rates. This increased twist rate creates a longer electrical path per given cable length, as depicted by Pair A in Figure 5. This results in increased resistance to current flow and increased heat generation.

3. **Current**: As current increases, so does heat generation.

4. **Thermal Insulation/Diffusion**: This refers to the ability to shed or disperse the generated heat to the outside environment. Cables unable to cool will increase in temperature until equilibrium is reached.

5. **PoE Deployment Density**: Heat generation increases as the number of PoE drops increase within a pathway.

![Figure 5: Increasing twists (Pair A vs Pair B) increase DCR](image)
The Impact of Higher Power on Cabling

There are four major reasons for an interest in heat: environmental heat loading to the facility, safety, the impact to electrical performance and the potential for energy efficiency.

Environmental heat loading

This can be a fairly straightforward calculation as it is based upon the number and length of the drops in conjunction with the cable unit resistance and electrical current traversing the pairs. Deploying large amounts of high power PoE may increase the HVAC requirements for a facility and raise the average ambient and peak temperatures experienced by the cabling.

Safety

Excessive temperatures from heating may lead to melting insulation and the immediate failure of infrastructure components. However, elevated temperatures also age components at a faster rate, and the jackets and insulations may become brittle when exposed to elevated temperatures for extended periods. This may result in cracking or segments of insulation falling off the cable. Flame retardant properties may also be reduced as vital components within the compounds degrade or evaporate. Cables have temperature ratings, such as 60 or 75°C, which are designed to ensure their operation over their lifetime. However, failing to account for thermal gain from PoE deployments may drive a cable above its safety listing when installed in a hot environment. Given the increased current load and the increased heat generation that comes along with it, those specifying cabling infrastructures should consider cabling with rating of at least 75°C, particularly for those areas with an already elevated ambient operating temperature.

Electrical Performance

Heat increases the losses within the cable and reduces the effective reach of copper cabling, making a 100-meter reach with minimally compliant cable unobtainable. Therefore ambient conditions as well as thermal gains must be considered when calculating length reductions for system operations. Thermal gains vary per category of copper cables; Category 5e UTP show the highest level of thermal gains and shielded Category 7A show the lowest level – see figure 6.

![Figure 6: Relationship between bundled number of cables running PoE+ and temperature gains](image-url)
Energy Efficiency

Figure 6 also shows the effect when multiple cables of a category are bundled together for PoE+ application. Although IEEE 802.3at for PoE+ does not address this issue, the ISO technical report does, which has since become an ‘informal’ benchmark for PoE+. At the minimum required level using UTP Category 5 cable bundles, the temperature increase is quite remarkable. Not only does this require more cooling, leading to escalating energy costs, but higher temperatures also increase attenuation, resulting in potentially lower network performance and shorter drive distances. Such issues should be considered when both selecting cables and during infrastructure design.

Sparks on RJ45 while disconnected under power

Another consideration when applying PoE+ is how the high wattage affects the RJ45 connector when moving from PoE to PoE+ and higher. Due to the increased wattage involved, sparks will occur when disconnecting patch leads when devices are under load. This occurs during moves, adds and changes to the network when the PoE+ devices are active. These sparks are usually not noticeable to users and do not represent a personal safety hazard, but over time they will damage contacts on a typical RJ45 jack. Therefore, suppliers of the connectors need to make additional tests to ensure the damage does not affect the connector durability. Nexans R&D tests show that on the LANmark connectors, any damage caused by sparks will not degrade performance over time and these connectors are therefore compatible with all four types of PoE.

Conclusion

As the ecosystem of powered devices continues to grow, power delivery and heating characteristics will soon join other traditional cable performance parameters as a factor in the selection of cabling. Cabling must be able to ensure the delivery of increasing power and data speeds in adverse conditions over its expected lifetime. To maximize the capabilities and efficiencies of tomorrow’s system, the correct cabling infrastructure will need to be implemented. Selecting a higher grade of cabling will reduce heat generation within the cabling infrastructure, increase efficiency of power delivery, minimize the impact to IP traffic traversing the network and reduce the aging effect that heat can have on insulating materials. Over time, as more devices are connected and powered over the network infrastructure, the selected solution employed in the network will have a growing impact on network performance.

It is important to think about the expected lifespan of the network infrastructure, and the total lifecycle costs of selecting one option over another. In the vast majority of network IT projects, the cabling cost is negligible relative to the total project costs. Yet it can have a very significant impact on your network’s performance for years to come.

Finally, Nexans offer a wide range of cabling options. While its LANmark-7A offer superior power delivery efficiency compared to lower categories of copper cabling, LANactive FTTO, an alternative LAN infrastructure, is very efficient with FTTO access switches (PDE) located close to the end-device (PD) ensuring short power delivery distances and minimum power loss.