CABA™ Continental Automated Buildings Association

Power-over-Ethernet: Basics 2020

A CABA WHITE PAPER

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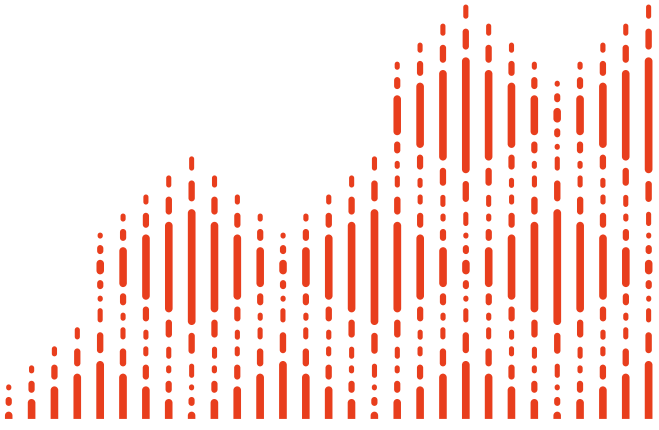

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ABOUT CABA

The Continental Automated Buildings Association (CABA) is an international not-for-profit industry association, founded in 1988, and dedicated to the advancement of intelligent home and intelligent building technologies. The organization is supported by an international membership of over 360 organizations involved in the design, manufacture, installation and retailing of products relating to “Internet of Things, M2M, home automation and intelligent buildings”. Public organizations, including utilities and government are also members. CABA's mandate includes providing its members with networking and market research opportunities. CABA also encourages the development of industry standards and protocols, and leads cross-industry initiatives. CABA's collaborative research scope evolved and expanded into the CABA Research Program, which is directed by the CABA Board of Directors. The CABA Research Program's scope includes white papers and multi-client market research in both the Intelligent Buildings and Connected Home sectors. www.caba.org

ABOUT CABA’S CONNECTED HOME COUNCIL (CHC)

Established in 2004, the CABA Connected Home Council initiates and reviews projects that relate to connected home and multiple dwelling unit technologies and applications. Connected homes intelligently access wide area network services such as television and radio programming, data and voice communications, life safety and energy management/control information and distribute them throughout the home for convenient use by consumers. The Council also examines industry opportunities that can accelerate the adoption of new technologies, consumer electronics and broadband services within the burgeoning connected home market. www.caba.org/chc

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INTRODUCTION

Ethernet was invented in 1973 to network computers. In the 1980s it gained commercial popularity and The Institute of Electrical and Electronics Engineers (IEEE) began to develop standards to address the technology. By the 1990s it became a common way to provide Local Area Networks (LANS) for personal computer connections, and installation of Ethernet cabling became popular in commercial buildings. More recently, Ethernet cables became a viable way of transmitting electrical power. This power transmission is called Power over Ethernet (PoE), where power sourcing equipment send data and power over Ethernet cables to powered devices. PoE is gaining applications with voice over Internet phones, cameras, lighting and other devices .

With the introduction of PoE, The National Electrical Code (NEC), Underwriters Laboratories (UL) and NEMA began to focus on developing safety requirements to address the technology. With these new codes and standard requirements, there are some questions arising regarding installer licensing and inspection needs. The goal of this paper is to objectively address those concerns.

WHAT IS POE

PoE is a system that uses Ethernet cable to transmit both data and power, and uses RJ-45 type connectors to unite power source equipment (PSE) to powered devices (PD):

PoE Power Source Equipment (PSE)

A PoE network switch is the most common PoE PSE device, where a PoE power supply is built in. Where a non-PoE network switch is used, a midspan PoE injector is used to add a PoE power source. Both are typically listed to UL 60950-1 or UL 62368-1 and their output is considered Class-2 by NEC, Part III, section 725.121(A)(4). IEEE standards 802.3af and 802.3at apply to PoE PSE devices. The requirements in these standards contain handshake protocols that check that attached PDs are proper PoE devices and restrict the power that they consume. Recently, IEEE published standard 802.3bt that allows higher power than the

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previous IEEE standards but is still compliant with NEC, Chapter 9, Table 11(B) Class-2 limits.

Ethernet Cables

Ethernet cable basically consists of eight insulated wires, arranged in four twisted pairs, contained within an outer sheath. Such cables are assigned a Category, such as Cat 5e, 6, 6a, and 7 that correspond to data handling capacity. Typical temperature ratings are 60°C, 75°C, and 90°C. NEC section 725.144 and Table 725.144 provide installation requirements for Ethernet cables used in PoE applications. Table 725.144 provides ampacity limits for bundles of cables based on the number of cables, wire gauge, and temperature rating. Additionally, some cables are rated "LP." That is an alternate ampacity rating, with the ampere limit marked adjacent to the "LP" designator. These cables can be used up to their ampacity rating in any size bundle. Some cables are rated for installation in spaces used to convey environmental air (e.g., ceiling plenum), denoted by a "P" designator. For PoE applications, Ethernet cables are terminated in type RJ-45 connectors.

Powered Devices (PD)

Devices intended to be powered by a PoE system include VoIP telephones, cameras, RF ID lock devices, access points for wireless LANs, and lighting. Such PDs are provided with handshake data protocols to ensure compatibility and power requirements with the PSE. They connect to the PoE system via RJ-45 receptacles and are listed using the appropriate applicable safety standards.

WHY POE

PoE is often implemented when integrating some or all building systems (e.g., Heating, Ventilation and Air Conditioning (HVAC), lighting, and security) onto an Internet Protocol (IP) network. Such integration facilitates the sharing of data between systems to support better control; for example, motion sensors from the lighting and security systems may be used to enable occupancy-driven ventilation. This integration is possible in conventional building systems architecture but is rarely done in practice due to the level complexity, one that is greatly reduced with an IP approach.

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Many building systems end devices (e.g. Variable Air Volume (VAV) boxes, luminaires, lighting system sensors, thermostats, security cameras) are available with PoE technology. PoE enables devices to receive both data and low/medium -voltage DC power supply from an Ethernet cable (rather than 120 V power from separate AC wiring). Early applications of this approach (see case studies) suggest there are cost/energy savings from: reduced electrical work, lower operational overhead, better control from shared system information, and lower labor costs.

Better control results in better indoor environment delivery; furthermore, PoE devices typically support sensors at every end point, and a denser sensor network enables more special customization of indoor environment conditions. It is also conceptually straightforward to make building data available to building occupants through mobile devices, and to enable their input to control decisions. These advantages promise to deliver behavioral and organizational productivity benefits based on occupant well-being.

SAFETY

Class-2 power limitations specified in NEC Chapter 9, Table 11(B) address risks of electrical shock and fire. Additionally, NEC Article 725 provides requirements for Class-2 wiring. These provisions, reflected in the product safety standards applicable to PSEs, Ethernet cables, and PDs assure electrical safety of a PoE system. Additionally, the applicable IEEE standards add an additional layer of protection because of the handshake protocols described earlier in the paper. To address heating concerns involved when multiple power-carrying Ethernet cables are installed in bundles, Section 725.144 was added to address cable heating. There has been some concern that NEC Article 720, Circuits and Equipment Operating at Less Than 50 Volts, might apply to PoE installations. However, section 720.2, clearly indicates that installations operating at less than 50 Volts covered by other articles, such as Articles 411 and Parts I, II and III of 725 shall not be required to comply with Article 720; basically, exempting PoE from Article 720 requirements.

INSTALLATION

Electricians, communications technicians, and Ethernet specialists all install PoE systems. In large installations in

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commercial settings, where extensive cabling networks are bundled in raceways or cable trays, or where cables are routed though spaces used to convey environmental air, installers need to follow the applicable requirements contained in the NEC. For such large installations, the competence of the installer regarding Ethernet guidelines must also be considered to ensure data integrity. For small installations, where just a few PDs are involved, installation instructions provided with the listed system components must be followed.

INSPECTION

PoE installations, including the PSEs, cabling and PDs, are likely to require inspections by the local Authority Having Jurisdiction in locations where the rules in Article 725 of the NEC are enforced.

CERTIFICATION / LICENSING

Installations of PoE systems must be done by a qualified individual in compliance with permit and licensing requirements applicable to the jurisdiction where the installation is being performed. When extensive cabling requiring bundling is installed between the PSE and PDs, ampacity requirements of the NEC must be observed. Additionally, the NEC rules in 725.135 for the installation of cables in plenums, risers and the like are applicable. For such large installations, installers must be competent regarding the applicable NEC requirements and installation guidelines for Ethernet installations. Traditional electrical contractor licensing requirements may not adequately address the special installation techniques or guidelines needed for a safe and top performing Ethernet installation. In such applications, installer certification may be appropriate. In small installations, where cables are run individually in normal environments, the need for specialized knowledge may not be required. In such situations, the installation instructions provided with the listed devices comprising the PoE system can be relied upon to ensure correct installation without any special certification of the installer. Where PDs are merely connected to an installed PoE system, no special knowledge is needed, this is very similar to connecting a computer to a LAN or plugging in a VoIP phone.

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EXISTING POE CODES & STANDARDS

The following is a non-comprehensive list of US and International standards covering PoE:

IEEE 802.3bt: IEEE Standard for Ethernet Amendment 2: Physical Layer and Management Parameters for Power over Ethernet over 4 pairs

The maximum PD power available is increased by this amendment to IEEE Std 802.3-2018 by utilizing all four pairs in the specified structured wiring plant. This represents a substantial change to the capabilities of Ethernet with standardized power. The power classification information exchanged during negotiation is extended to allow meaningful power management capability. These enhancements solve the problem of higher power and more efficient standardized PoE delivery systems.

Applications:

- Building management (connected LED lighting)
- Pan-tilt-zoom (PTZ) security cameras
- Kiosks
- Point of Sale (POS) terminals
- Thin clients
- Access points
- Small cells

IEC 60364-7-716 ED1: Low-Voltage electrical installations - Part 7-716: Requirements for special installations or locations – DC power distribution over Information Technology Cable Infrastructure

Specifies requirements in electrical installations for the distribution of ELV DC range power using balanced, information technology cables and accessories primarily designed for data transmission, as specified in terms of a Category within the reference implementations of ISO/IEC 11801-1 using power feeding equipment in accordance with IEC62368-3.

Application:

Telecommunications infrastructure for distribution of ELV DC power and systems specifically installed for distribution of ELV DC power using cables and accessories that are primarily designed for telecommunications or data transmission.

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IEC 61156-5:2009+AMD1: Amendment 1 - Multicore and symmetrical pair/quad cables for digital communications - Part 5: Symmetrical pair/quad cables with transmission characteristics up to 1,000 MHz - Horizontal floor wiring - Sectional specification

Describes horizontal floor wiring cables. Those cables are intended to be used to support the delivery of low voltage and power applications such as IEEE 802.3af PoE and IEEE 802.3at PoE+.

Applications:

Same as IEEE 802.3bt

ISO/IEC 11801: Information technology — Generic cabling for customer premises — Part 1: General requirements

This part of ISO/IEC 11801 specifies requirements that are common to the other parts of the ISO/IEC 11801 series. Cabling specified by this document supports a wide range of services including voice, data, and video that may also incorporate the supply of power.

This document specifies:

a) the fundamental structure and configuration of generic cabling requirements within the types of premises defined by the other parts of the ISO/IEC 11801 series,
b) channel transmission and environmental performance requirements,
c) link performance requirements,
d) backbone cabling reference implementations in support of the parts of the ISO/IEC 11801 series,
e) component performance requirements, referring to available International Standards for components and test methods where appropriate,
f) test procedures to verify conformance to the cabling transmission performance requirements of the ISO/IEC 11801 series.

Applications:

Analog and ISDN telephony, various data communication standards, building control systems, etc. It covers both balanced copper cabling and optical fiber cabling.

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IEC TR 62652: Effects of engaging and separating under electrical load on connector interfaces in cabling used to support IEEE 802.3af (PoE) applications

Provides information on the effects of engaging and separating under electrical load on the connector interfaces in cabling, used to support IEEE 802.3af (PoE) applications.

Applications:

Same as IEEE 802.3bt

UL 2108: Standard for Safety Low Voltage Lighting Systems

Requirements cover:

a) Power units in which output is limited to 25 A and below the risk of electric shock voltage levels as defined in 3.19; and

b) Class 2 exposed bare conductor, PoE, and other low-voltage luminaires and lighting systems.

Applications:

Low voltage lighting systems and components intended for permanent installation and for use in locations in accordance with the National Electrical Code, NFPA 70, Article 411.

UL 294B: Standard for Power Over Ethernet (PoE) Power Sources for Access Control Systems and Equipment

Provides requirements for the evaluation of PoE power sources for access control systems and equipment. PoE sources covered by this standard are not intended to be located in an outdoor environment. The PoE source shall meet the applicable requirements of the Standard for Access Control System Units, UL 294.

Applications:

All connected equipment and interconnections necessary to ensure normal operation of the PoE powered control system.

ANSI/NEMA WC 66/ICEA S-166-73: Standard for Category 6 and 6A, 100 Ohm Individually, unshielded twisted pairs, indoor cables (with or without an overall shield) for use in LAN Communication Wire Systems

Covers mechanical, electrical and flammability requirements for thermoplastic insulated and jacketed, copper conductor,

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individually unshielded twisted pairs, with or without overall shield intended for use as horizontal cables, backbone cables, or in the manufacture of patch cords. Depending upon the application and system requirements, this standard provides choices for materials and flammability ratings.

The standard also covers the minimum performance requirements for cables up to four pairs, with transmission characteristics specified up to 250 MHz for Category 6 cables and up to 500 MHz for Category 6A cables.

Applications:
These Category cables are intended for voice, text, data, video, and image transmission and low voltage power supply (PoE & PoE+). The cables are categorized by electrical transmission characteristics based on existing system requirements and projected application needs determined by IEEE 802.3.

Category cables intended for voice, text, data, video, and image transmission and low voltage power supply (PoE & PoE+). The cables are categorized by electrical transmission characteristics based on existing system requirements and projected application needs determined by IEEE 802.3.

TIA TSB-184-A Guidelines for Supporting Power Delivery Over Balanced Twisted-Pair Cabling

These guidelines cover the transmission and electrical parameters needed to support power over category 5e or higher performance twisted-pair cabling. Different cable categories, cable types, installation and operating conditions including pathways and bundling are covered. The document provides design, installation, and administration guidelines for effective deployment of remote powering over balanced twisted pair cabling. This TSB provides additional guidelines with respect to:

a) parameters needed for remote powering;
b) different installation conditions that require special considerations;
c) application considerations;
d) mitigation considerations; and
e) cabling configurations and related field test considerations

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The cabling systems detailed in these guidelines are designed to support Separated Extra-Low Voltage (SELV) LPS power, as defined in IEC 161 60950-1. Safety and electromagnetic compatibility (EMC) requirements are outside the scope of this standard.

Applications:
Same as IEEE 802.3bt

ANSI/TIA 568 Balanced Twisted-Pair Cabling Telecommunications Cabling and Components Standard

This standard specifies minimum requirements for balanced twisted-pair telecommunications cabling (channels and permanent links) and components (cable, connectors, connecting hardware, cords, and jumpers) that are used up to and including the telecommunications outlet/connector and between buildings in a campus environment. This standard also specifies measurement procedures for all transmission parameters.

Applications:
Same as IEEE 802.3bt

EN IEC 60512-99-002 Connectors for electrical and electronic equipment - Tests and measurements - Part 99-002: Endurance test schedules – Test 99b: Test schedule for unmating under electrical load

This part of IEC 60512 is used for testing connectors within the scope of SC 48B that are used in twisted pair communication cabling with remote power, such as ISO/IEC 11801 Class D (or better), balanced cabling in support of IEEE Std 802.3bt, (PoE+).

The object of this document is to detail a test schedule to determine the ability of pairs of connectors to withstand a sequence of tests with a total of 100 engagements and separations. The electrical current is passed through the connectors during the separation (unmating) step only, in accordance with IEC 60512-9-3.

Applications:
Same as IEEE 802.3bt

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UL 62368-1 Audio/video, information and communication technology equipment – Part 1: Safety requirements

This standard is applicable to the safety of electrical and electronic equipment within the field of audio, video, information and communication technology, and business and office machines with a rated voltage not exceeding 600 V. This standard is applicable to PSE and PD equipment.

Applications:
Same as IEEE 802.3bt

UL 13 Power-Limited Circuit Cables

Covers the safety listing of Power Limited Cables used for Ethernet applications such as CL2 (general use), CL2R (riser cable) and CL2P (plenum cable)

Applications:
Same as IEEE 802.3bt

UL 444 Communications Cables

Covers the safety listing of Communications Cables used for Ethernet applications such as CM (general use), CMR (riser cable) and CMP (plenum cable)

Applications:
Same as IEEE 802.3bt

GAPS AND RECOMMENDATIONS

The following is a non-comprehensive list of gaps and recommendations for PoE standards:

1. A strategy to leverage industry expertise to affect the development of device/product standards is lacking.
2. The newly published IEEE 802.3bt standard will enable delivery of 90 W over four pairs of Cat5e cables and above. This standard pushes the PoE levels for the existing cabling and connectors deployed in today's infrastructures.
3. The Wire and Cable community must address the safety issues for fire and shock hazard imposed by the new

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requirements in IEEE 802.3bt for higher power and data speeds.
4. Need a paper/standard to address using non-shielded and shielded conductors.
5. Need a white paper to address pain points and best practices in PoE wire and cable.
6. Need an industry standard for safe practices for PoE installations. The standards will address safe use of simple PoE applications and applications that approach 100 watts. The intent of the standard will be to provide guidance to the electrical safety community and the data community on how to address the safety issues of when using increased power over PoE.

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