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TECHNOLOGIES

WHITE PAPER

Optimizing High-Power PoE

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Power over Ethernet (PoE) and PoE+ provide businesses and facilities with a simple and convenient option for powering devices. 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 costs for additional cabling material, labor, and administration. This consolidation also allows for faster deployment at the endpoint, especially to devices at far-off building locations such as wireless access points, security cameras, warehouse transaction work areas, and sales kiosks.

PoE also allows for the centralization of power into one location, playing a key role in supporting new smart building controls that adapt to individual users and the internet of things (IoT). Instead of having separate power supplies for every device, centralized power can be controlled for much greater efficiency. With lower energy costs, PoE helps organizations meet corporate sustainability goals.

As PoE continually evolves to support more devices and smart building initiatives, it will become even more ubiquitous throughout enterprise networks. At the same time, other energy saving technologies have evolved in parallel to take advantage of PoE, such as LED lighting.

PoE has found success across a variety of applications:

- Wireless access points powered by PoE can be installed in areas where there is typically no A/C power outlet, and they can even be managed through the PoE switch.
- 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.
- Smart buildings rely on PoE to support lighting systems, HVAC control, digital signage, emergency systems, and more.
- PoE can be used 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 that are powered by the switch.
- Point-of-Sale (PoS) terminals and kiosks in malls, hotels, and other areas can be connected to and powered by a single cable.

PoE will continue to grow and support a greater range of devices and applications. However, without the right cabling and network design in place, next-generation PoE may encounter cable heating and connectivity issues that can adversely affect performance. Cabling standards bodies are working to expand the potential of PoE while addressing safety and performance issues.

Evolution of PoE Standards

PoE first emerged in 2003 with the IEEE 802.3af standard and was originally built around Category 5 specifications, to deliver approximately 13 watts to a powered device through 350mA of current with Ethernet speeds up to 100 Mbps. The standard allowed for delivering power over two pairs (**Figure 1**). However, these early PoE standards did not permit power simultaneously over all four pairs.

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.

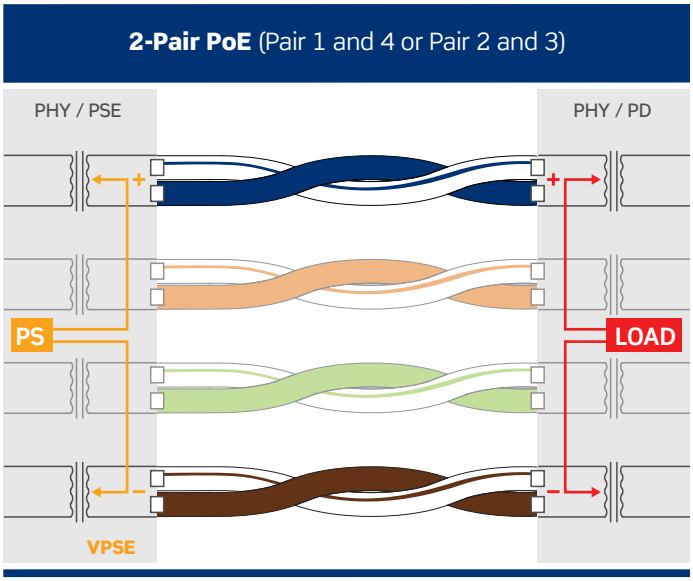

Figure 1

Today, there is a need for standards to define PoE for higher power devices, as many require power in excess of what is supported by existing standards. There are numerous markets with an identified need for higher power PoE, including healthcare, retail, finance, commercial, office, security, and industrial. Significant growth is also projected for industrial automation and thin clients. **Figure 2** depicts the projected growth in the PoE market through 2025.

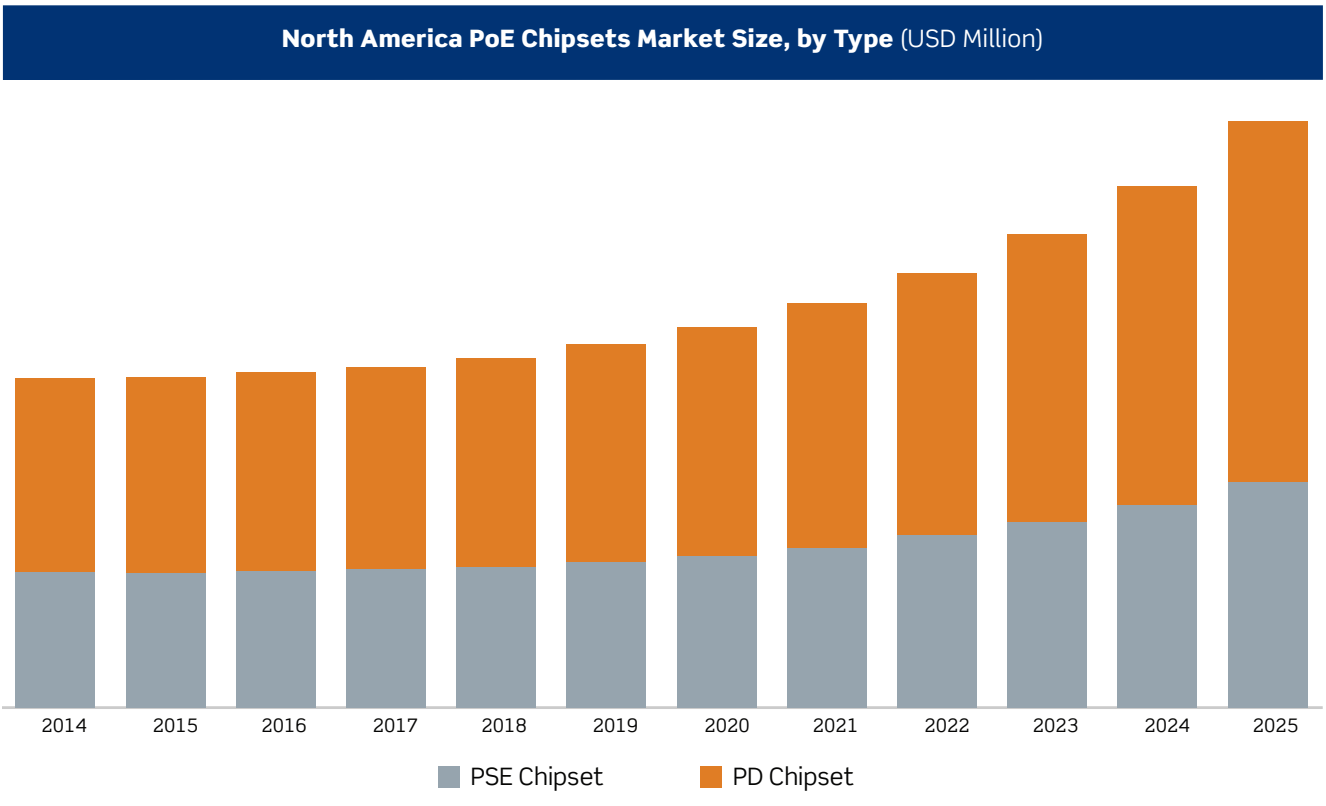

Figure 2 Source: Grand View Research

In 2013, IEEE announced a task force to create a new PoE standard, 802.3bt, which will include support for 10GBASE-T and define two new power levels for power sourcing equipment: Type 3 for up to 60 watts, and Type 4 for up to 100 watts. 802.3bt was published in September 2018 (**Figure 3**).

IEEE 802.3bt transmits 90 watts of power and up to 10 Gbps.

	TYPE 1 (802.3af)(2003)	TYPE 2 (802.3at) (2009)	TYPE 3 (802.3bt) (2018)	TYPE 4 (802.3bt) (2018)
PSE	Class 1 4W Class 2 7W Class 3 15.4W	Class 4 30W	Class 5 45W Class 6 60W	Class 7 75W Class 8 90W
	2-pair only (Type 1 & 2) 2-pair or 4-pair power (Type 3 & 4)		Always 4-pair	
PD	Class 1 3.84W Class 2 6.49W Class 3 13W	Class 4 25.5W	Class 5 40W Class 6 51W	Class 7 62W Class 8 71.3W

Figure 3: The power levels defined by 802.3bt for Power Sourcing Equipment (PSE) and Powered Device (PD) shows that power and data demand will only increase over time. Source: Ethernet Alliance

The new standard now allows power delivery 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 13 and 25 watts. But as PoE has expanded to support high-power devices, four-pair PoE, as shown in **Figure 4**, doubles the amount of available power. When carried over the same cabling pairs, power transmission and data transmission will not interfere with each other.

TIA and ISO committees are also updating standards that address cabling to support 4-pair PoE in accordance with 802.3bt. The TIA TSB-184-A Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling — published in March 2017 — and the draft ISO/IEC TR29125 Edition 2 offer cabling guidelines to support IEEE 802.3bt four-pair PoE and other applications. These guidelines provide recommendations on maximum bundle size for different category cables based on installation conditions and the maximum power delivered (from 3.84 watts to 71.3 watts).

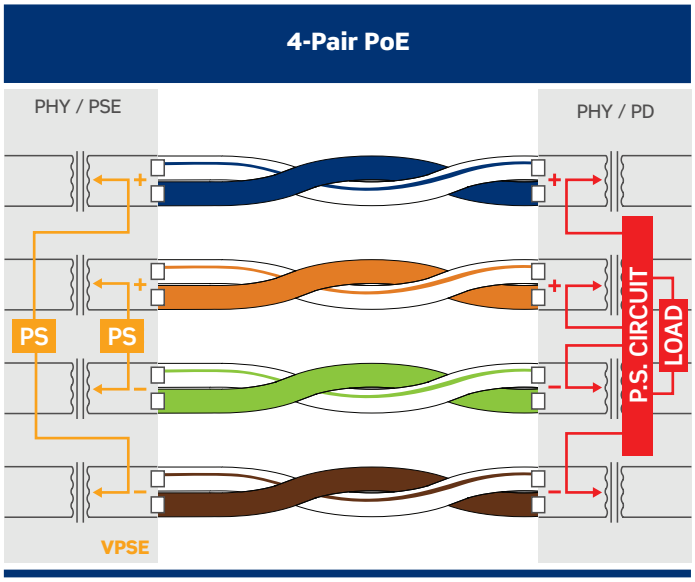

Figure 4

Additional Evaluation of High-Power PoE

In addition to TIA, ISO, and IEEE, other organizations are addressing concerns surrounding high PoE. In 2015, independent safety and certification company Underwriter's Laboratory (UL) conducted a fact-finding study to investigate the effects of higher levels of current on communications cable. The study found that when power greater than 60 watts was sent over twisted pair cables that were grouped in large bundles, an increase in the operating temperature of the cables was possible that was beyond their listed temperature rating. As a result, UL introduced an optional Limited Power (LP) Certification marking to indicate that the cable has been evaluated to deliver the marked current per conductor regardless of bundle size, without exceeding the cable's temperature rating and assuming a 45 °C ambient temperature. LP marked cables are optional, and are not required for PoE or any other type of installation.

In addition, in August 2016 the National Fire Protection Association (NFPA) published changes to the 2017 National Electric Code (NEC) that will affect PoE deployment. The NEC provides standards for the United States, and while not a law, it is a code commonly adopted by states and cities around the country. The NFPA voted to create a new table to be referenced when the power supplied to communication cables exceed 60 watts. Table 725.144 in the new 2017 NFPA 70 document recommends the maximum number of cables that can be bundled based on the ampacity of the conductors according to their wire gauge, and the cable's listed temperature rating.*

The 2017 NEC also includes a reference to the new LP cable classification. LP-rated cables can act as an alternative to conventional cables and the new ampacity table. However, these designations are only valid up to 30 °C maximum ambient temperatures. Above 30 °C, the appropriate current derating table in the code needs to be used. LP cables are not mandated by the 2017 NEC code published in August of 2016, but included as an option.

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Testing that Replicates the Real World

To accurately determine the effect of heat on a cable's performance, testing scenarios must replicate real-world installation environments as closely as possible. To this end, the TEK Center at Berk-Tek has both modeled and tested the temperature profiles of numerous sizes of cable bundles in preparation and support of the standardization efforts for the next generation of PoE. This includes examining temperature rise when power is applied to different types of cable in open trays, in addition to cable inside conduit.

Recently, the TEK Center evaluated the performance of various cables from several different manufacturers, and included Category 5e through Category 6A. To avoid confusion, this paper will focus on one representative product from each category tested:

- Category 5e: LANmark-350™
- Category 6: LANmark™-1000
- Category 6A (unshielded): LANmark™-10G2
- Category 6A (foil-isolated): LANmark™-XTP

* Note 1 under Table 725.144 states that "For bundle sizes over 192 cables, or for conductor sizes smaller than 26AWG, ampacities shall be permitted to be determined by qualified personnel under engineering supervision." Berk-Tek Leviton Technologies has qualified personnel under engineering supervision and can safely provide cable bundles much larger than what is stated in Table 725.144. See your local Berk-Tek Leviton Technologies sale representative for more information.

The testing focused on two bundle sizes of 37 and 259 cables. The quantity 37 was selected to match testing being done by the industry standards bodies, and because of its approximate size to cable bundles servicing 24 and 48 port panels.

The 259-cable bundle was built from seven bundles of 37 and would closely approximate the deployment of 240 cables addressing ten fully populated 24-port patch panels. All bundles were subjected to currents representing various projected power levels of future PoE deployments, and the resultant temperature increases were measured. Thermal gains were calculated by measuring the temperature increase of the inner-most cable after the bundle reached equilibrium (6-8 hours) and comparing it to the recorded ambient temperature.

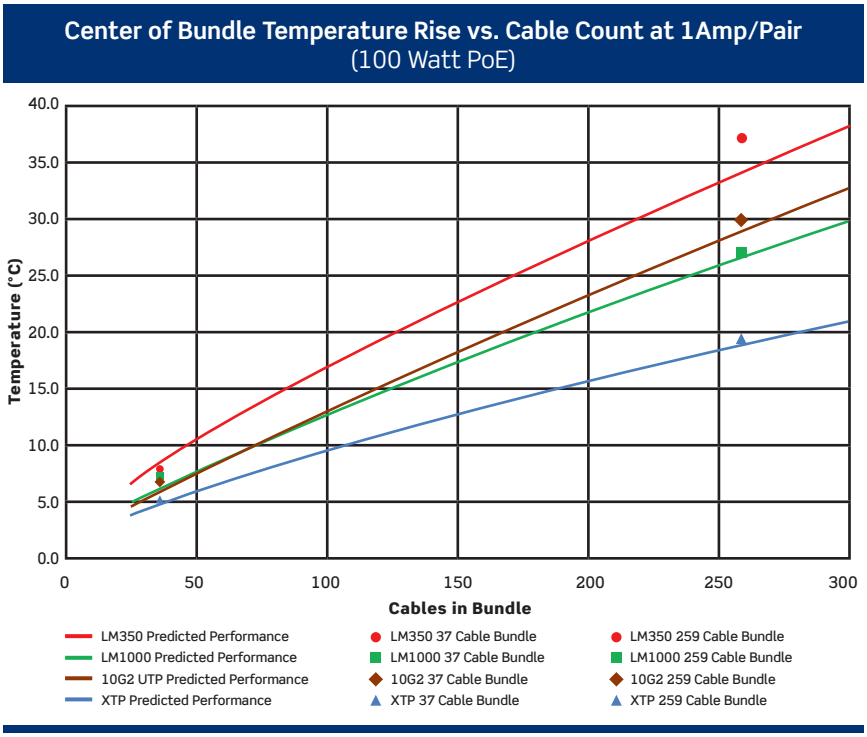

Figure 5: Modeled vs. measured temperature rise of innermost cable in bundle in an open tray.

These results were compared to a TEK Center model for predicted heat generation. **Figure 5** represents the comparison of the highest temperature rise of the various cable constructions with respect to the size of the bundle when carrying 1000mA (100 Watts) of current across each pair, which closely approximates the conditions of Type 4 power delivery. The model provides a high degree of correlation between the measured and predicted data in this test configuration, confirming the accuracy of the TEK Center model compared to real-world installations.

The testing found that, in general, as a cable's electrical performance improves, the thermal performance also improves. **Specifically, the TEK Center's testing showed**:

1. Higher category cables experienced less temperature rise than lower category cables.
2. In larger bundles, LANmark-10G2 (Category 6A UTP) performed only slightly better than LANmark-1000 (Category 6 UTP). This is attributable to the construction of a Category 6A UTP cable, specifically its higher twist rate and increased jacket thickness, both of which are needed to meet internal and external crosstalk requirements.
3. The best solution for high PoE deployment is the foil isolated Category 6A product, LANmark-XTP. The XTP cable exhibits significantly less temperature increase with 100W PoE deployment. In a 259 cable bundle, the XTP cable is approximately 18 °C (32 °F) degrees cooler than the LANmark-350 Category 5e cable. This is a significant difference, and will become even more critical as more devices demand higher levels of power delivery over the network. This reduced temperature rise with the XTP cable reinforces its suitability to high power PoE deployment as it helps to ensure the cable reach is maximized under adverse conditions.

Jack Performance Under Higher Temperatures

As with cable, temperature rise in jacks can also affect channel performance. Leviton engineers tested its Atlas-X1 jacks against standards requirements. The jack was tested to the IEC 60512-5-2 Jacks for Electronic Equipment standard.

Tests showed that Atlas-X1 UTP jacks dissipated more heat than other UTP jacks. This is largely due to its metal body construction, as shown in **Figure 6**. The testing found that using metal in the jack body creates a 53% increase in heat dissipation over conventional plastic bodies.

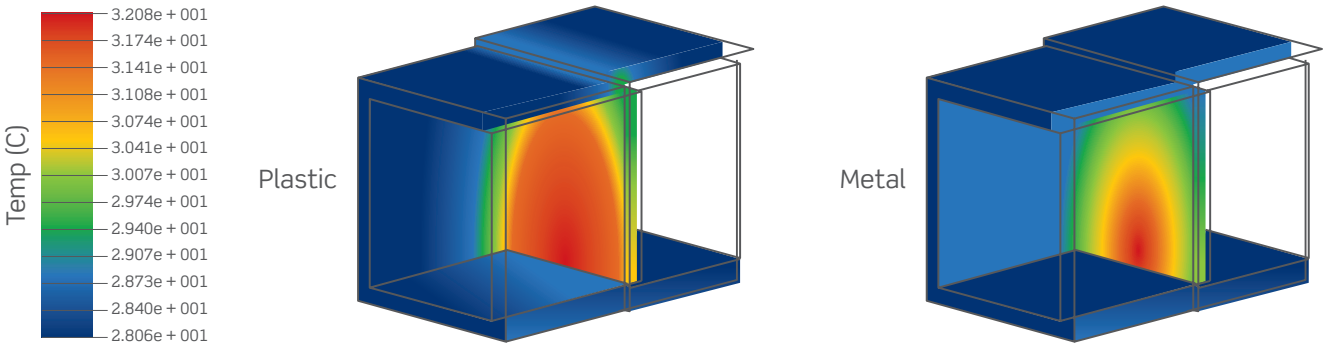

Figure 6: Thermal simulation of jack bodies using plastic and metal

Another concern 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.

Leviton recommends using a jack that keeps pitting damage away from the mated connection point between the jack tines and plug contacts. Leviton jacks are designed with PoE optimized tine geometry that distances any pitting from the mated data passing zone, as shown in **Figure 7**.

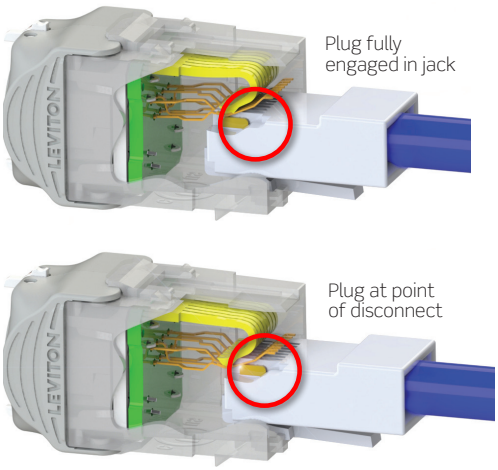

Figure 7

Testing from the Leviton System Verification Lab confirms that the location of the pitting in its 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.

Also, jacks and patch cords with 50 µm gold-plated tines should always be used, as specified by ANSI/TIA-1096-A and ANSI/TIA-568.2-D standards. The cost of the gold is a substantial part of the cost of jacks, and there are companies that cut corners by not using gold on their jacks in order to offer them at a lower cost. These options are not TIA-compliant and more likely to fail when used for any application — including PoE.

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 also tested Atlas-X1™ Patch Cords for compliance with the TIA TSB-184 temperature rise limit of 15 °C above ambient at 50 watts, and found its Cat 6 and Cat 6A cords maintained a temperature rise of less than 10 °C in bundled configurations.

Optimizing High-Power PoE

With so many devices now compatible with PoE, and with more organizations eager to adopt intelligent building systems and the internet of things, PoE will become ubiquitous across all types of enterprise applications. For these new installations, it is important that companies use the right cabling and connectivity. 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.

Foil-insulated cables such as the Berk-Tek LANmark-XTP product will provide increased robustness with the best deployment options for PoE due to the minimized thermal gains inherent in its design. Metallic tape on the XTP product allows heat to transfer out of the cable much more efficiently than cable designs without this type of construction. This will allow for maximum performance and flexibility when planning for PoE deployment. The LANmark-XTP product has been specially designed to be Berk-Tek's best performing product for PoE applications.

Berk-Tek Leviton Technologies Category 6 and 6A cable and connectivity systems were successfully tested to deliver 100-watt PoE, enabling the transmission of power and data to a wider range of remote devices. The ability to deliver 100 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 these solutions at BerkTekLevitonTechnologies.com.

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Build your high-performance networks with Berk-Tek and Leviton, two of the most innovative, reliable, and service-oriented names in the industry. Berk-Tek cable and Leviton connectivity combine to create the industry's premier copper, fiber and AV, end-to-end solutions.

Berk-Tek has spent the last 50 years maximizing the capabilities of cabling systems. This focus has enabled the development of innovative cabling that addresses the particular needs of enterprise, campus and data center networks, including high-speed transport, high-density installations and rapid deployment.

The products offered by Berk-Tek lead the industry in performance, reliability and robustness. Independent verification to product specifications, not just industry standards, offers customers an added level of certainty of the quality being delivered.

For the past quarter century, Leviton Network Solutions has engineered and manufactured copper and fiber optic connectivity products for enterprise, data center, government, education, health care and residential markets around the globe.

Leviton manufactures nearly all of its branded products in company-owned, ISO 9001-2008 certified facilities located in the United States. All Leviton products are engineered to exacting standards, offer industry-leading performance and are backed by the industry's best service and support. That's what makes Leviton the smart choice for a better network.

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