#smartconnection

White paper

PoE technology

Part 3 - Impacts on cables and connectors

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Introduction

PoE technology is used to simultaneously transmit power and data using an Ethernet cable. Standardised for almost 20 years, it has developed in commercial buildings thanks to IP convergence.Today, in companies the majority of telephone sets, Wifi access points and video surveillance cameras use this technology. This plebiscite can be explained by the simplicity of implementation and the economic aspect of such an infrastructure: a single cable for data and energy.

A first white paper introduced you to the main characteristics of PoE technology and normative bases.

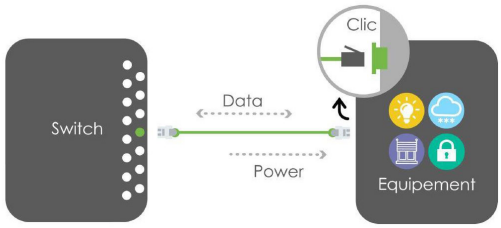
This second paper presented the penetration of this technology by application and geographic area.

This third white paper describes the impact of PoE on cables and connectors, but also on implementation procedures to ensure the sustainability of installations, the safety of people and transmission performance.

PoE technology

PoE technology is used to power remotely connected devices and simultaneously transmit data using an Ethernet cable consisting of 4 pairs of twisted copper wires.

Power over Ethernet cable allows up to 100W of power to be injected to a remotely connected device (max 100m). PoE technology allows data to be transmitted simultaneously at a rate of 100Mbps, which can be increased to 10Gbps depending on the type of Ethernet cable used and the router/switch used.



The principle of PoE power supply is based on the use of twisted copper pairs of the data cable to power from the source called Power Sourcing Equipment, the remote equipment called Power Device. The IEEE 802.3 standard sets the maximum distance of the Ethernet cable at 100 meters to take into account losses induced by the resistivity of the cable.

In-building PoE applications

Against the backdrop of tighter environmental regulation, particularly in terms of energy consumption, manufacturers are seeking to diversify by offering more services to their customers to reduce their environmental footprint (cf. green building) and enhance the safety of buildings. We talk about Smart Building or Smart Home.

In this context, PoE technology is very well placed to meet all these needs. Indeed, to develop these services,it is necessary to connect an increasing number of equipments and objects that require supervision and maintenance. The phrases Building Management System (BMS) and Centralised Technical Management

(CTM) are used to describe the management of this building, which is becoming a real telecom network. The issues are complex and similar to those of information systems (scalability, safety, interoperability): the use of structured cabling based on 4-pair Ethernet cable and the evolution of BMS/CTM applications towards IP now allow centralised management of all building applications.

The main uses are :

- Energy savings: water and energy management with smart metering
- Safety: 24/7 building supervision (video surveillance, alarm settings), fire and intrusions detection, elevators management
- Comfort: management of the lights, heating and air conditioning, predictive and preventive maintenance of the building
- Efficiency: management of indoor mobile coverage, meeting rooms, digital signage and parking spaces

Heating

What are the Aginode solutions to reduce impacts ?

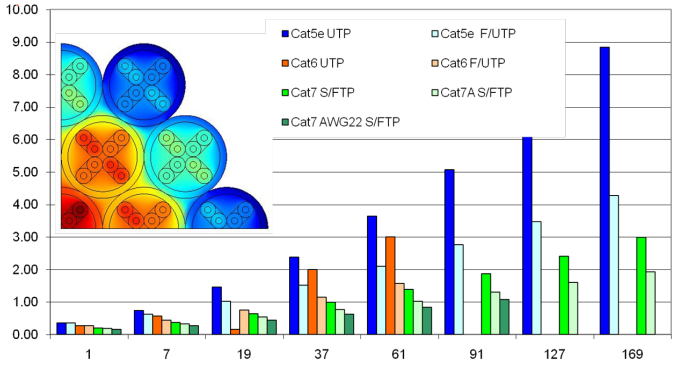
Heat affects data transmission. The basic parameters for data transmission are set at 20°C in the standards. However, with an isolated cable or a few cables in a bundle, the temperature rises due to PoE. The problem becomes more complicated when there are many cables.

Data cables have a low voltage level of a few volts. PoE is a technology that allows data and power to be transmitted in a single cable (maximum 90W). This avoids excess cable, but there may be Joule effect loss that must be dissipated.

Aginode has modelled the heating in different configurations. This modelling has been used by the IEEE and ISO to define new performance limits and installation rules. Aginode received a certificate of appreciation from the IEEE for all this work and contribution.

Temperature increase depending on the category

PoE+ (2 pairs energized - 0.35A per wire)



Nb of cables in the bundle

Building cabling solutions are structured in a multi-level star configuration. The international standards ISO/IEC 11801 clearly define these configurations.

The star configuration allows for flexibility of use and reconfiguration. Each end device is connected directly to a central device (switch for networks) via its distribution cable. Depending on the size of the installation, the floor distribution frames (FD) concentrate a large number of cables (several hundred cables per 19» rack). When all the cables are fed in, the temperature in the core of the cables and bundles can quickly rise.

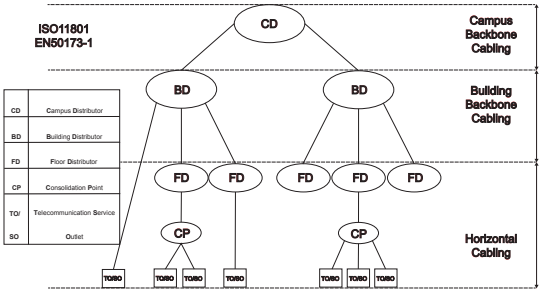
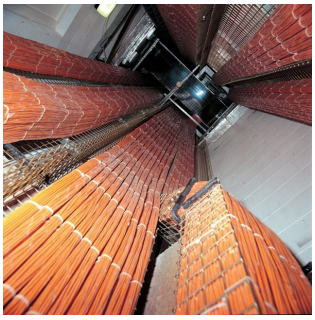
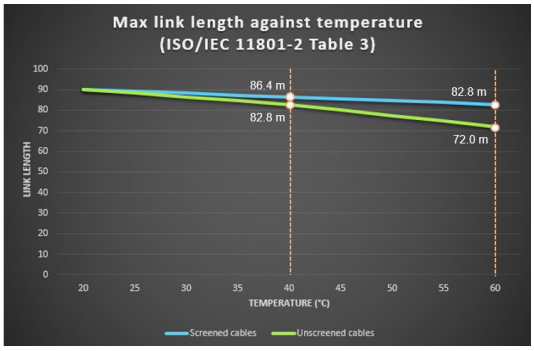


Illustration of cable expansion in installations with technical ducts. This expansion illustrates the problem of overheating



Standardisation committees and industry have modelled and then defined equations for calculating the maximum permissible lengths as a function of temperature for data transmission. According to the standard, the maximum horizontal cable length should be reduced by 0.2% per degree up to 60°C for screened cables and by 0.4% per degree up to 40°C + 0.6% between 40°C and 60°C for non-screened cables. The graph clearly shows that screened cables should be recommended.



Source: Aginode

Impact on cables

Cables and installations will have to be designed to withstand these new heating constraints.

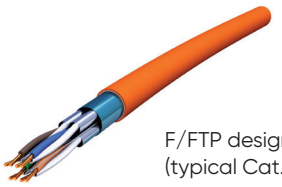
Heat dissipation in cables is achieved by:

The copper conductor: copper cables have evolved significantly from category 5 (100Mbit/s transmission) to category 8 (2Gbit/s transmission). The exponential increase in data rates requires a reduction in attenuation, managed by the assembly of 4 pairs but also by an increase in the conductor cross-section.

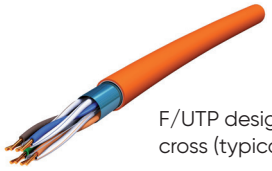
Category 5 is often made with 0.51mm AWG24 conductors; category 6A is often made with 0.58mm AWG23 conductors; some category 7A cables are made with AWG22 (0.65mm conductors. The latest generation of cables are very efficient in terms of attenuation and heat dissipation.

The shielding elements (aluminium screen and/or copper braid) dissipate the heat over the entire length of the cable, especially the copper braid.

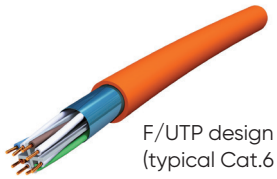
Geometry: increasing the diameter of the cable creates additional air spaces which also contribute to the dissipation effect.



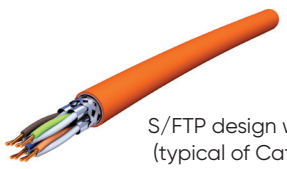
F/FTP design
(typical Cat.6A cable)



F/UTP design without inner cross (typical Cat.5 cable)



F/UTP design inner cross
(typical Cat.6 & Cat.6A cable)



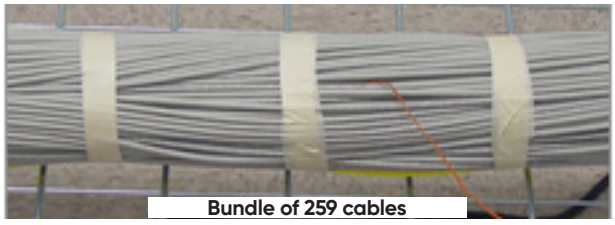
S/FTP design with braided shielding
(typical of Cat.7A cable)

International data cable standards require copper as the conductor material. Some unscrupulous suppliers put on the market cables with aluminium, copper/aluminium alloy and sometimes steel conductors. The consequences are out-of-range attenuation levels, degradation of insulation and sheathing materials. These non-compliant cables present real safety risks for goods and people.

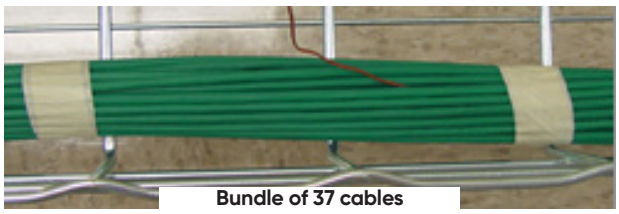
Characteristics of different cable structures:

- Dissipation is better as the grade increases and the conductor diameter increases (the gauge is expressed in AWG).
- Aluminium screens used to improve transmission performance and electromagnetic immunity act as a «radiator» and improve heat dissipation (e.g. F/FTP better than F/UTP)
- F/UTP structures exist in 2 versions
  Category 6: the inner cross ensures optimal cable symmetry which is necessary to maintain transmission performance.
  Category 5: the inner cross is not necessary for transmission performance.
  This cross allows symmetry control and creates some air spaces which also improve thermal dissipation.

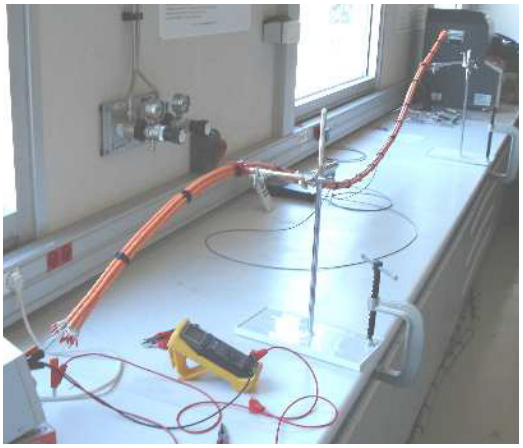
Tests were carried out in different installation configurations and bundles sizes and confirmed several hypotheses.



Bundle of 259 cables



Bundle of 37 cables



A current of standardized intensity and voltage is injected into all the pairs that are looped. A temperature sensor is placed in the centre of the bundle to measure the temperature rise in different configurations: bundles with different numbers of cables, plastic conduits or covered or open cable trays. These configurations are intended to recreate real installation configurations.

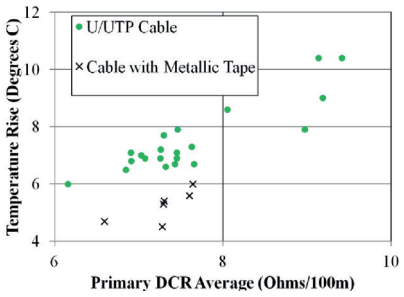
Temperature Rise of Category 5e 80-Cable Bundle Place in Different Installations and Energized with 1000mA

Installation	Resistance	Modeled Temp. Rise	Measured Temp. Rise
	Ω/100m	°C	°C
In Tray	9.0	14.5	16.1
In PVC Conduit	9.0	19.7	19.9
In Metal Conduit	9.0	24.4	23.8

Source: «Temperature Rise of Category 5e 80-Cable Bundle Place in Different Installations and Energized with 1000mA» by Aginode

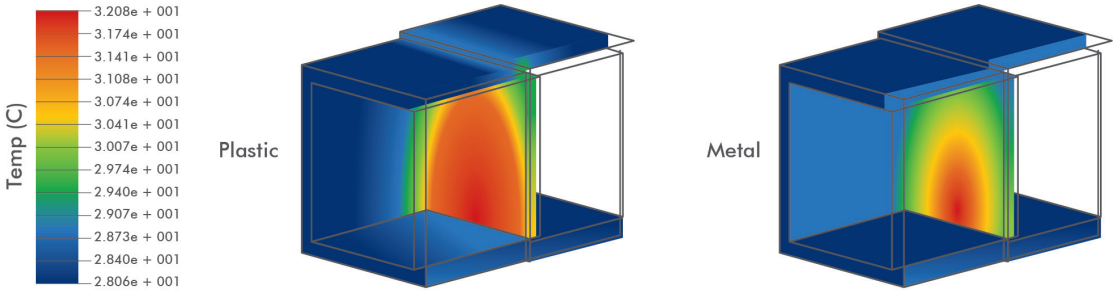
The test results led to the development of new installation recommendations, which are included in the EN and ISO installation standards.

These measurements confirm that the metallic layers will improve heat dissipation. These shielded cables have similar resistance values to unshielded cables and therefore similar heat generation, but they better dissipate heat and therefore have lower temperature increase.



Impact on connectivity

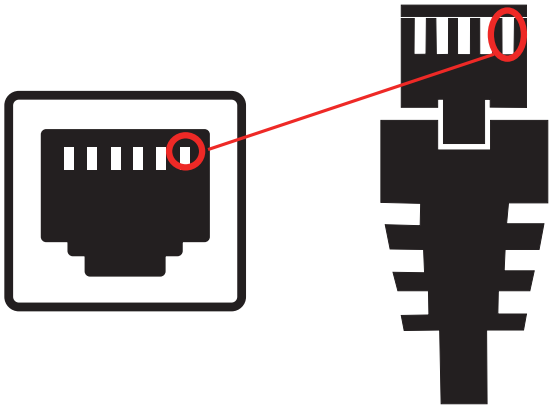
Connectors also dissipate heat, indeed many tests have been carried out to re-model the behaviour of connectors according to their design with or without shielding.

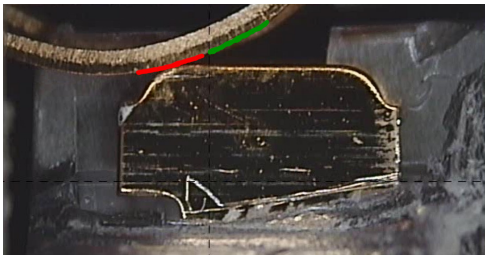


Thermal simulation of connector bodies using plastic and zinc

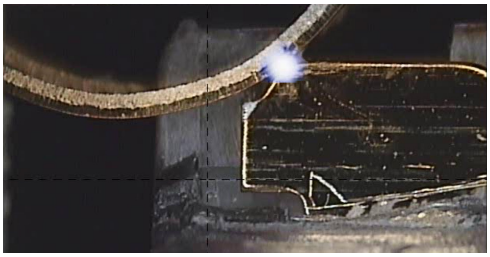
Overheating is not the main issue with the connector. Connecting and disconnecting the connector in the socket when the circuit is supplied with POE generates arcing, localised on small contact areas. The consequence is a degradation of the contact protection (protection made with a gold layer). Once the protective layer is corroded, the contact quality is weakened and the effects of corrosion amplify this degradation. The result of this corrosion is an increase in attenuation or even a total loss of connection.

Connecting and disconnecting connectors on load (RJ45)



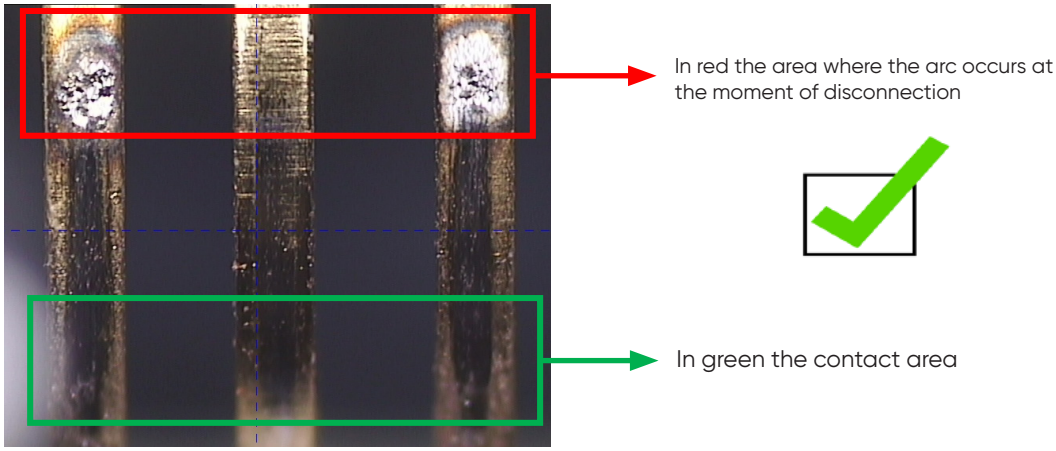


Connection
In green friction area
In red permanent contact area



Disconnection
Area where arcing occurs at the time of disconnection

Tests carried out according to IEC 60512-9-3 Ed. 2 et IEC 60512-99-002:



When the protective layer is weak and the contact area fragile, degradation is more rapid.

To deal with this problem of loss of connection or increased attenuation due to arcing, the best connectors on the market have advanced designs to separate the contact area from the disconnection area; the gold layers are also thicker.

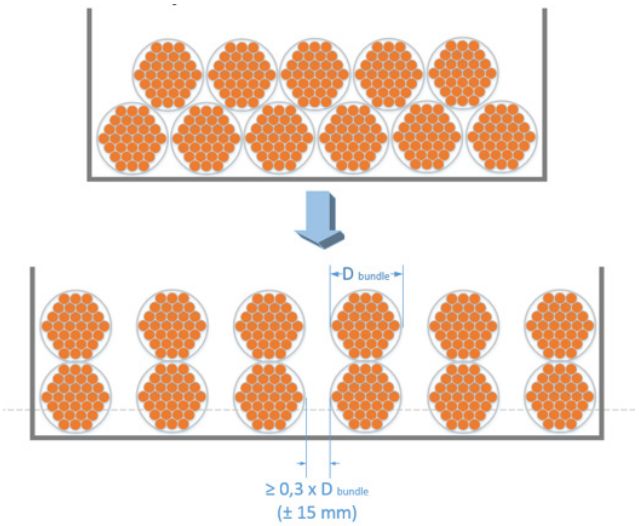
The standards that define connectors are evolving and now include specific tests. This is the case for IEC 60512-9-3 Ed 2.0 (Test 9c: Mechanical operation (engaging and separating) with electrical load) and IEC 60512-99-002 Ed 1.0 (Pre-Release Version December 2018) (Test 99b: Test schedule for engaging and separating connectors under electrical load).

Impact on implementation

The implementation defined installation standards (IS0/IEC 14763-2 & EN 50174-2:2018) have also evolved to take into account the heating related to POE.

In summary, these standards specify some simple rules:

- Applicable to bundles longer than 1m
- Bundles of maximum 24 cables (generic recommendation not related to PoE)
- Rows separated by vertical stacks
- Separation of 0.3x strand diameter (+/- 15 mm) which allows convection cooling



Separation of cable bundles to minimise heating

Groups of cables bundles subject to remote powering produce higher temperature rises as embedded bundles are unventilated.To minimise the heating wuthin groups of bundles of LAN copper cable, the cable bundles should be separated by vertical 'chimneys' allowing each bundle to cool by convection.

Conclusion

POE technology is becoming increasingly popular, with growth rates of around 20% (between 2018 and 2025). All sectors (commercial and industrial buildings, hotels, hospitals, etc.) are concerned. The widespread use of IP-based applications means that POE can now be used for almost all building applications (from IP telephony to video surveillance, from LED lighting to indoor mobile coverage).

This technology brings additional constraints on cables, connectors and the overall installation, which intelligent building designers, operators and installers must master.

Aginode has developed real expertise in this area over many years and regularly contributes to the development of standards in Europe and the United States. Our product ranges are among the most efficient on the market and allow a wider range of use, ensuring the durability of installations and investments.

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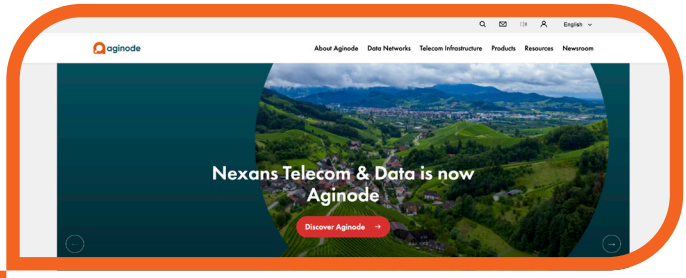

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