

PoE (Power over Ethernet)

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Introduction

Power over Ethernet (PoE) is the technology that enables data transmission along with electrical power over a four-pair twisted pair (UTP) network cable (LAN), by providing power and data simultaneously to remote devices. This application has significantly altered cabling infrastructure networks, as it provides considerable reduction in installation costs.

With the increasing popularity of Ethernet, new types of devices are being over-connected to the structured cabling network: high-definition security cameras, IP phones, RFID (*Radio Frequency Identification*), readers, wireless access points, sensors, access controls, LED lighting and more.

These devices have an increasingly high power requirement, which has required continued development of PoE standards by IEEE working groups.

When it began, in 2003, there was only the IEEE 802.3af standard, which used 2 pairs for a power of 15.4W output with 350 mA current per pair. Further on, it was developed PoE+, which delivers 30W in 2 pairs with a current of 600mA per pair. Today, PoE is already in its 802.3bt 4PPoE standard, which provides a maximum output power of 99.9W using the 4 pairs with a 1000mA current by pair.

It is important to remember that all the levels of PoE existing to date comply with the SELV (*Safety Extra Low Voltage*) classification, ie, 60 Volts / 100 Watts per IEC 60950-1. This makes PoE a very secure technology for power and data delivery via twisted-pair cables for LAN.

Attention points

The use of PoE technology in network cables, and consequent power transmission, made it necessary to evaluate the heating of conductors. The rise in temperature of the network cable conductors directly influences the attenuation parameter, which can jeopardize the network performance by creating bit errors. In extreme cases, it may even cause a total interruption in data transmission.

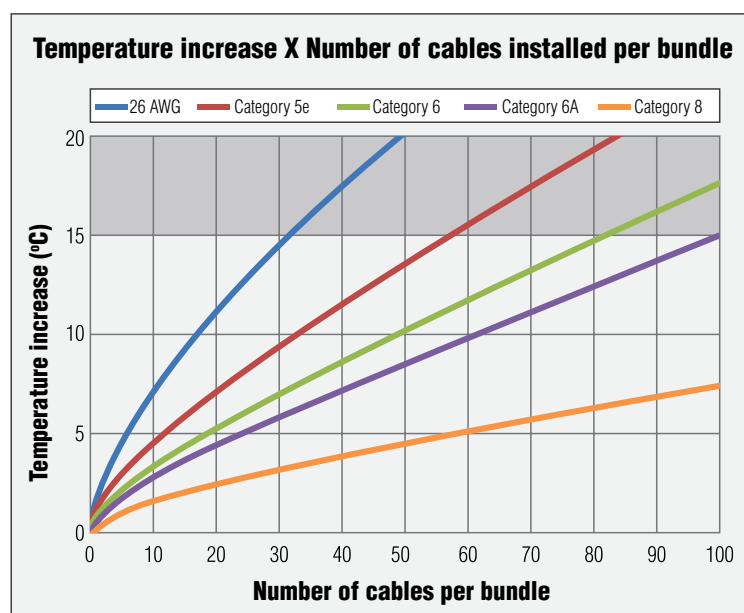
Therefore, when designing applications using PoE, great care must be taken in the proper choice of cable to optimize the structured cabling system. In certain situations, it is necessary to impose some limitations. The smaller the conductor gauge of the cable used, the more critical this heating x bit error condition becomes. It is important to note that the main concern about heating in the cables when using PoE comes from bundling.

On the other hand, there is also a concern with connectors. When a plug is removed from a working PoE connector, an electrical arc forms that can damage both the plug and connector contacts and cause data transmission problems. The validation of these components for PoE application is done through the IEC 60512-9-3 and IEC 60512-99-001 standards.

In summary, it is always necessary to consider 4 factors when sizing a network for PoE use:

- Current and number of energized pairs in the cable;
- Conductor Gauge (AWG);
- Cable bundle number;
- Electrical arc in the connectors (Female Connector and Patch Cord).

The graph below, according to TIA Bulletin TSB-184A, illustrates the temperature increase for different cable categories as a function of the number of cables per bundle, considering current of 1000 mA per pair (or 0.5 A per conductor). You can basically see the great influence of the gauge of the conductor when the temperature rises due to the current flow.



The U.S. National Electrical Code (2017 NEC®) contains the table (*Section 725.144*) of ampacity or maximum current for network cables, which is a useful reference in the sizing of network cables for PoE application (below).

AWG	Number of cables in bundle																				
	1			2 - 7			8 - 19			20 - 37			38 - 61			62 - 91			92 - 192		
	Temperature Class (°C)			Temperature Class (°C)			Temperature Class (°C)			Temperature Class (°C)			Temperature Class (°C)			Temperature Class (°C)					
	60°	75°	90°	60°	75°	90°	60°	75°	90°	60°	75°	90°	60°	75°	90°	60°	75°	90°	60°	75°	90°
26	1.0	1.0	1.0	1.0	1.0	1.0	0.7	0.8	1.0	0.5	0.6	0.7	0.4	0.5	0.6	0.4	0.5	0.6	NA	NA	NA
24	2.0	2.0	2.0	1.0	1.4	1.6	0.8	1.0	1.1	0.6	0.7	0.9	0.5	0.6	0.7	0.4	0.5	0.6	0.3	0.4	0.5
23	2.5	2.5	2.5	1.2	1.5	1.7	0.8	1.1	1.2	0.6	0.8	0.9	0.5	0.7	0.8	0.5	0.7	0.8	0.4	0.5	0.6
22	3.0	3.0	3.0	1.4	1.8	2.1	1.0	1.2	1.4	0.7	0.9	1.1	0.6	0.8	0.9	0.6	0.8	0.9	0.5	0.6	0.7

The Table identifies the ampacity of each conductor on a Class 2 or Class 3 4-pair network cable. The ambient temperature used for the development of this table is 30°C with all conductors transmitting electrical current in all cables. The Table shows results in 3 different temperature ranges: 60°C, 75°C and 90°C.

The data in the table considers bundled cables as described in *UL 444 CRD – Standard for Safety Communications Cables; New LP ratings – Cable Heating Test*. It is a test methodology for evaluating cable heating when bundled as an option to the NEC table to determine the amperage that the conductor in the cable can support and consequently an LP (limited power) for the network cables.

Thus, the table provides guidance in the process of choosing the appropriate network cable to power PoE devices. Indicates the maximum current (in Ampere) for each network cable conductor (4 pairs), for different temperature classes and cable bundles provided in an installation. It is observed that the scenario of 92 to 192 cables per bundle constitutes the worst-case scenario. Installation conditions greater than 192 cables require determination by specialized professionals.

PoE STANDARDS x NETWORK CABLING CATEGORIES

The following table correlates the PoE types and the maximum cable bundle size, resulting from the temperature increase analysis for the various network cable categories. The goal is to ensure the performance of data transmission.

The power loss in the network cable channel should be evaluated accordingly to the DC loop resistance of the channel at the maximum operating temperature in order to ensure the minimum power required for the PD (Powered Device).

PoE TYPE & NETWORK CABLE CATEGORY				STANDARD	IEEE 802.3af	IEEE 802.3at	IEEE 802.3bt		HDBaseT
				PoE / Type Denomination	PoE	PoE+	PoE++	4PPoE	PoH
					Type 1	Type 2	Type 3	Type 4	N/A
				Maximum Current per pair (mA)	350	600	600	960	1000
				Number of energized pairs	2	2	4	4	4
				PSE power supply (power sourcing equipment)	15.4W	30W	60W	90W	100W
				Minimum power in the PD (powered device) ⁽¹⁾	13W	25.5W	51W	71W	100W
Type of practical applications	Biometric Access Router 802.n	IP phone Alarm system Cameras, LED lighting...	Access Control AP 802.11ac, Cameras, Laptop, LED Lighting...	Desktop, Videoconferencing TVs, 802.11ax, LED lighting...	HDBASE-T PoH Devices				
CATEGORY	Nominal Conductor (AWG)	Freq., MHz	Ethernet Application	CABLE HEATING TEST - Number of cables per bundle ⁽²⁾ In accordance with UL 444 LP Test					
CAT.5e MultiLan U/UTP 24AWG (CM, CMR, LSZH, Euroclass Dca)	24	100	100BASE-TX (100Mbps)	PoE application approved without specific restriction⁽⁵⁾	192⁽⁴⁾	96⁽³⁾	96⁽²⁾		
CAT.5e MultiLan F/UTP 24AWG (CM, CMR, LSZH, Euroclass Dca)	24	100	100BASE-TX (100Mbps)		192⁽³⁾	128⁽²⁾	128⁽²⁾		
CAT.6 GigaLan U/UTP 23AWG (CM, CMR, LSZH, Euroclass Dca and B2ca)	23	250	1000BASE-T (1Gbps)		192⁽³⁾	128⁽²⁾	128⁽²⁾		
CAT.6 GigaLan F/UTP 23AWG (CM, CMR, LSZH, Euroclass Dca and B2ca)	23	250	1000BASE-T (1Gbps)		192⁽³⁾	192⁽²⁾	192⁽²⁾		
CAT.6A GigaLan Augmented F/UTP 23AWG (CMR, LSZH, Euroclass Dca and B2ca)	23	500	10GBASE-T (10Gbps)		192⁽³⁾	192⁽²⁾	192⁽²⁾		

Note:

- (1) The power loss in the channel containing the bundled network cable should be assessed according to for the DC loop resistance of the channel at operating temperature to ensure the minimum power required in the PD.
- (2) A maximum of a bundle of 96 cables is recommended for easy cable management in the installation;
- (3) Approved LP 0.5A considering a bundle of 192 cables according to UL 444 and 75°C thermal class. In case of failure, it is tested considering a bundle of 128 cables or 96 cables;
- (4) LP 0.3A approved considering a 192-cable bundle to UL 444 and 75°C thermal class;
- (5) Approved without restrictions for cable heating in the application current to Type 1 and Type 2.

Furukawa Recommendation

Furukawa recommends that all new structured cabling installations be evaluated and designed to meet current and future technologies. From the point of view of PoE, the ideal is that the category of cable most suitable for the application in use to be chosen for the project, always evaluating the level of PoE required, predicting the temperature increase in the cable in order to ensure the performance of data transmission and the delivery of the minimum power required for the device. F/UTP (shielded) GigaLan Augmented CAT 6A cables, in addition to supporting the various types of PoE in the highest and most rigorous limits of cables in bundles, also operates high transmission rates for applications up to 10GBASE-T and HDBaseT.

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