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WHITE PAPER

Cabling and Connectivity for Power over Ethernet

Trends, standards, and recommendations for high-power PoE

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Power over Ethernet **(PoE) is a proven method** of delivering DC power over the same twisted pair cabling used for LAN data transmission.

PoE has made great strides in recent years. Driven by the demand for ease of installation and boosted by new standards that expand support to more devices, PoE is expected to see explosive growth rates that match the period shortly after the technology was initially introduced in 2003.

There are several appealing reasons for adopting PoE. Foremost, by running power and data transmission over the same cable, PoE eliminates the need for additional wiring installations, saving on cost and redundant cabling. This consolidation also allows for faster deployment at the endpoint, especially to devices at far-off building locations and warehouse transaction work areas such as security cameras. PoE also allows for the centralization of power into one location. And it supports new applications such as centralized building controls that can adapt to individual users and the internet of things.

PoE has found success across a variety of applications:

- IP surveillance cameras using PoE can be located in more remote areas, and higher power PoE can support more camera features, such as pan-tilt-zoom and built-in heaters.
- PoE has found adoption for AV controls in boardrooms, classrooms, and auditoriums, as well as displays for marketing, info displays at schools, and other interactive devices.
- PoE-enabled Voice over IP (VoIP) phones are a popular choice today in large offices, universities, airports, and more. These often include video screens and touch screens.
- Wireless access points powered over PoE allow them to be installed where there is no power outlet, and they can even be managed through the PoE switch.
- Point-of-Sale (PoS) and Kiosks — PoS systems and help desks in shopping centers, hotels, and other areas can be placed in remote locations.
- IP PoE based lighting is an emerging technology that, if it achieves market acceptance, will add significantly to the growth of IP PoE devices in the enterprise.

PoE has evolved to encompass a tremendous range of devices and applications. However, without the right cabling and network design in place, next-generation PoE can encounter issues related to heating and connectivity that may adversely affect performance. Cabling standards bodies are working to expand the potential of PoE while addressing safety and performance issues.

STANDARDS OVERVIEW

In addition to existing standards that define low levels of PoE, new standards have paved the way for PoE up to 60 and 90 watts, expanding the types of devices and applications supported in the enterprise. However, higher-current PoE brings important cabling and connectivity considerations that must be addressed in order to ensure consistent network performance. **These considerations are outlined in current and emerging standards.**.

2002 **The Institute of Electrical and Electronics Engineers (IEEE) published the 802.3af standard,** which outlined Power over Ethernet at up to 15.4 watts of DC power, while supporting 10BASE-T and 100BASE-T. Power was delivered over two of the four twisted pairs of Cat 3 cable or higher.

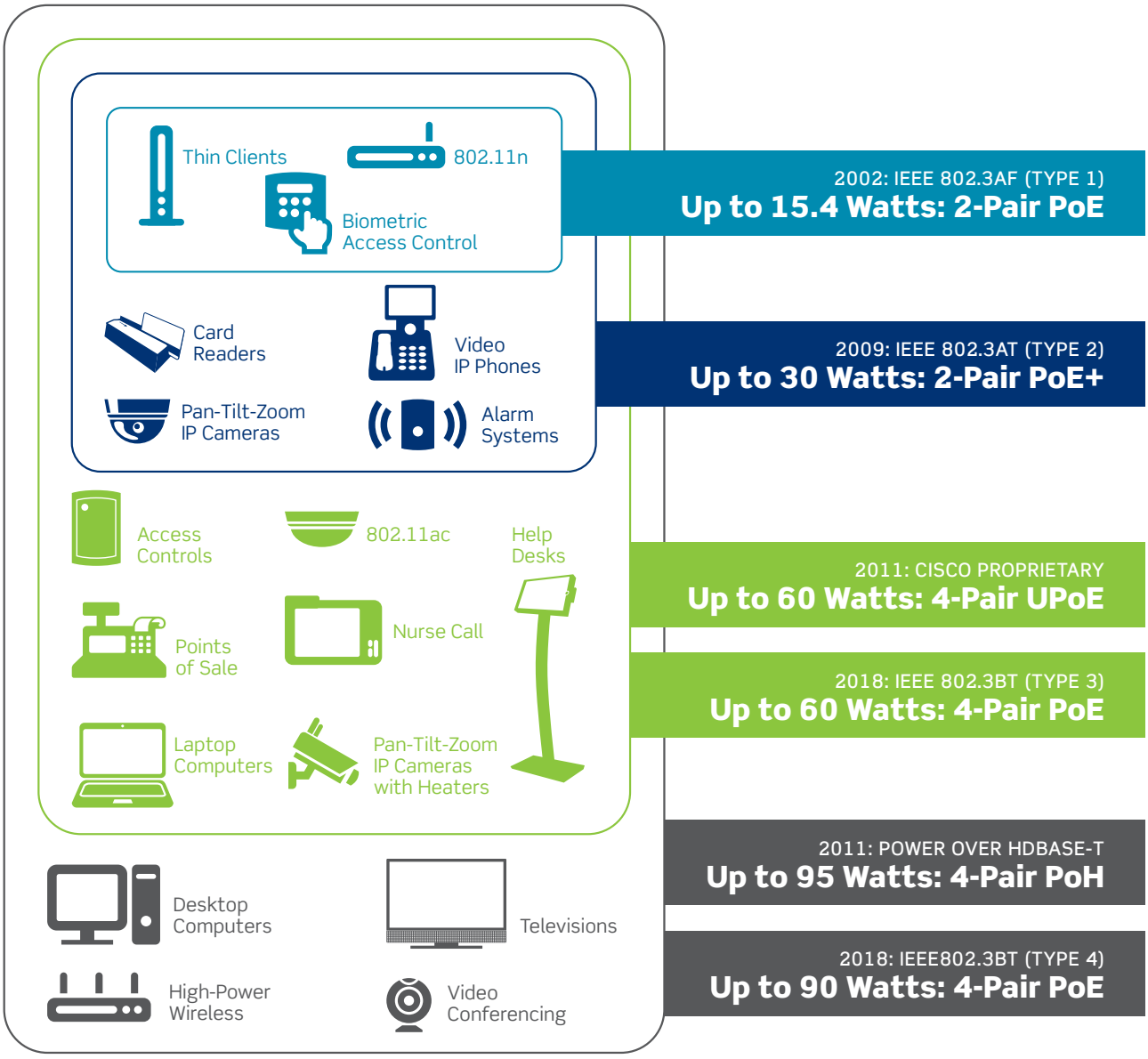
2009 **IEEE introduced 802.3at, also known as the "PoE+" standard.** This update allows delivery of up to 30 watts, and supports 1000BASE-T over Cat 5e or 6. It transmits power over two of the four cabling pairs, and is backwards compatible to 15.4 watt PoE.

2010 **The HDBaseT™ Alliance introduced Power over HDBaseT (PoH).** HDBaseT delivers video, audio, control, 100 Mb/s Ethernet, and power. The PoH standard is based on the 802.3at standard, modified to enable delivery of up to 95 watts over 4-pair Cat 5e, 6, or 6A. Leviton recommends Cat 6A components for PoH installations to ensure the most reliable performance.

2011 **Cisco created a non-standard PoE implementation called Universal Power over Ethernet (UPoE).** UPoE can use all four cabling pairs and supply up to 60 watts, further expanding the types of devices that can be supported.

2018 **IEEE introduced 802.3bt**, which defines PoE over four pairs and supports 10GBASE-T. The standard defines two new tiers of PoE: Type 3 for up to 60 watts, and Type 4 for up to 90 watts. Both support devices requiring higher power, such as laptops, displays, and next-generation wireless access points.

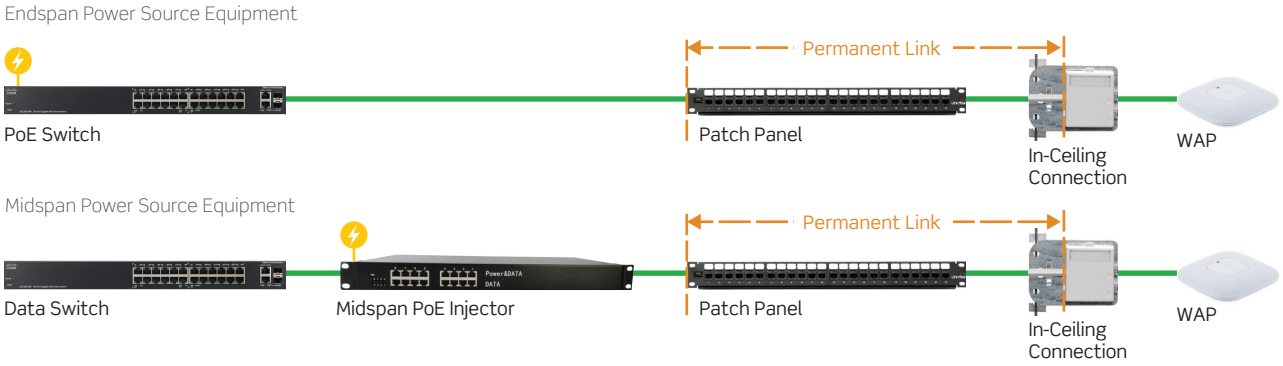
The Telecommunications Industry Association (TIA) and the International Organization for Standardization (ISO) have updated standards that address cabling to support 4-pair PoE in accordance with 802.3bt. TIA TSB-184-A Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling, ISO/IEC TS29125:2017 "Information Technology — Telecommunications Cabling Requirements for Remote Powering of Terminal Equipment" and CENELEC TR 50174-99-1 offer cabling guidelines to support IEEE 802.3bt 4-pair PoE, as well as other applications. The guidelines provide guidance on maximum bundle size for different category cables based on installation conditions and the maximum power delivered (15.4, 30, 60, or 90 watts).



EQUIPMENT FOR DELIVERING POE

A PoE system has two primary components: Power Sourcing Equipment (PSE) and a Powered Device (PD). The PD receives its power from the PSE using standard Ethernet cabling. The PSE can be divided into two types: endspans and midspans. Endspans are essentially Ethernet switches with PoE circuits added, while midspans are positioned between the switch and the powered device.

Midspan Versus Endspan



Midspans, also known as PoE injectors, are typically used when PoE is the only upgrade being made to the network, such as when adding IP phones or wireless access points to an existing non-PoE network. This avoids replacing switches that do not offer PoE but are still within their productive life cycles. Midspans may be located anywhere, as long as they are installed in a standards-compliant facility, such as a telecommunication room or enclosure, and are not installed as a part of a permanent link.

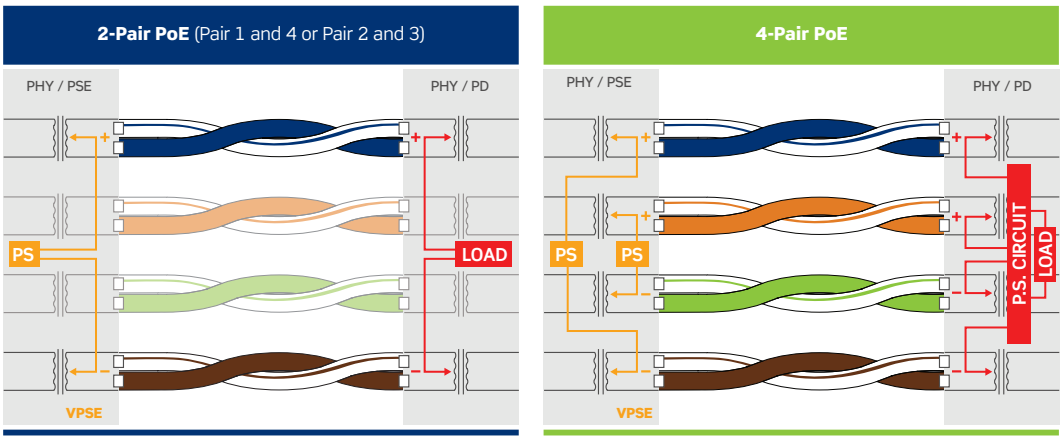
The chart below shows the acceptable power loss between the PSE and the PD. It is important to note that this indicates the maximum allowable power loss between the devices, not the typical or expected loss.

PoE Type	PSE Output (watts)	Power at PD (watts)	Standard
1	15.4	12.95	IEEE 802.3af
2	30	25.5	IEEE 802.3at
3	60	51	IEEE 802.3bt
4	90	73	IEEE 802.3bt

The loss in the cable is a function of the resistance of the cable, mostly driven by gauge size of the copper conductors. Smaller gauges have more resistance. For example, when subjected to PoE, a 24 AWG cable will have a higher energy loss when compared to a 23 or 22 AWG cable. The distance between the PSE and PD can also affect power loss. As an Ethernet application, PoE is designed to work over a 100 meter long channel as established by IEEE, and channels longer than 100 meters may see increased power loss beyond what is listed above.

TWO-PAIR VS. FOUR-PAIR POE

As mentioned in the standards overview, recently updated PoE standards enable power delivery over all four pairs of the cable. The standards developed by IEEE will also define PoE over four pairs. In previous standards, power was limited to just two pairs, which meets the needs of devices that require lower power such as 15 and 25 watts. But as PoE has expanded to support high-power devices, four-pair PoE doubles the amount of available power.



CABLING RECOMMENDATIONS FOR POE

As the operating temperature of a communications cable rises, its signal attenuation will also rise and will therefore have a negative effect on network performance. The permanent link cable maximum distance limitation of 90 meters defined in cabling standards is based on an ambient operating temperature of 20 °C. According to TIA and ISO standards, this maximum distance needs to be de-rated as operating temperatures rise according to defined factors. It is therefore important to keep cable operating temperatures at levels below the maximum operating temperature of the cable as indicated by the manufacturer.

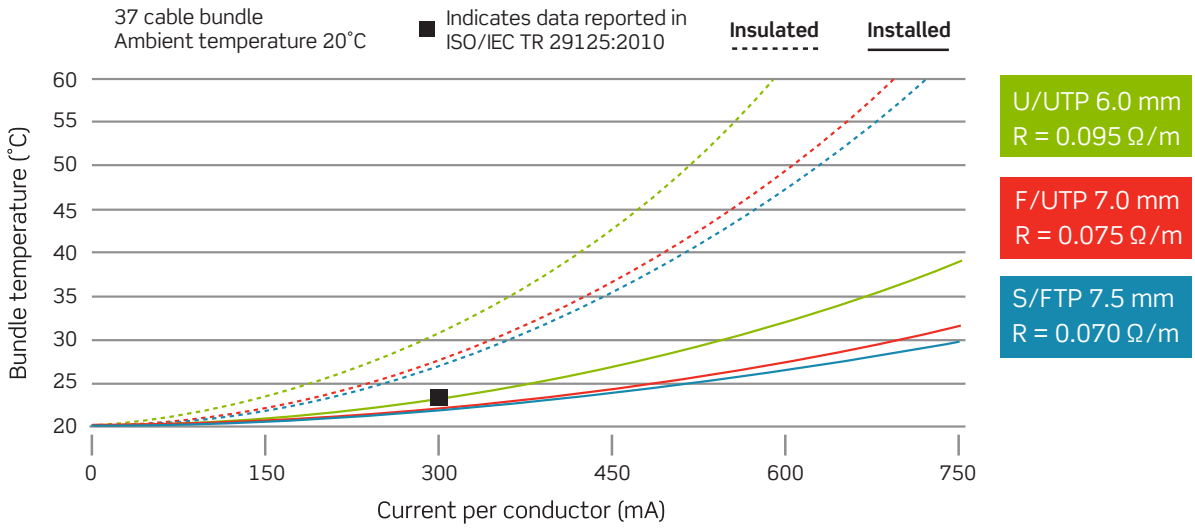
When power is added to balanced twisted-pair cabling, the copper conductors generate heat (Joule effect) and will cause the cable temperature to rise. This internally generated heat needs to dissipate to the surrounding environment in order to prevent excessive temperature buildup in the cable beyond ambient conditions. This temperature buildup is exacerbated by the common practice of bundling cables together in cable pathways and conduits and therefore preventing the natural heat escape to the surrounding air. The introduction of higher power PoE and the resultant heat effect has the potential of causing additional insertion loss and therefore bit errors unless cable lengths are shortened. As recent PoE standards allow for higher power transmissions, temperature concerns will likely become even more prevalent. TIA standards recommend 15 °C as the maximum allowed temperature rise above 45 °C ambient as a result of power over the cabling. ISO standards recommend a 10 °C maximum rise over a 50 °C ambient temperature.

Cable temperatures should also not exceed the long term operating temperature rating of the cable, and premises cabling typically have a maximum temperature rating of 60 °C (140 °F). However, today there are many cables available with higher temperature ratings, including those at 70, 75 and even 90 °C. Exceeding the long term operating temperature rating of a cable will lead to premature deterioration of the cabling jacket and insulation compounds and may cause the cable to fail. In addition to considering cable with higher ratings, there are other ways to avoid performance issues related to higher cable temperatures, including considering cable construction, category rating, and installation best practices.

Use Higher Category Cabling

Higher category-rated cable typically means larger gauge conductor sizes which are more efficient in delivering power (less Joule effect). Standardized testing of bundles of Category 5e, 6, 6A, 7, 7A, and 8 cabling show a significant improvement in heat dissipation with higher grades of cable. The higher-category cabling is able to support more current capacity at the maximum allowable 15 °C. It becomes clear that higher category cabling will be necessary to minimize temperature increases while supporting PDs that require more power. For this reason Leviton recommends using a minimum of Category 6A for all new 4-pair PoE applications. In addition, ISO/IEC 11801-6:2017 Distributed Building Services standard recommends Cat 6A or higher to accommodate increased power delivery requirements.

Leviton has performed 52 different tests related to PoE, with extensive PoE testing on every major cable the company sells. These tests also compared temperature increases between category ratings, at 37, 61, and 91 cable bundles. Leviton testing found significant differences in temperature increases between Category 5e, 6 and 6A ratings.



Reduce the Number of Cables per Bundle

If cables are bundled or closely grouped with other cables, cables near the center of the bundle have difficulty radiating heat out into the environment. Therefore, the cables in the middle of the bundle heat up more than those toward the outer layers of the bundle. The larger the bundle size, the more the cables in the center will heat up.

Separating large cable bundles into smaller bundles or avoiding tight bundles will reduce temperature rise. For example, ISO/IEC 29175:2017 recommends separating large bundles into smaller bundles to reduce the maximum temperature rise (e.g. 3 × 37-cable bundles had a lower temperature rise than a 91-cable bundle). ISO/IEC 14763-2:2019 recommends a maximum bundle size of 24 cables, regardless of PoE considerations.

Also, where possible, plan the rack layout for non-powered and powered cables to be mixed in the same bundle, and place non-energized cables in the center of the bundle and energized cable in the outer layers of the bundles.

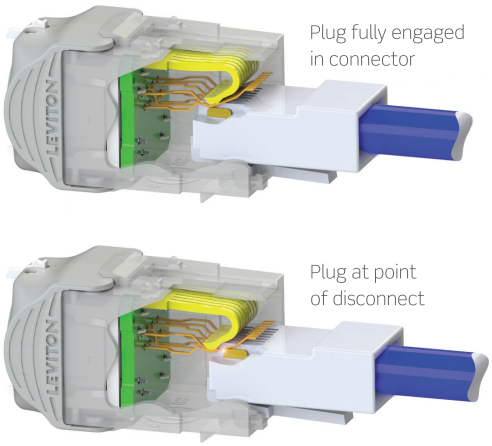
Design pathways to support airflow

Enclosed conduit can contribute to heat issues. When possible, use ventilated cable trays for better airflow. Open mesh cable trays and ladder racks will improve heat dissipation and create more opportunities for loosely grouping cables instead of tight bundling. Also, avoid squeezing or “necking down” cable to small areas such as through holes and firestops. Provide as large an area possible for this transition.

Install Shielded Cable

Test results from both Leviton and standards bodies show shielded cable performs better than traditional UTP cable. When Leviton engineers tested 37 cable bundles under temperature rise, the average temperature for shielded bundles increased at a rate 2 °C below the UTP cable bundles. ISO/IEC testing reveals similar results as shown in the figure below, from ISO/IEC TS 29125:2017. The figure also shows the difference in temperature rise between insulated and ventilated pathways.

CONNECTION INTEGRITY AND PERFORMANCE

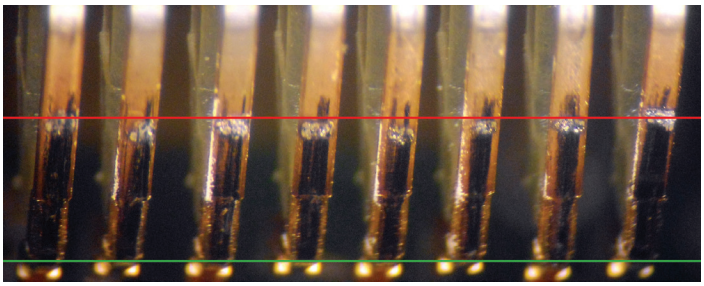


Another consideration with higher current PoE is the potential for damage over time to RJ-45 jacks in the network. Specifically, when a patch cord is unplugged while the connection is energized, a small electrical arc can occur between the jack and the plug. During operation, the plug's contacts rest on the "knuckle" in the jack tines. Arcing occurs at the point where the plug's contacts separate from the jack tines during disconnect. While there is no immediate damage (and the arc is not dangerous to users), it can create pitting on the jack tines and patch cord plug contacts over numerous disconnections, weakening the integrity of the connection.

Jacks and patch cords with 50 µm gold-plated tines should always be used, as specified by Industry standards. There are jacks and patch cords available on the market that do not have the requisite amount of gold plating — often sold at a much lower cost — and these non-compliant options will fail more rapidly when used in PoE applications. Jacks should also meet contact resistance requirements found in the IEC 60512-99-002: 2019 standard covering jacks for electronic equipment.

In addition, Leviton recommends using a jack that is designed to keep the connection point between the mated jack tines and plug at a distance from the point of arcing damage. Leviton has designed the geometry of its Atlas-X1® jacks so that arcing occurs at a different area from the point of contact during data transmission.

Leviton lab testing confirms that the location of the pitting in Leviton jacks is sufficiently far from the point of contact between the tines and plug when mated. This means that the pitting does not affect the electrical performance of the jacks within a channel, providing additional longevity.



Red line = Point where pitting damage occurs from PoE+ disconnect while energized

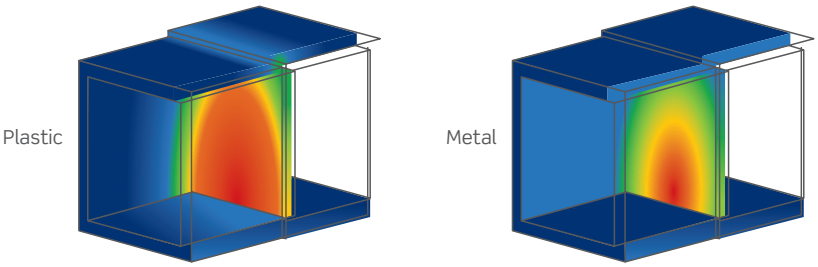
Green line = Point of contact between connector tine and plug when mated

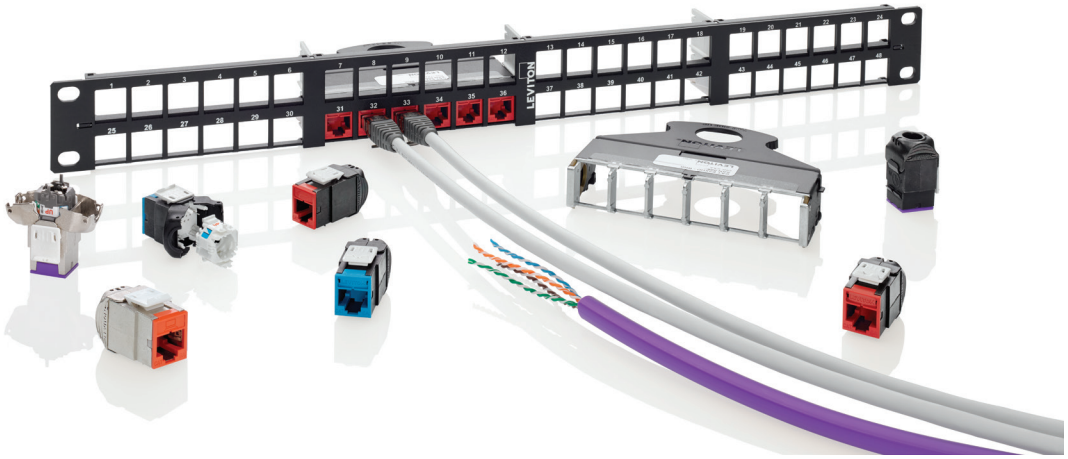
In addition, Leviton jacks include patented Retention Force Technology (RFT), which maintains constant contact force at the jack and plug interface, preventing inadvertent intermittent disconnects caused by vibration or operational movement of the plug in the critical jack and plug mating region. The result prevents tine damage, saves on costly repairs and increases overall system longevity.

Leviton Connectivity Performance Under Higher Temperatures

As with cable, temperature rise in jacks can also affect channel performance. Leviton engineers tested Atlas-X1® jacks and patch cords against standards requirements. The jack was tested to the IEC 60512-5-2:2002 Connectors for Electronic Equipment standard and exceeded all test parameters. The higher performance in the Atlas-X1 jack is largely due to its unique metal-body construction. Leviton testing found that using a metallic jack body — instead of commonly-used ABS plastic — creates a 53 percent improvement in heat dissipation.

Thermal simulation of connector bodies using plastic and zinc





PREPARING FOR NEXT GENERATION, HIGH-POWER POE

High-quality connectivity is essential for attaining the performance and reliability needed in current and future PoE network operations. System components should be designed to minimize temperature increases and meet industry standards for performance. This ensures system longevity and prepares networks for future upgrades and growth, such as higher power requirements from PoE-enabled devices or larger cable bundles.

Leviton systems for PoE — including cable, jacks, patch cords, and patch panels — are component rated, and third-party tested and verified to exceed industry standard performance. Leviton Atlas-X1 connectivity was successfully tested to deliver 90-watt PoE, enabling the transmission of power and data to a wider range of remote devices. The ability to deliver 90 watts supports the IEEE 802.3bt (type 4) PoE standard. System components have undergone rigorous lab testing to meet the need for higher bandwidth and power, while limiting the temperature rise in large cable bundles and remaining within the cable's listed rating.

Learn more about PoE and Leviton's PoE-optimized solutions at **Leviton.com/PoE**.

Today's networks must be fast and reliable, with the flexibility to handle ever-increasing data demands. Leviton can help expand your network possibilities and prepare you for the future. Our end-to-end cabling systems feature robust construction that reduces downtime, and performance that exceeds standards. We offer quick-ship make-to-order solutions from our US and UK factories. We even invent new products for customers when the product they need is not available. All of this adds up to the **highest return** on **infrastructure investment**.

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