Cabling to a Higher Power

Infrastructure Challenges and Considerations with Remote Powering (PoE)

"As we explore the implications of PoE technology, today is the worst you will see it; it only gets better from here. PoE is changing low-voltage applications and will transform our lives," states Farukh Aslam, CEO of Sinclair Holdings, LLC, a consultant and designer of emerging Internet of Things (IoT) applications.

By Carol Everett Oliver, RCDD, ESS

One of the hottest infrastructure game changers to hit the ICT industry is the recent ratification of the IEEE 802.3bt *Power over Ethernet (PoE) over 4 Pairs amendment* (i.e., Type 3 and Type 4), which allows transmission of higher wattage to many IP-enabled devices over communications cabling. Power over Ethernet (PoE) now enables up to 90 watts (W) to be transmitted over four pairs of a twisted-pair cable. PoE has been around since 2003 with the introduction of Type 1 (15 W at the power source equipment, average 13 W at the powered device). The newly published IEEE 802.3bt Type 3 (60 W at the powered source equipment, average 51 W at the powered device) and Type 4 (90 W at the powered source equipment and up to 71 W at the powered device) open the flood gates of applications by doubling or tripling the power output from the previous Type 2 at 30 W, which was ratified almost 10 years ago.

What does this mean and how will it affect the ICT world? The higher power available with Types 3 and 4 means that many more devices and applications will be able to be remotely powered without the installation of a local AC power circuit. It will also add expanded capabilities to devices that are already PoE enabled. The great news is that PoE will increase business for ICT contractors, because it will allow the design and installation of applications that were previously installed by electricians or specialty services.

Understanding PoE can sometimes be daunting as this is a new challenge for low-voltage installers. It is best to focus on the "need to know" concepts and understand that there are "nice to know" assists. The "need to know" is to understand how this will change the ICT cabling landscape and installation practices. The "nice to know" is that there are published standards and codes available to help guide the planning and installation for these higher power PoE deployments. Also, it is always a "nice to know" that manufacturers of cabling systems and devices can provide training and design options. But even though there are infrastructure standards for the cabling, there are no specific standards or protocols for the individual devices (e.g., LED lights). It is still a "wild, wild West" as implementation topologies vary among system and device manufacturers.

THE POWERS THAT BE

To deliver PoE, there must be a power source and a PoE-enabled device to receive the power. The power sourcing equipment (PSE) can deliver a variety of power levels, depending on the requirements of the powered device (PD). All the powering takes place in the network's Ethernet link layer, which differs from plugging a device into an AC outlet.

It is important to understand these different types in the selection of powered devices, which must be compatible with the PSE. When a PD is connected to the PSE, power is generated only when a compatible PD detection is found. The PSE discovers how much power the PD is required to draw. The PSE then monitors the power draw and can disconnect the circuit if the PD exceeds a set limit or if the PD is disconnected.

There are four "Types" of power delivery over Ethernet as defined by IEEE standards and specifications (see Table 1). Type 1, which was ratified in 2003, addressed a low range of 4 to 15.4 W at the PSE and up to 13 W at the PD (depending on the distance and voltage drop) and is often informally referred to as "802.3af." Type 1 was created to address digital security cameras that were utilizing balanced twisted-pair cabling to connect to an IP network and delivered power over two of the unused pairs. Type 2, which was ratified in 2009, addressed the power needs of more complex security cameras (e.g., pan, tilt and zoom) and delivered up to 30 W DC at the PSE and up to 25.5 W at the PD. Type 2 is often referred to as "PoE Plus." The newly ratified Type 3 and Type 4 use all four pairs of a balanced twisted-pair cable to push PoE to 60 W and above. Therefore, they are often referred to as "4-pair PoE." Because the standards

	Standard	Minimum Power at PSE Output	Maximum Power at PD Input	Number of Pairs	Maximum Current per Pair
Power over Ethernet (Type 1)	IEEE 802.3af-2003	15.4 W	13.0 W	2-pairs	350 mA
Power over Ethernet Plus (Type 2)	IEEE 802.3at-2009	30.0 W	25.5 W	2-pairs	600 mA
4-pair PoE (Type 3)	IEEE P802.3bt-2018	60.0 W	51.0 W	4-pairs	600 mA
4-pair PoE (Type 4)	IEEE P802.3bt-2018	90.0 W	71.3 W	4-pairs	960 mA

TABLE 1: Overview of power types by IEEE standards.

are aimed to retain full backwards compatibility, all types are fully interoperable.

In addition to understanding the IEEE Ethernet PoE standards, there are other standards and codes that are applicable to the ICT designer and installer when faced with implementing a cabling system to transmit both power and data. These should be added to every contractor's bookshelf:

TIA

- ANSI/TIA-862-B-2016, *Structured Cabling Infrastructure Standard for Intelligent Building Systems:* specifies minimum cabling requirements for intelligent building applications (previously called building automation system or BAS) that use IP communication and accommodates other protocols that are typically used between devices. Specific content addresses recommended cabling components and topology, architecture, design and installation practices and test procedures.
- TIA-TSB-(Technical Systems Bulletin)-184-A-2017, *Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling:* developed by TIA Subcommittee TR-42.7 to provide guidelines focusing on managing cable temperature rise to keep cables operating below maximum temperature ratings.
- ANSI/TIA-569-D-2-2018, *Additional Pathway and Space Considerations for Supporting Remote Powering Over Balanced Twisted-Pair Cabling:* provides additional pathway and space considerations for supporting remote powering over balanced twisted-pair cabling.

BICSI

- ANSI/BICSI-007-2017, *Information Communication Technology Design and Implementation Practices for Intelligent Buildings and Premises:* developed by the BICSI standards committee (consisting of manufacturers, consultants, designers and architects). This standard provides recommendations for design and implementation of the structured cabling system, as well as building system applications for any size building or premise.
- ANSI/BICSI-005-2016, *Electronic Safety and Security (ESS) System Design and Implementation Best Practices:* provides the security professional with the requirements and recommendations of a structured cabling infrastructure needed to support today's security systems, while providing the cabling design professional information on different elements within safety and security systems that affect the cabling infrastructure design.

ISO/IEC (INTERNATIONAL STANDARDS)

- ISO/IEC TS 29125 (2017): *Information Technology – Telecommunications Cabling Requirements for Remote Powering of Terminal Equipment:* specifies the use of generic balanced cabling for customer premises, as specified in the ISO/IEC 11801 series, for remote powering of terminal equipment. It provides guidance on new cabling installations and renovations.
- ISO/IEC 14763-2 (2012): *Information Technology – Implementation of Operation of Customer Premises Cabling (Part 2: Planning and Installation):* specifies requirements for the planning, installation and operation of cabling and cabling infrastructures (including cabling, pathways, spaces, earthing and bonding) in support of generic cabling standards.

NEC

- NFPA 70: *National Electrical Code (NEC)* 2017:
  - *Article 725.144 Transmission of Power and Data:* addresses Class 2 and Class 3 circuits that transmit power and data to a powered device and includes ampacity Table 725.144, which provides the maximum allowable ampacity of such cables based on the size of the individual conductors and the number of cables in a bundle.
  - *Article 800 Communications Circuits, Section 800.3(H):* requires that cables used in communications circuits comply with Section 310.15(A)(3). The only cables permitted to be used for communications circuits are communications cables (i.e., Types CMP, CMR, CMG, CM and CMX).

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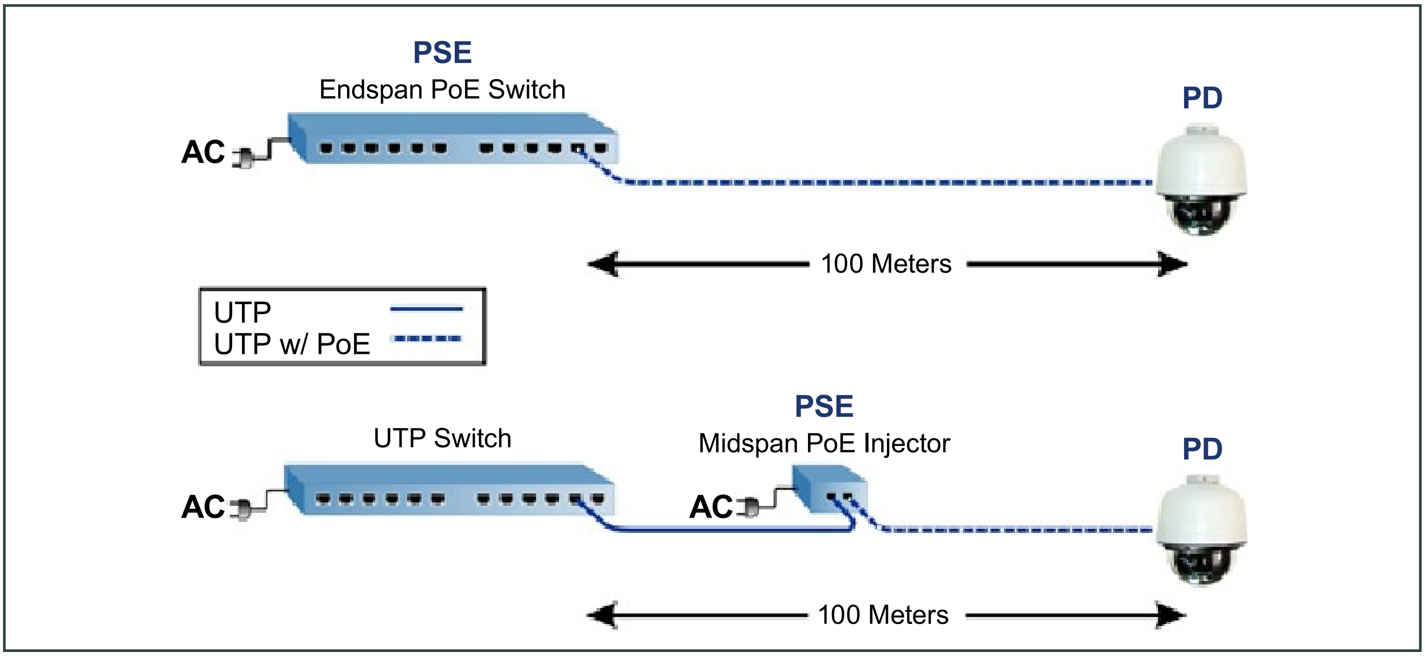

FIGURE 1: Example of midspan and endspan PoE.

UNDERSTANDING THE POWER OF DELIVERY

There are two ways power is delivered from the PSE to the PD: through an endspan device or a midspan injector as illustrated in Figure 1. An endspan device is usually located in the telecommunications room (TR) in the form of a switch with PoE capabilities that sends both power and data over the horizontal cable to the device. A midspan injector is inserted into the horizontal link between the TR and end device and injects power onto the cable from that point forward. This allows PoE to be added onto any Ethernet link that does not employ power from a PoE switch in the TR.

As a network designer, there are two types of infrastructure topologies to decide upon early in the planning stages depending on whether deploying an endspan device in the TR or closer to the PDs. The two topologies are either centralized or decentralized, respectively. The deciding factors include the amount of power required at the PD, the required transmission speed of the PD, the distance from the PSE, and cost. It is important to note that a decentralized topology is not recognized within most industry structured cabling standards.

In a centralized topology, all the processing power and active equipment (i.e., PoE-enabled switches) are in a centralized location. From there, the horizontal cabling is installed to the powered device, creating a point-to-point scenario. This centralizes all the cabling and connectivity in the TR, enabling all the moves, adds and changes (MACs) to be performed at patching fields through a cross-connect or interconnection to the active equipment. When a new application or PD is added, another horizontal cable would then be installed to the PD.

A decentralized topology puts the DC power closer to the PDs. This can be accomplished with a PoE switch located in the plenum space between the TR and the PD. The decentralized PoE switch manages both network computing power as well as DC power to the device, eliminating individual connection from each PD to a switch in the TR. "A plenum-rated PoE switch can connect to the device or to a node and allows you to originate several runs aggregated on one uplink," explains Luis Suau, technical leader, Industrial Products, Cisco Systems. "A digital building switch is an active component that actually regenerates the signal and allows more cables to provide downstream connectivity to the node or the devices themselves, either in a point-to-point or daisy-chained topology, dependent upon the power and bandwidth required," he adds. *(Note that as of this writing, PoE switches used for this application are limited to 10/100 Mb/s applications, so they may not be suitable* *for all IB applications and also require the installation of AC power to these switch locations.)*

Zone cabling, which utilizes a horizontal connection point (HCP) as outlined within TIA-862-B and detailed in the ANSI/BICSI-007 standard, is a cabling design that allows greater flexibility for PDs that are typically installed above the ceiling in plenum environments, such as wireless access points (WAPs), security cameras, fire alarms, speakers and many other applications (see Figure 2). Zone cabling does not include any active components and can be configured in both a centralized and decentralized topology (see Figures 9-11). It is important to note that ISO/IEC 11801 standards refer to the HCP as a service concentration point (SCP), but for the purposes of this article, HCP is used. According to ANSI/BICSI-007, a zone cabling design consists of horizontal cables installed from the TR to an HCP that is typically housed in an enclosure located in the ceiling space, on the wall, or below an access floor. From the HCP, cabling is installed to equipment outlets (EO) [TIA] or service outlets (SO) [ISO] for connections to devices. The use of zone cabling provides a flexible infrastructure to accommodate current and future MACs for building devices.

This year's hottest infrastructure game changer is the ratification of the IEEE 802.3bt Power over Ethernet (PoE) over 4 Pairs amendment.

"While the initial cost for a zone cabling design is higher than for the traditional design because of the zone enclosure due to additional connectivity in each channel and pre-cabling between the TR and zone enclosure for future connections, savings become realized when adding more devices or performing MACs, as this can be accomplished between the zone enclosure and the device, eliminating the need to install cabling all the way back to the TR," says Bob Allan, global business development manager, Intelligent Buildings, Siemon Company. "While dependent on the exact number of MACs performed, a zone cabling design where the zone enclosure is fully pre-cabled to the TR and includes 25% spare port availability reaches its return on investment within a two to five-year span."

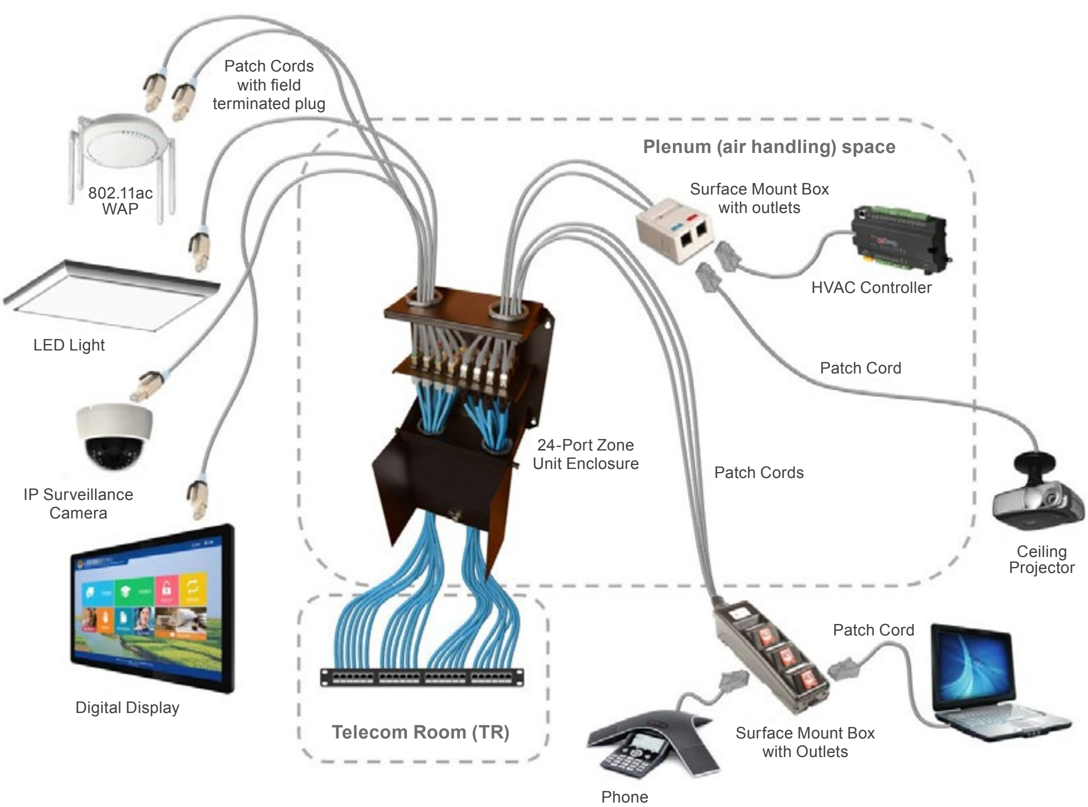

FIGURE 2: Zone cabling utilizes a horizontal connection point (HCP) and allows greater flexibility for powered devices, which are typically installed above the ceiling in plenum environments.

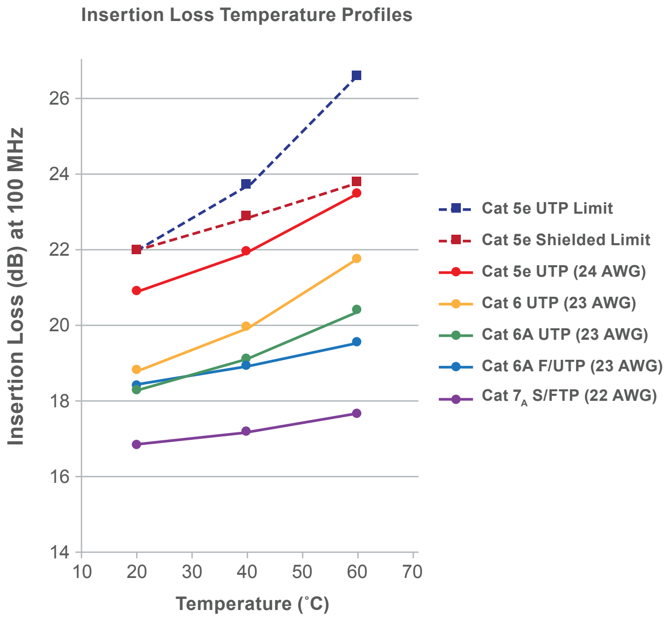

FIGURE 3: Insertion loss profiles of category cables when transmitting power.

ICT system designers should be aware of how to layout a zone cabling topology so that the zone enclosure is strategically located to service its coverage area. The size of a coverage area can vary depending on the device coverage areas and number of devices expected to be supported. However, as WAPs and other building systems may be supported by zones, the radius of the EO coverage area should not exceed 13 m (43 ft), which is equivalent to the following shape dimensions in two different layout formats:

- Square—not to exceed 18.4 m (60 ft) length or width.
- Hexagonal—not to exceed 22.5 m (75 ft) length by 19.5 m (65 ft) width.

Refer to ANSI/BICSI-007 or manufacturers' specifications to help with the layout of a zone enclosure topology.

THE HEAT IS ON

Whether the topology is centralized or decentralized, one of the main concerns, especially with running remote powering above 60 W, is heat build-up within cable bundles (see Figure 3), as well as the potential for electrical arcing damage to the connector contacts supporting remote powering applications. Although Type 3 and Type 4 PoE (60-90W from the PSE) is not significant enough to cause cables to melt or conductors to short, internal temperature rise within bundled cables increases insertion, power and efficiency losses, which may require the overall channel length to be reduced.

ICT system designers should refer to the NEC 2017, TIA-TSB-184-A and ANSI/TIA-569-D-2 for safety and design practices for best cable performance and sizing of pathways. These documents focus on defining acceptable temperature rise as it relates to the bundle size, conductor size (AWG), ambient temperature and insulation temperature ratings. In addition, these documents provide best installation practices to ensure optimal cable performance for both data and power.

NFPA 70, better known in the United States as the *National Electrical Code*, added a new section, NEC 725.144, that provides an ampacity table outlining the maximum number of cables and associated bundle sizes for remote powering applications greater than 60 W (e.g., Type 4 PoE). *NEC 2017* also identified a new classification of cable, known as Limited Power (or LP). An LP rating carries a UL-tested temperature rating of the cable properties (jacketing and conductors). Determination of the UL-rating includes powering all the conductors in a large, tightly packed bundle in conduit (insulating the ends of the conduit to prevent heat escape) and adding

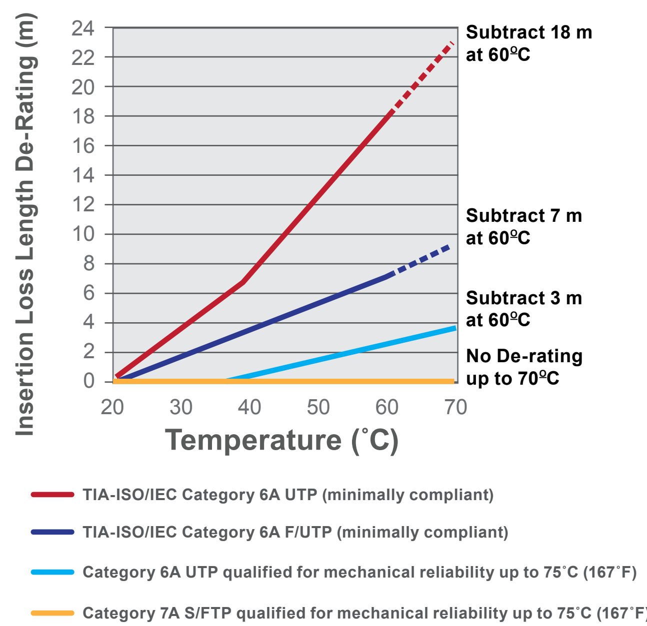

FIGURE 4: Channel length de-rating due to heat rise.

a +20°C adjustment factor over a 25°C normal ambient to the temperature results. NEC Article 725.144(B) permits the use of Class 2-LP or Class 3-LP cables with no bundle size limits. However, LP-rated cables are not required; non-LP rated Class 2 and 3 cables with 22-26 AWG sizes should follow the ampacity table for temperature ratings and bundle sizes not to exceed 192 cables.

Each standard and code might have different definitions of a cable bundle, but most of them standardize around multiple cables, contact between the cables and proximity (or distance limits) between cables. When planned properly, heat build-up and signal loss can be minimized or mitigated. Here are some of the techniques recommended by TIA:

- Derating the cable by reducing the horizontal channel length. (See Figure 4 showing that the insertion loss increases in proportion to temperature.) This requires length derating at temperatures above 40°C (68°F). Installers need to make certain that they do not exceed the channel length that matches the cable type, depending on the rise of the temperature.
- Unbundle cable in the cable tray to allow for improved heat dissipation.
- In a pathway, mix cables carrying PoE power with those only carrying data signals.

When in doubt about cable, mechanical or heat dissipation capability, installation environment, or remote powering application, a conservative practice is to limit maximum bundle size to 24 cables. This easy-to-remember practice addresses most media, environmental and application scenarios.

Since there is no easy method to monitor temperature or cool pathways, the recommended approach to minimize the risks associated with elevated temperatures is to select cabling media that is rated for operation in higher ambient temperature environments. Cables rated for operation at temperatures higher than the ISO/IEC and TIA specified upper operating temperature of 60°C (140°F) offer additional flexibility for deployment of greater than 60 W remote powering applications, and shielded cables offer much better heat dissipation over unshielded cables. For example, shielded category 6A and category 7A cables that are mechanically rated for operation up to 75°C (167°F) are ideal for support of up to 100 W (1A per pair) in bundle configurations of up to 192 cables.

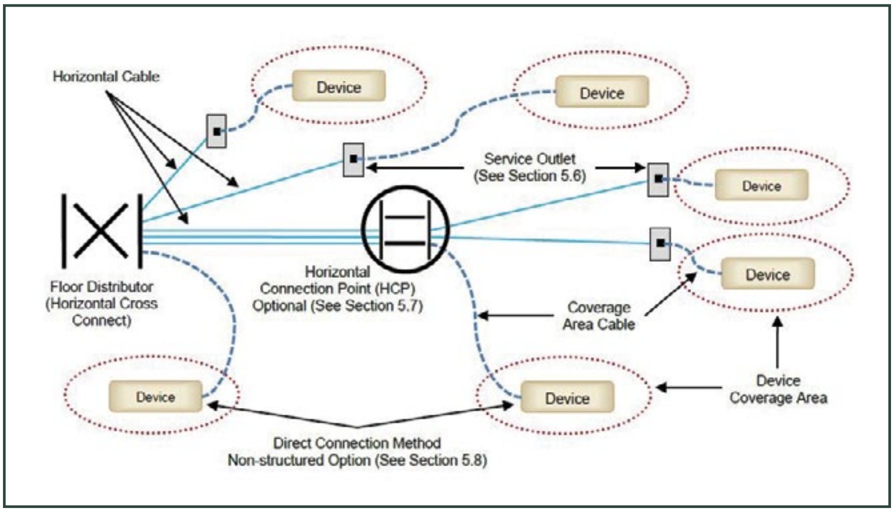

FIGURE 5: ANSI/BICSI-007: Building system horizontal cabling elements within a star topology.

FIGURE 6: A modular plug terminated link (MPTL) is a field-terminated plug for connecting directly to intelligent building devices and is recognized by TIA-568.2-D.

CONNECTING OUTSIDE THE BOX

Another consideration when installing devices in an intelligent building is the different connection configurations. The term "EO" is used by TIA to indicate an equipment outlet for facility or building applications outside the definition of telecommunications outlets (TOs) that are used to connect to computers, printers or phones.

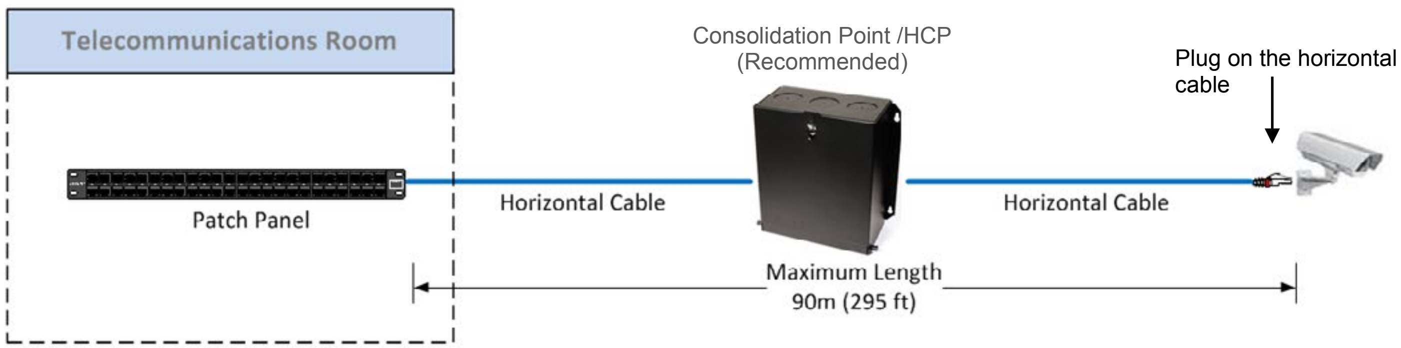

FIGURE 7: TIA-862-B recommends that a plug-ended horizontal cable link is terminated from an HCP (such as a zone enclosure) or work area outlet. ANSI/BICSI-005 and 007 standards recognize this option or as a direct connection.

When digital IP security cameras were introduced, security integrators were terminating RJ45 plugs onto the cable and connecting directly into the cameras when an outlet and patch cord was not feasible to deploy at the camera location. Today, ANSI/BICSI-005 and ANSI/BICSI-007 (see Figure 5) both refer to this as a direct connection method at the device end and is allowed in certain circumstances. Another reason for enabling this topology includes the fact that not all outlets and patch cords are plenum rated as required by code, and the use of a plug attached to a plenum-rated cable eliminates these concerns.

ANSI/TIA-568.2-D recognizes a similar method referred to as a modular plug terminated link (MPTL) that is an option for connecting devices where it is deemed impractical or unsafe to deploy a TO and equipment cord (see Figure 6). The difference between the TIA and BICSI standards is that BICSI approves a plug to be attached directly to the horizontal cabling either from the TR or the HCP as shown in Figure 7.

For TIA, the preferred horizontal cabling topology is to have a TO and a patch cord at the device end or where deemed necessary an MPTL directly from an HCP or zone box. Today, connectivity manufacturers have developed modular field-terminated plugs that are higher performing and much more durable and robust than previous RJ45 field terminated plugs. System warranties can also be extended as major equipment manufacturers have developed methods to test this configuration.

When remote powering current loads are present, it is important that critical connecting hardware contact mating surfaces are not damaged by the arc that occurs when modular plugs and outlets are unmated or disengaged. While the current level associated with this arc poses no risk to humans, arcing creates an electrical breakdown of gases in the surrounding environment that results in erosion and pitting damage on the plated contact surface at the arcing location. When the erosion

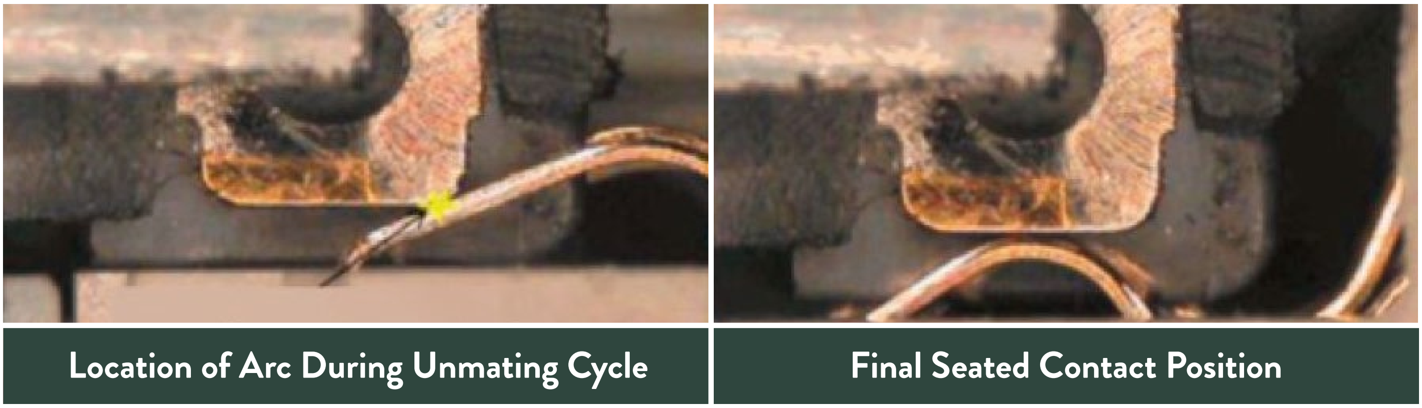

FIGURE 8: In this connecting hardware example, the location of the arc during unmating under load occurs well away from the final seated contact position on both the jack and the plug for superior PoE reliability.

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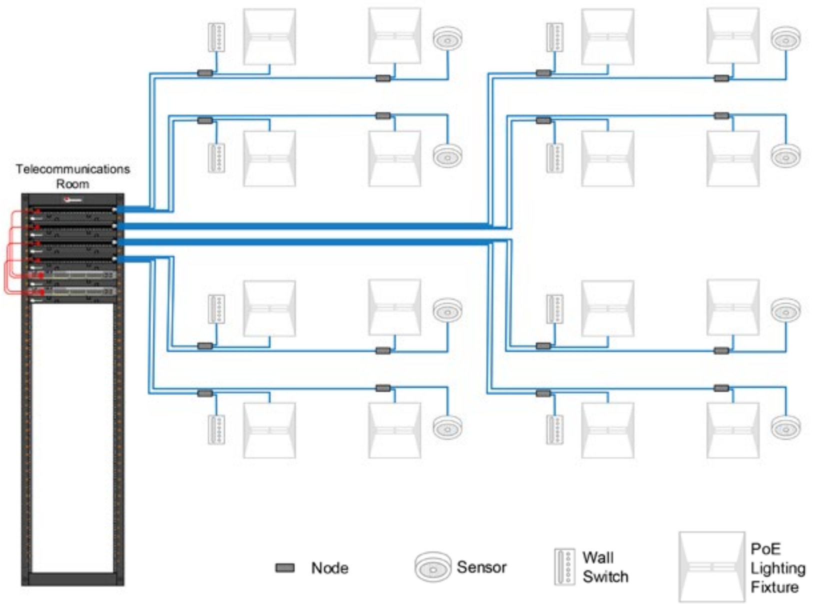

FIGURE 9: Centralized node centric architecture.

Centralized Node Centric	
Pros	**Cons**
• Can employ structured cabling • Relatively easy administration • Minimal connections • Only requires centralized power in TR • Optimizes use of PoE power • Reduces cabling from nodes to fixtures • Supports all IB applications speeds	• Limited flexibility to support MAC activity • High volume of cable • Additional connection point

TABLE 2: Pros and cons of the centralized node centric architecture.

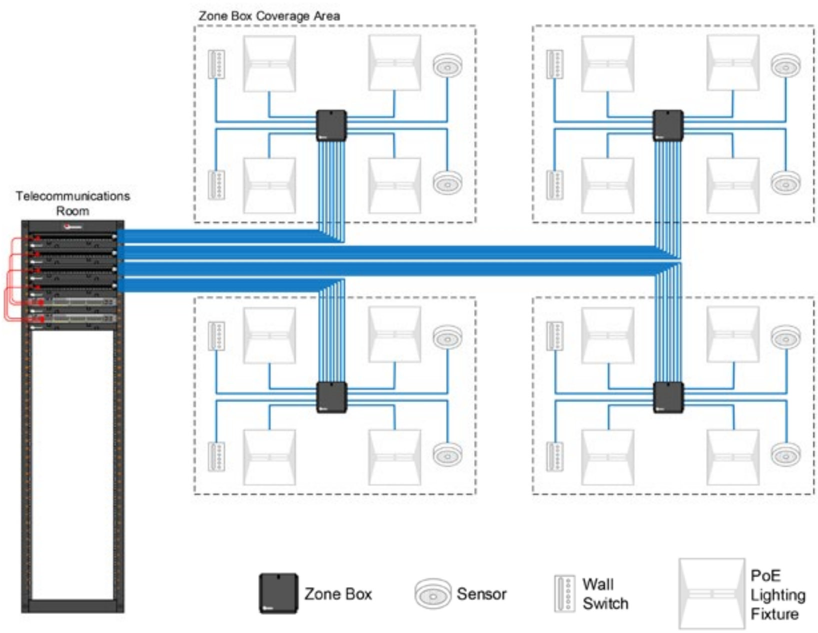

FIGURE 10: Centralized zone-fixture centric architecture.

Centralized Zone - Fixture Centric	
Pros	**Cons**
• Employs structured cabling • Easily administered • Only requires centralized power in TR • Provides support of future IB applications • Supports all IB application speeds • Optimal support of MAC activity	• High Day One cabling CAPEX • Additional connection point

TABLE 3: Pros and cons of the centralized zone-fixture centric architecture.

occurs in the area of the final seated contact position, the result can cause increased resistance resulting in everything from power delivery inefficiencies to compromised connector reliability. Some connecting hardware manufacturers have succeeded in ensuring that arc location that occurs during the unmating cycle is separate from the fully mated position (see Figure 8). Connecting hardware having the required performance for mating and unmating under the relevant levels of electrical power and load (i.e., compliant to the test schedule described in IEC 60512-99-002 for engaging and separating connectors under electrical load) should be chosen.

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The cabling topology can take several forms and can vary depending on application speeds, intelligent building applications and cost among other variables. For example, when connecting low-voltage LED lighting, the cabling can be fixture centric or node centric. In a decentralized model, a digital building switch is placed between the TR and the nodes and devices to provide the processing power closer to the end device. This works well for LED lighting, but it is limited in bandwidth so may not be suitable for WAPs or high-resolution security cameras. In addition, these digital building switches require an AC outlet. A zone cabling topology can be utilized with either a centralized or decentralized set up and offers the greatest flexibility for adding more devices later, which becomes key when installing cabling infrastructures to last into the future. There are pros and cons to each scenario (see Tables 2-4), and the system designer needs to weigh each to select the layout that best suits the environment and growing needs of the end user.

"One of the biggest challenges is for the low-voltage installer to understand these different architectures because it varies between device manufacturers, as there are no device standards like there are for the network infrastructure," states Luis Suau. "For example, looking at LED lighting, one manufacturer might use category cabling directly to the fixture with an RJ45 connection or plug, whereas others have their own unique layouts to a node, or a driver," Suau further explains. "In these layouts, they are using structured cabling to the node or driver and then delivering power and serial data through an 18/2 cable [18 AWG, two-conductor cable] that can be daisy chained to control devices, such as the lights and sensors and other fixtures," he adds. "And, most importantly, the installers will need to understand how to set up the power source equipment, the switch."

"The number of total devices powered by the node is determined by the amount of power from the port. With 60 W at the PSE we could power up to 9 devices. The node has 2 outputs for lighting and each can power three lights daisy chained via RJ45 connection for a total of six fixtures. The third output for controls can power up to three different control devices," states Wendell Strong, GENISYS PoE lighting manager. "Since 'node centric' is different from fixture centric designs, it's very important that the installer rely on the device manufacturer for help in the design and installation," he adds.

WHERE'S THE BEEF?

"When we are talking lighting, HVAC and other building applications that were previously installed by electricians, who makes the decision for the installation when PoE is involved?" asks Alan Hill, president of Tera Bridge, who has been involved in many intelligent building designs and installations. "Since we are basically a design/build integration company, we are involved up front to show end users and architects the value of integrating power and data. Showing real OPEX and CAPEX savings and

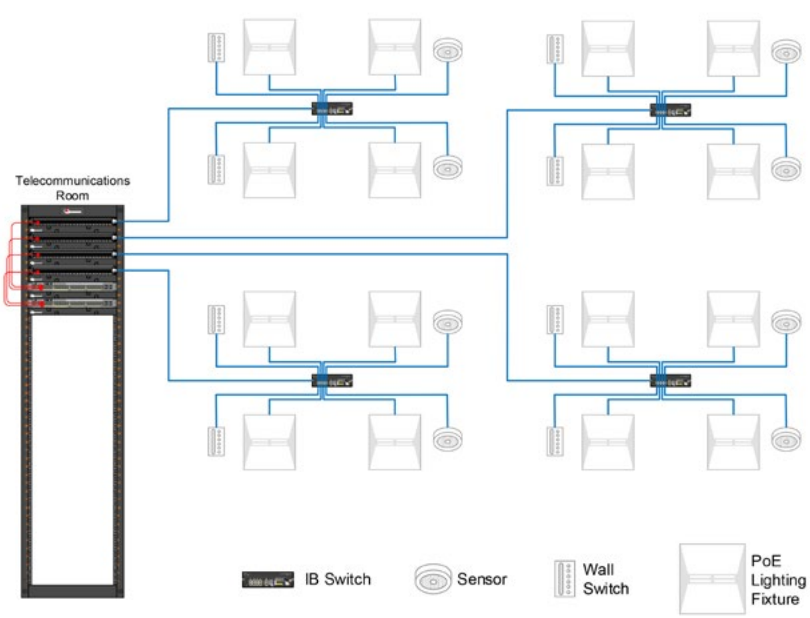

FIGURE 11: Decentralized-fixture centric architecture.

Decentralized - Fixture Centric	
Pros	**Cons**
• Reduced Day 1 cabling CAPEX • Minimal connections	• Limited to 10/100 Mb/s • Requires AC power at remote switches • Difficult to administer • Limited support of MAC activity • Limited support of future IB applications • Limited use of structured cabling • Network security access is compromised • Additional connection point

TABLE 4: Pros and cons of the decentralized-fixture centric architecture.

successes gets them over the hump, but we are still at the lower end of the 'J' curve in this process," he adds. "And, now that we can deliver 90 W per channel, this is going to open doors for low-voltage," predicts Billy Nantz, senior project manager for Tera Bridge.

"We believe high voltage will always have a place in the market, but with the emergence of IoT (category cabling) solutions, we have been working diligently to educate ourselves as well as test and integrate PoE lighting, security, and other management systems traditionally installed by the MEP (Mechanical, Electrical, Plumbing) contractors," states Shane Slater, vice president of operations with DMI Technologies. "One of our concerns is that any MEP contractor will attempt to install this new technology without the proper education and without the standards that a quality low-voltage contractor would utilize, thus creating a problematic system and giving PoE lighting a bad reputation," he explains. "There will need to be coordination between the trades to ensure a seamless installation, but ultimately it will need to meet or exceed BICSI standards including documentation, labeling and testing by a certified low-voltage contractor," he adds.

"Today it is the code that dictates this decision. It depends on the city and AHJ," notes Farukh Aslam. "My city of Fort Worth has embraced this technology and does not require electrical inspections for the low-voltage. Hopefully more companies and cities will realize these advantages because low voltage can save both energy and money," he adds.

DOTTING THE "I'S" AND CROSSING THE "T'S"

"Education will be essential for end users, architects and of course for the low-voltage installers," states Slater. "By educating them about systems monitoring, cost savings, building efficiencies and the People Factor, everyone involved will benefit from this technology. Imagine an IP-based PoE lighting system that can include a circadian rhythm playlist as well as daylight harvesting while monitoring CO_2 levels. With the right platform, these IP-based systems will be able to talk to each other and maintain an acceptable level of CO_2 and increase productivity as well as comfort. We at DMI feel that the sky is the limit for IP and PoE integration."

Now that 90 W per channel can be delivered, doors are going to open for low-voltage.

"One of the most vital steps is to engage and communicate with the infrastructure and device manufacturers as they would have a professional or specialist knowledgeable of the design and application," states Bob Allan. "Understanding that applications requirements are a baseline, it will be critical to select cabling systems that meet or exceed industry standards. And that there is no 'one size fits all' as each installation will have different systems with different requirements," Allan adds. The standards (both TIA and BICSI) state that the minimum cable for new installations is a category 6A. But, be aware of the effects on the cable and the connectivity when transmitting higher PoE with data over all four pairs.

It is imperative that a well-planned commissioning process is in place to make sure that all applications running over the network meet the specifications set by the manufacturers. For the contractor, this means understanding the testing procedures through functional network test equipment. Make sure that all systems are documented and cables labeled. Understanding PoE and the different layouts will be an ongoing exercise in education, but these new challenges will provide increasing opportunities for the ICT industry.

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