NEW GENERATION OF ELECTRICAL INSTALLATIONS
REMOTE POWERING: "POWER OVER ETHERNET"

Technical Reference Book

EuropeOn
ELECTRICAL CONTRACTORS ASSOCIATION

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Introduction to Power over Ethernet

Reducing global consumption, improving energy efficiency, exploring the universe of data, managing devices are a necessity for all types of buildings or infrastructure. The transition from traditional installations to Power over Ethernet has started in all European countries. With PoE, installers can better meet their clients' need and demand for efficient, connected and "next generation" buildings. European electrical contractors must adapt NOW. This technical reference guide is a common standard for all European electrical installers and may also be useful for designers, architects and controllers.

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1. Why PoE?

Remote Powering or "Power Over Ethernet" (PoE) is a technology that transfers Safety Extra Low Voltage (SELV) current over an Ethernet cable while transmitting and receiving digital data. PoE allows to deliver power and digital data from a DC source to terminal equipment. This way, installations can be supplied and managed while being powered via an Ethernet network.

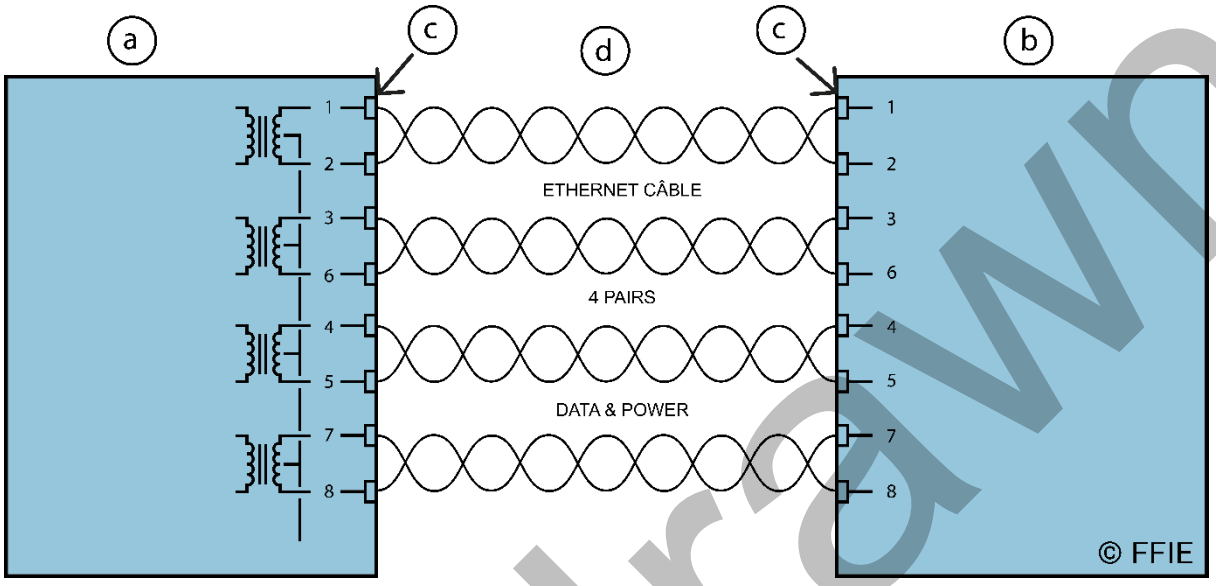

Figure 1: how a PoE installation works

a. PSE
b. PoE receiver or PoE module
c. RJ45
d. 4-pair ethernet cable

1.1 PoE applications

There is a wide variety of PoE applications, from lighting, video-surveillance over IP, voice over IP, sensor management, access control, the power of IT equipment (directly from the RJ45 sockets without AC / DC power supply), printers, wireless access points, payment terminals, fan coils, DECT telephony, meters, solenoid valves, HVAC control, automatic gates, TV screens (single-cable TV), clocks, networking modules, motorized shutters or blinds, displays, cameras, etc. PoE also allows diversifying applications related to outdoor installations such as lighting for facades, parks and gardens, or swimming pools. It is also particularly suitable for renovation projects.

With the evolution of transmission of data, PoE is useful to support the increase in the flow of data. For instance, PoE is a technological answer to the uptake of fiber optic networks.

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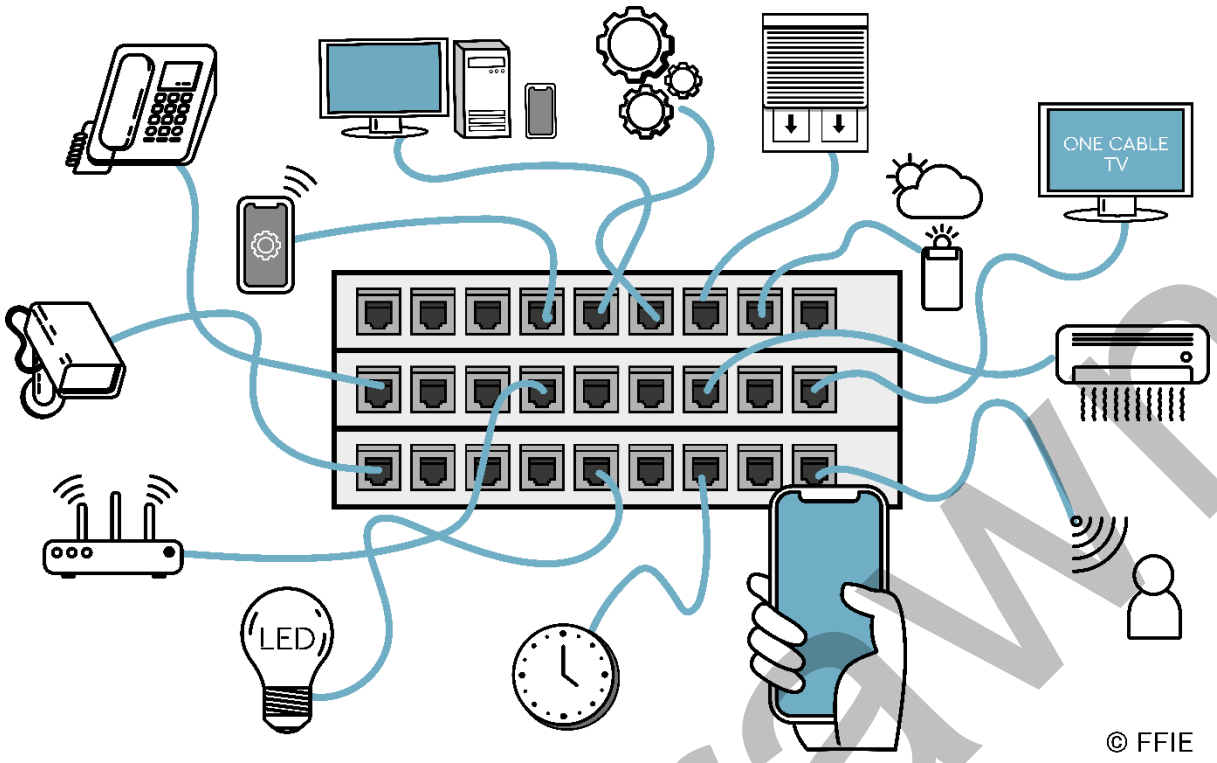

Figure 2: examples of PoE applications

1.2 PoE key numbers

A worldwide growing technology

Globally, demand for PoE is growing. For example, total worldwide sales of PoE hardware soared from 511 million US $ in 2013 to almost 962 million US $ in 2018.

Moving towards an IoT world

PoE growth can be compared with the growth of connected devices. PoE interoperability allows fast deployment of connected objects in buildings as well as the exploitation of their functionalities.

PoE can help installers diversify their activities

PoE is a reliable technology that is available to all installation professionals dealing with energy management, optimization of energy generated from DC renewable power sources, and technical building management. This technology is also essential for the diversification of installer-integrator activities, particularly when related to data collection and management. Big data generation and the ability to manage a building remotely means that facility management (FM) professionals are also deeply impacted by PoE.

For example, 20,000 m² of offices with a PoE installation (lighting, sensors, blinds, HVAC control, ...) is equivalent to collecting 75 Gigabytes of data daily.

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1.3 Key principles for a PoE installation

A new generation of Power over Ethernet (PoE) installation is used to power and control all or part of the end-user equipment (receivers) by connecting it with a single (Ethernet) cable. The diagram below is a typical representation of a PoE electrical installation consisting of one or more PoE switches connected directly via Ethernet cables, PoE receivers, or non-PoE receivers via PoE modules.

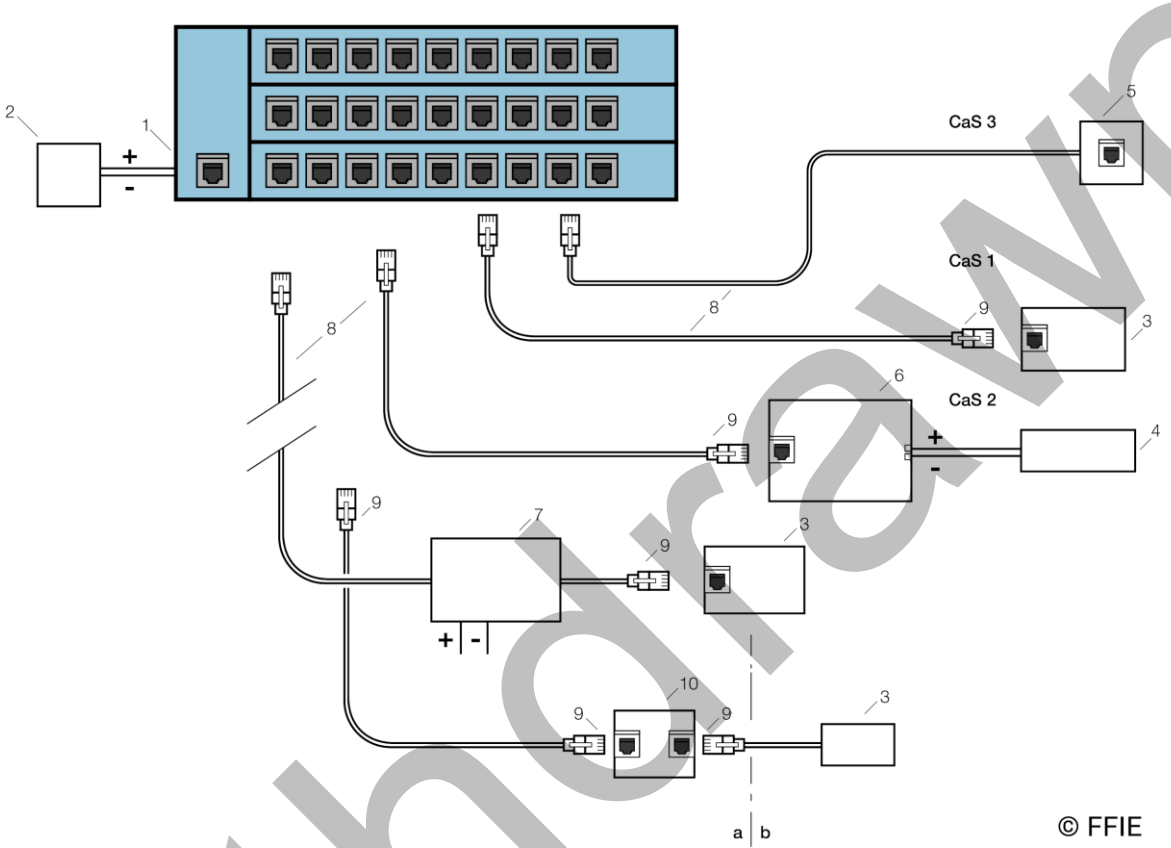

Figure 3: main elements of a PoE installation

1 PoE switch (Power Sourcing Equipment (PSE))
2 Switch supply (with SELV transformer)
3 PoE receiver (PoE Device): meeting IEEE[1] requirements; it is supplied directly by the PoE switch. It is also called « Powered Device ».
4 Non- PoE receiver
5 Connection point
6 PoE module
7 PoE injector
8 Ethernet cable
9 RJ45 connector
10 PoE surge protection device

Note: Some manufacturers consider that installations, where the final receiver is not a PoE receiver by construction, are not strictly PoE installations. We **do not** make that distinction here.

Power Over Ethernet (PoE) is the 57V DC SELV maximum power supply of electrical equipment on twisted-pair cabling for the transmission of digital information, through the computer port (e.g. RJ45).

[1] Institute of Electrical and Electronics Engineers

PoE installations can simultaneously power and control the following electrical equipment:

- Receivers that are intrinsically designed for PoE applications. This type of equipment is called a "PoE receiver" (see Figure 3 - CaS 1) or PoE Device (PD).
- Receivers that are not intrinsically designed for PoE applications (see Figure 3 – CaS 2). are called "non-PoE receivers". Equipment that is powered and controlled upstream by a PoE module is also called a PoE Driver. Receivers are powered by PoE sources that are also called PSE.
- Terminal points (see Figure 3 - CaS 3) are delivered by a connector (preferably RJ45 but can be of another type too (excluding USB)).

It is not necessary to have PoE terminal equipment by construction to carry out a PoE installation. It is possible to use application-specific terminal equipment, such as:-

- SELV equipment.
- powered in the high limit of 57 V DC.
- less than or equal to 90W.

In addition, the maximum distance between the source and the equipment to be powered for equipment at 48V DC is 90 m.

The link between a PSE and a receiver may include interfaces, for example repeaters or PoE injectors (see Figure 3 - CaS 4). The term Power Interface (PI) can be used to designate these interfaces. The PoE interface should not be confused with PoE drivers. The integrity of the SELV shall be checked when using injectors.

When at least two modules are connected together, this configuration is called "PoE chaining". This configuration assumes not to exceed 90W on all ports. However, it allows the ability to distribute the 90W available on all modules and / or PoE receivers placed in series on the same circuit.

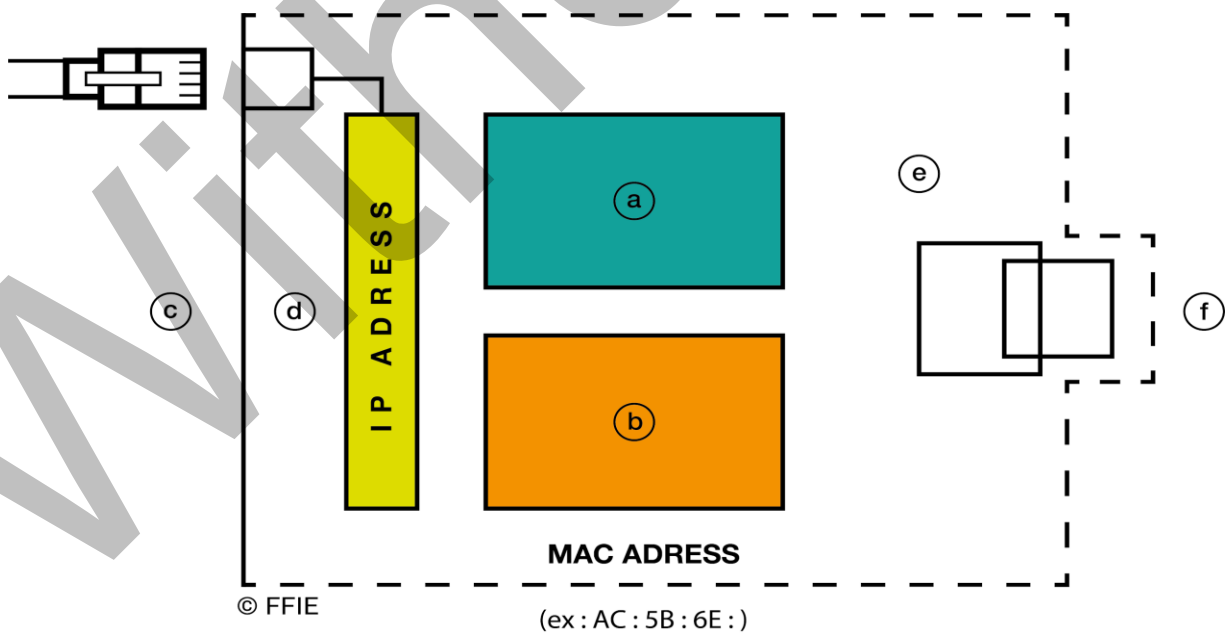

Figure 4: main elements constituting a PoE receiver

a. power card
b. calculator
c. communication card
d. RJ45 connector
e. Function (optical function depicted)
f. camera

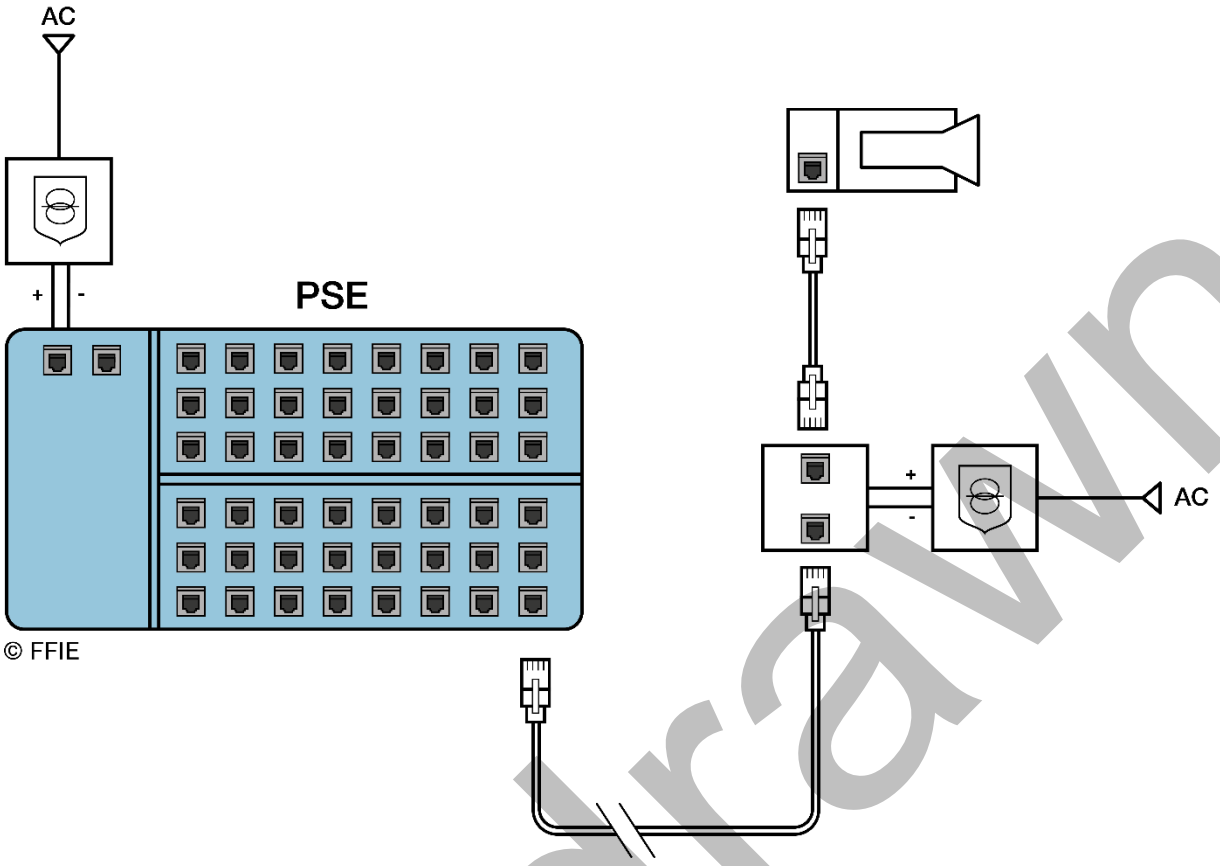

Figure 5: how a PoE injector works

a. *PSE*
b. *PoE receiver*
c. *PoE injector*
d. *Ethernet cable 6a category*
e. *Isolation transformer*

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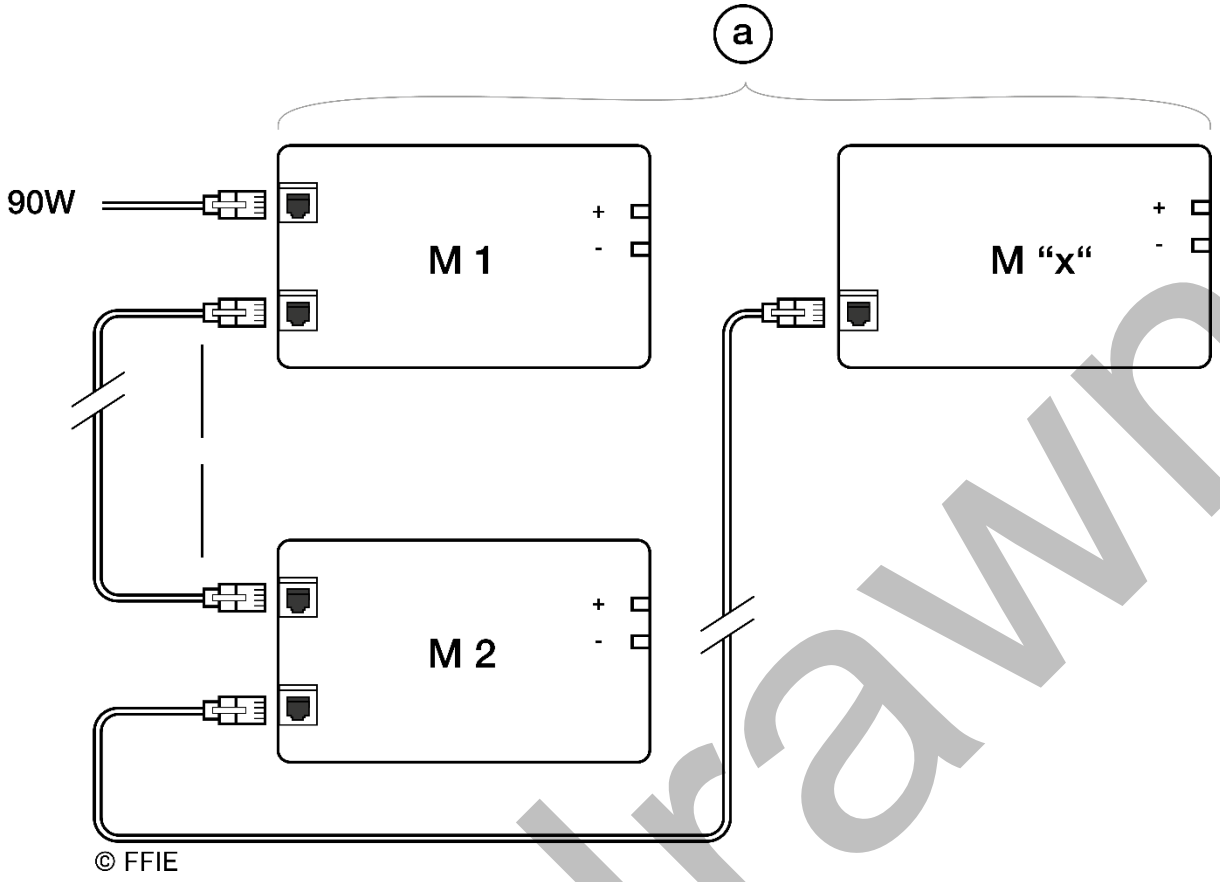

Figure 6: scheme overviewing the "chaining" of PoE modules

a: Distribution of 90W on all modules of the same circuit.

M1: module 1

M2: module 2

Mx: module X

1.4 Key elements of a PoE installation

1. **PoE switch (PSE):** it is the power supply of the power and data installation in Power over Ethernet. The power supply of the PoE installation is delivered by a switch or several switches. Each switch has to be considered as a PSE. This switch is integrated into an electrical switchboard. This is not a simple switch dedicated to communication. However, a PoE switch can replace a switch dedicated to communication. The power supply of the switch: is via a safety transformer.
2. **PoE receiver**: meeting the IEEE standard, it is powered directly from the PoE switch. It is also known as a Powered Device (PD).
3. **Non-PoE receiver**: does not meet the IEEE standards. It requires to be powered by a PoE module.
4. **Connection point**: typically, by the use of an RJ45-type connector. However, for the purposes of this guide, it refers to any wall connection on which it is possible to connect to the PoE installation.
5. **PoE module**: meeting the IEEE standard, it is upstream of any non-PoE receiver. Depending on the equipment to be supplied and each use, a suitable module must be chosen: module for DC motorization, module for lighting, HVAC control module, ...
6. **PoE injector**: a PoE injector makes it possible to send power between the PSE and the equipment to be powered. It is used mainly in the case of long cable lengths.

7. **Ethernet cable**: any connection between the elements located either between the PoE switch downstream and the PoE modules (or the injectors if applicable), or between the PoE switch downstream and PoE devices.
8. **RJ45 connector**: Each RJ45 connector used for a PoE installation must have been designed for PoE applications.
9. **PoE surge arrester**: composed of an input and an output within the RJ45 connector it is placed directly on the PoE circuit (for example at the point of penetration in the building of a cable supplying an external piece of equipment, such as a camera, for example) or telephone line input. The PoE arrester is located inside the building for outdoor receivers. It is complementary to use surge arresters upstream of PoE switches and cannot replace their function.

1.5 PoE types

There are currently four types of PoE:

1. PoE (Type 1),
2. PoE + (Type 2),
3. UPoE (Type 3) and
4. PoE ++ (Type 4).

Each of these types is governed by an IEEE (1) standard that contextualizes their attributes.

This document deals with the most advanced form of PoE, meeting the IEEE 802.3bt standard. This IEEE 802.3bt compliant technology is commonly known as 4PPoE (4-pair PoE). With the IEEE 802.3bt[2], power and data are distributed over the 4 pairs of the Ethernet cable, unlike earlier versions (see insert "PoE ENDSPAN and PoE MIDSPAN").

PoE is not a new technology, with growth beginning in the early 2000s and the emergence of telephony and IP video surveillance. Today, this technology has matured and benefits from a broad penetration within the world of Buildings and infrastructures, thanks to the broader application of the IEEE 802.3bt standard.

Indeed, this technology allows:

- To distribute power to receivers up to 90W on 4 pairs (see insert "A power distribution on 4 pairs thanks to the IEEE 802.3bt". This allows the addition of 4 new classes of PoE: classes 5 to class 8 - see table 2).
- Cable bandwidth extension of up to 10 Gbps.

[2] IEEE 802.3bt “Draft standard for Ethernet Amendment: Physical Layer and management Parameters for DTE Power via MDI over 4-Pair”

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The table below defines for each type of PoE the number of pairs distributing the power as well as the maximum power at the source (PSE) and the terminal equipment.

Current name	IEEE standard And Type of PoE	Maximum current by pair (mA)	Number of pairs distributing power	Max power delivered by the PSE (W)	Power to the PoE Device or PoE module (W)
PoE	IEEE 802.3af Type 1	350	2	15.4	13
PoE+	IEEE 802.3at Type 2	600	2	30	25.5
UPoE (4PPoE)	IEEE 802.3bt Type 3	600	4	60	51
PoE++ (4PPoE)	IEEE 802.3bt Type 4	960[3]	4	100	90

Table 1: number of pairs distributing the power and maximum power at the source (PSE) and the terminal equipment per PoE Type

Some applications use the PoE class. The table below lists the classes in force according to the powers at the PoE / receiver. The class assigned to PoE devices depends on the respective rating of each device.

[3] Tests on connectors framed by IEC 60512-9-3 "Connectors for electronic equipment - Tests and measurements - Part 9-3: Endurance tests" and IEC 60512-99-01 "Connectors for electronic equipment - Tests and measurements - Part 99-001: Test program for connections and disconnections under electrical load - Test 99a: Connectors used in twisted-pair communication cabling for remote power supply "are performed for connections disconnections at value currents less than or equal to 750 mA.

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PoE Class	Power delivered by the PSE (W)	Power to the PoE device or PoE module (W)
Class 1	4	4
Class 2	7	6
Class 3	15	13
Class 4	30	26
Class 5	45	40
Class 6	60	51
Class 7	75	62
Class 8	90	71

Table 2: PoE classes according to the power at the PoE / receiver.

Note: There are also so-called "class 0" PoE devices, for which the manufacturers of these devices have not assigned a class.

The interoperability of PoE devices is governed by three standards as of the date of publication of this reference document. The IEEE 802.3 standard is the most accomplished of these standards:

- IEEE 802.3af (PoE) standard: The power supplied by the PSE is at most 15.4W, for which the receivers can use a maximum power of 12.9 W. The voltage is 48V.
- IEEE 802.3at (PoE +) standard: Receivers connected to a PoE power supply can use a power between 24 and 30W. The voltage is also 48V.
- IEEE 802.3bt (Draft Standard for Ethernet Amendment: Physical Layer and Management Parameters for DTE Power via MDI over 4-Pair) published January 31, 2019, also called 4PPoE (4-Pair Power over Ethernet), it introduces two of maximum power distributed over the 4 pairs of the Ethernet cable.
- 55 W (with a maximum intensity per pair of 600 mA).
- 90 W (with a maximum intensity in pairs of 960 mA).

The voltage for the IEEE P802.3bt standard is maximum 57 V DC.

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4-pair power distribution thanks to IEEE 802.3bt

Thanks to the last version of the IEEE standard regarding PoE (IEEE 802.3bt power and data distribution can now happen through 4 pairs simultaneously. Previous versions (IEEE 802.3af and IEEE 802.3at) specify two PSE power methods using two pairs of a four-pair data cable:

- Either the power supply is distributed over the unused pairs using pairs 1 and 4, ensuring compatibility with receivers using only two pairs (pairs 2 and 3), including 10 / 100BASE-T applications.
- Or the power supply and the data are delivered on pairs 2 and 3, ensuring compatibility with two and four pair receivers, including 10 / 100BASE-T and 1000BASE-T.

Power and data distribution on 4 pairs thanks to IEEE 802.3bt

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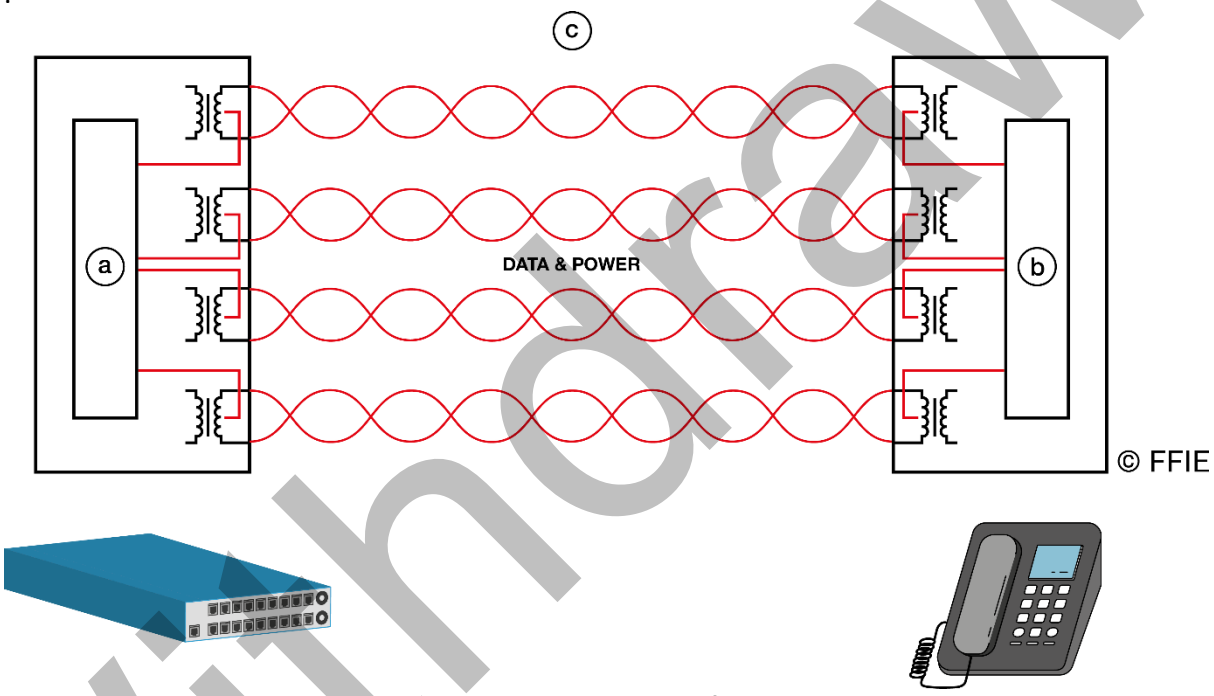

Figure 7: scheme showing power and data transfer in a 4-pair PoE installation

a) PSE
b) PoE receiver or module
c) *Ethernet cable of category 6a in which both power and data flow*

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Endspan PoE / Midspan PoE

When working with technologies pre-existing IEEE 802.3bt, it is important to know what Midspan and Endspan PoE are. Midspan is a PoE installation with an additional power suppy placed between the receivers and a non-PoE switch. Endspan is a PoE installation with receivers that are directly powered by a PoE power supply.

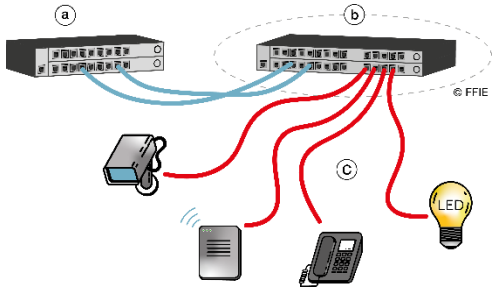

Figure 8: Midspan PoE

a) Non-PoE switch
b) Midspan PSE
c) *PoE receiver or modules*

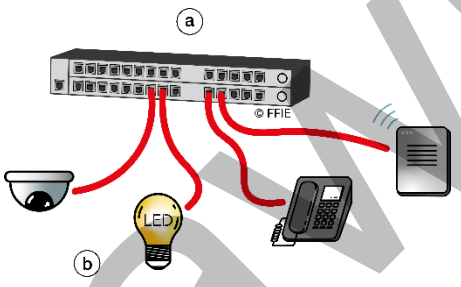

Figure 9: Endspan PoE

a) PSE (PoE switch)
b) *PoE receivers or modules*

2. PoE benefits

Installer Benefits

- One cable for power and data
- Reduce the size of cable trays
- Simplicity and speed of installation
- Universality of the RJ45 connection
- Easy setting by graphic interfaces
- Reduction of electrical risks for users and professionals (compliance with SELV ≤57V DC)
- Easier installation with lighter cables compared to a traditional installation
- Commissioning during construction and therefore easy reception
- Monitoring the progress of the remote site, anticipating the construction phases
- Connections and pairings facilitated
- Compatibility of PoE devices
- Possible chaining by PoE modules
- Less risk of theft (less copper, possible alarm in case of disconnection, traceability of a malicious depot, coupling with video protection, ...)
- Devices adapted to new building or existing ones
- Easy replacement of duct cables facilitated by the small section of the Ethernet cable
- Discretion of Ethernet Cable in apparent layout vs U1000R2V cable, more visible
- Industrial process (e.g. PoE octopus for hotel rooms or office trays) and therefore testable in the workshop
- Positionable installation indoors and outdoors
- Also allows to overcome the problems of cable passage in rehabilitation sites,

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- Control of AC equipment via the low voltage contacts integrated in PoE modules by design
- Reliability of parts of plant tested at the factory: example octopus for PoE.
- Reduction of the impact on the structures of the electrical installation: considerable gain in weight for LED converters and cables
- Less risk of fire
- Handling of the constituent elements of the installation facilitated (e.g. weight of the cable plies)
- Unified laying (in sheet) or under duct or tray
- Traditional installations reduced to some dedicated circuits as lifts, cooking, electrical heating,...
- Number of points extended by the number of switches
- Interchangeability of the switch for the same size
- Fewer requirements on the attachment of junction boxes and access to connections
- Easy integration of connected objects
- Service proposal associated with facilitated installation

Client Benefits

- Modern building management
- Energy management
- BMS function integrated by design
- A communication network that provides voice-data-images, strong currents and GTB
- Simultaneous supply and control of lighting, blinds, opening, HVAC, ...
- Installation ready for 5G networks
- Power supply of computers without AC / DC converters
- Flexibility in scalability and reconfiguration of the facility or premises (e.g. a desktop tray may have been more easily compartmentalized with IP-based receiver assignment).
- Easy control of each receiver, PoE receiver or PoE module with an IP address

such as historical monuments or heritage building.

- Easy pairing
- Possibility to go further by setting modules and switches via open-source programs
- Independence from manufacturers and proprietary solutions
- Use of the IP network for current building uses (example: management of ENR workflows, cross-usage Video-protection and access control, etc.)
- IP infrastructure
- No need to develop a dedicated BMS
- No need to set up a dedicated BMS
- Installation ready for BEMS (Building Energy Management System) and BOS (Building Operating System)
- A less compartmentalized design between different uses
- Less constraint related to BIM

- Integrated energy optimization
- No need to deploy an additional installation for the computer network or IP telephony
- Lower consumption of products
- Possibility of supplying via Ethernet cable that are difficult to supply via a traditional circuit, especially from a cable routing point of view
- Easy facility extensions
- Installation tested as and when the site so easy reception and installation immediately ready for use
- Immediate installation of artificial intelligence with IoT potentially able to communicate with each other via PoE installation and manage user preferences
- Immediate data exploitation as soon as it is put into service

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- An installation immediately brought to the forefront of artificial intelligence with IoTs that communicate with each other and potentially manage user preferences
- Positioning and interchangeability of equipment simpler (no need to bring two cables)
- Possibility of interacting with its installation with a single interface: lighting, HVAC, blinds, auxiliary power of offices, ...
- Less halogen therefore less risk of toxic fumes emission in case of fire
- Independence from a computer protocol
- Fewer adapters
- Fewer connectors
- Reliability of connections
- Less risk related to connections
- Universe of interfacing WEB and secure
- Reduction from traditional installations to connected facilities
- Possibility of switching on other connectors that the RJ45 for example USB[4]
- Possible evolution of the installation by adding modules at the level of the switches
- No need to bring a power cable and a communication cable (for example for one-cable PoE Panels or TVs)
- Have a facility ready for operation
- Coupling of strong current functions with access control and video protection functions
- Possibility of simplified architectural lighting
- Optimum safety in case of accidental pinching or disconnection of Ethernet cables
- Gains of surface by grouping functions distribution board-communication board and Building Management System (BMS)
- Possibility of direct use of the energy produced by renewable energy by injection on the DC bus
- Less heat dissipation
- Security of the installation via the security of networks and their components
- The presence of UPS makes it possible to ensure the continuity of the supply of circuits in PoE
- Switch redundancy ensures service continuity for PoE-powered devices
- Easier to deploy in constrained environments
- IP mesh extension of a building
- Digital transition for BMS
- Generalization of LED lighting
- Compatibility of PoE devices
- No need for LED protection by the use of remote PoE LED drivers
- Respect induces regulatory conditions for fire protection including the use of cables with improved performance and the least amount of insulating material and the reduction of plastics
- Suitability Ethernet fiber
- Use of renewable energy production in DC without DC / AC conversion
- Extension of IP Network in Building
- Performances of PoE installations adapted to the connection of Buildings with fiber optic

[4] However, the following voltage/current limitations apply:
USB Standard: 5V 500mA pins 1 et 4 , +5V & ground USB Power delivery: 100W MAX 20Vdc
In different manufacturers data sheets of USB connectors, as for example Molex & Keycon, max. 30Vdc / 1.5A is mentioned

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Maintenance

- Kick-start and remote diagnostics on the installation
- Facilitated preventive maintenance
- Replacement of switches and facilitated portions of wiring
- Easy replacement of cables under sheaths
- Maintenance on safety and functional aspects
- Independence of communication programs
- Interchangeability and interoperability
- Easy intervention
- Follow-up of breakdowns and corrective operations

Environmental Benefits

- Reduction of copper quantity (estimated between -20 and -30% compared to a traditional installation)
- Reduction of plastics
- An installation allowing to measure and continuous improvement
- Possibility of collecting information of consumption in situ or at a distance allowing a better follow-up, a better anticipation, a continuous improvement made possible
- Improved customer carbon footprint
- Convergence of solutions between the respect of the objectives of the thermal regulation, the direct use of the ENR production, the predominance of the LED lighting, ...
- Respect of the European directive on the energy performance of buildings
- Facilitated anticipation of the need for tertiary buildings to have a BMS
- Energy management
- Less halogens (low halogen construction cables - LSOH) so reduction of the best for the planet
- Reduced DC / AC conversion
- Accompanies the development of self-consumption.

Points to consider:

- Limited power supply
- Cannot supply traditional socket outlet
- Small cross-sections of Ethernet cables compared to cables used in traditional power supply
- Heat…

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3. Designing a PoE installation

3.1 Fundamental principles of electrical safety

The basic principles of electrical safety include compliance with the basic electrical safety rules listed in this sub-chapter, and compliance with applicable regulatory texts (non-exhaustive list).

SELV protection measure - protection against indirect contacts

Power Over Ethernet (PoE) installations must comply with SELV requirements. This condition applies to all installations downstream of the PSE. This measurement applies from the PSE to the receiver or connection point. This measurement is valid even if the receiver or connection point is not compliant with IEEE 802.3. The use of SELV or PELV is prohibited.

Voltage limits

The upper limit of the legally regulated SELV at 120 V DC (see inset: "TBT Recall") is, according to IEEE 802.3bt, reduced to 57 V DC maximum for PoE installations.

57 V DC is currently the high ceiling for PoE technology. However, it is necessary to design installations whose voltage is adapted to the regulatory and normative conditions. For example, in a humid environment, the safety voltage is at most 30 V DC. This is the case in installations of rooms containing a bath or shower of volumes 0 and 1. The design rules must take into account the voltage drops, in addition to attenuation of the signal over long link lengths. Thus, for a voltage output of PSE at 57 V DC[5], the IEEE can deliver 48V to the PoE receiver located at 90 m under the conditions provided by the standard.

This limit is more restrictive for wall-mounted connections to receive PoE-enabled hardware than for PoE on non-PoE receivers in the installation. As required by the current IEEE 802.3 standard, the voltage at the connection points of PoE installations shall be such that: 44V DC ≤ U ≤ 57 V DC. However, solutions exist to connect lower voltage receivers to a PoE installation (see choice of equipment).

In addition, this limit is lowered to 30 V DC in damp rooms.

The drain of an Ethernet cable is considered a functional ground. Do not connect the drain to the electrical ground or functional ground (which, if present, must be connected to the building's electrical ground). In order to meet this requirement, the drain of each cable should be cut off at the patch panel to avoid the effects of antennas.

The metal strap of the Ethernet cables, if present, may be grounded because it does not affect the SELV[6].

[5] In practice the output voltages of PSE are provided between 52 and 57 V DC.
[6] This point is specified by the CENELEC low voltage installation standard in force.

Reminder on Extra-Low Voltage

The limits of the Extra-Low Voltage in direct current are:

- U ≤ 120 V in direct current in dry medium
- U ≤ 50 V in alternating current in dry medium

These limits are lowered in a humid environment.

In the field of Very Low Voltage there are:

- SELV: Safety Extra Low Voltage

No active part of the circuit and ground is grounded

- PELV: Protective Extra Low Voltage

An active part of the circuit and masses is grounded

- FELV: Functional Extra-Low Voltage

It does not meet the SELV rules or the PELV rules. It is a type of ELV where there is continuity of the protective conductor between the primary and secondary circuits; the grounding is only functional. With no guarantee of safety, this ELV is comparable to LV.

SELV

The conditions of the SELV provide simultaneously:

- The high limitation of the voltage of the installations in SELV at 120 V DC in a dry environment, which is lowered to 30 V in wet environments.
- The protection measure by separating the SELV circuits from the other circuits of the installation and the insulation between the different SELV installations.
- The insulation between the SELV installation parts and the earth (a SELV installation must not in no case be connected to the ground).

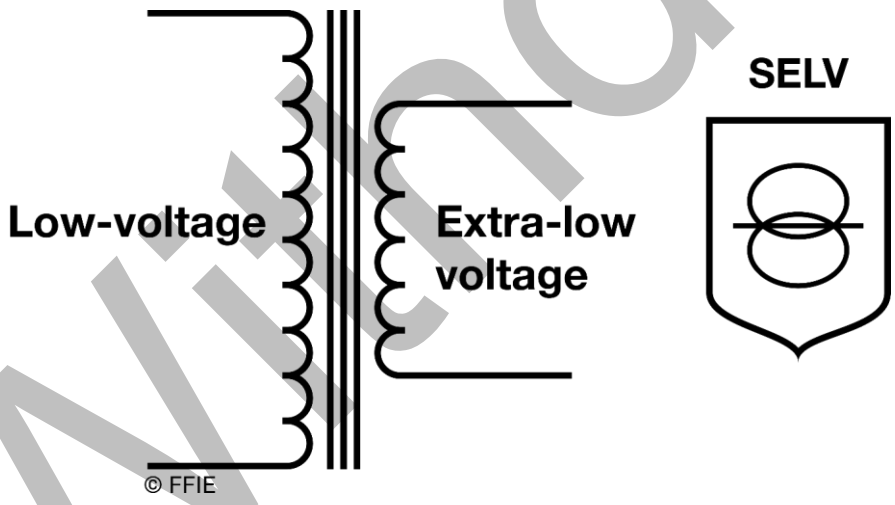

Figure 10: SELV symbol

A separation transformer ensures that a fault that occurs at the primary will not affect the secondary of the transformer.

An isolating transformer as shown above provides the separation function while providing additional security by lowering the voltage (in the case of PoE maximum at 57 V DC).

Each PSE, each PoE module, each receiver must be in accordance to the SELV rules by design. Each source must be labeled SELV. Modules and receivers must be class III (Equipment designed to operate in SELV less than or equal to 120 V DC).

Overload protection

Overload protection of cables downstream a PSE is provided by the PSE. These measures shall be taken in addition to the protective measures against overloads upstream of the PSE.

Protection against short circuits

Overcurrent protection of cables downstream a PSE is provided by the PSE. These measures add to the protective measures against overloads upstream of the PSE.

Protection against overvoltage

Overvoltage protection of cables located downstream of the PSE is provided by surge protective device located at the origin of the installation and / or at the level of each switchboard containing PSE. This protection is additional to the SPD at the origin of the circuit, the SPDs for power installations in switchboards, and the PoE SPDs on the circuits leaving the building (examples: cameras, external lighting, access control).

The overvoltage protection of the power networks upstream of the PSE induces the protection against over-voltages of the communication networks.

Warning: surge protectors, which may be incorporated into PoE system equipment, do not substitute surge protective devices of the PoE installation.

Protection against direct contact (Basic Protection)

By respecting the installation rules set out in this standard, there is no risk of direct contact in the PoE installation.

PoE connection point sockets must not have any conductive part accessible in normal use.

Additional protection measures

Before powering up the PoE circuit, the IEEE protocol requires establishing communication between the PSE and the PoE receiver. The PSE delivers a voltage of ten volts to the PoE installation. The receiver connected to this facility interprets this voltage as a request from the PSE. The query is similar to a class query (see Table 2). The receiver "responds to the PSE" by a current that measures the PSE. This determines the PoE class of the receiver based on the value of the current sent from the receiver. The PSE then establishes the receiver's power supply.

The IEC 60950-1 standard "Information Technology Equipment - Safety - Part 1: General Requirements" contains provisions to ensure the safety of telecommunication equipment. The tests of the IEEE 802.3bt although different from the tests of the IEC 60950-1 are in accordance with the requirements of this IEC standard in particular on the electrical insulation and SELV requirements.

As a protection measure, the PoE installation must not supply terminal connection points in zones 0, 1, 2.

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3.2 Basic operating principles

The constituent materials of the PoE installation are all compliant with IEEE 802.3bt; the connection of the hardware to each other within a PoE installation and mutual recognition PSE / receivers or modules is done automatically.

The PoE switches used are also sized according to the bandwidth. In the same way that one carries out a balance of electrical power it is necessary to carry out a balance of bandwidth. This is commonly done for example for video protection PoE uses.

Care should be taken not to connect PoE installations to non-PoE switches. The separation of the circuits is therefore required as is the separation of the paths of the so-called traditional installations of PoE installations.

For each non-PoE receiver of the installation, it is advisable that prior to installation the compatibility between the receiver and the module that it supplies is checked. The modules must be parameterized by the manufacturer or from the on-site programming interface.

3.3 Fundamentals of computer security

Risk analysis

The keystone of computer security is **risk analysis**. The results of the risk analysis will determine the **recommendations** and the appropriate **technological choices**.

The level of IT security must be adapted according to the type of clients, the infrastructures and materials to be protected, as well as the uses. The fundamental principles of computer security are to be considered "made to measure". It is necessary to consult the computer services of the client if they exist.

Among the possible solutions:

Physical security

The following provisions contribute to physical security. They also apply to other types of networks than PoE installations (for example those connected with PoE installation).

- A first level of security is to completely isolate the network in PoE. This provision prevents access from outside (e.g. for operators of vital importance or authorized economic operators).
- A second level consists in equipping the installation with manageable PoE switches. Thus, only declared IP addresses can access from outside.
- A third level is to isolate each PoE switch from other IT equipment. In particular, it is necessary to equip with RADIUS switches[7].

[7]RADIUS protocol relies mainly on a server (the RADIUS server), linked to an identification base (database, LDAP directory, etc.) and a RADIUS client, called NAS (Network Access Server), acting as an intermediary between the end user and the server. All transactions between the RADIUS server and the client are encrypted and authenticated.

- A fourth level is the use of the MAC address to create physical security.
- A fifth level is the inaccessibility or limitation of access to PoE facilities.

Encryption

The provisions that can be implemented for the encryption of data are described in the repositories relating to encryption.

Choice of systems

The choice of 802.1X type servers is preferred[8]. In addition to the PoE identification described in 3-1, the IEEE 802.1X standard is a standard for an authentication protocol on LAN and WLAN networks. Thus, a server type 802.1X:

- authenticates any device that tries to connect to the server and then allows the opening of a RJ45 port in case of positive authentication,
- records the events related to network access (connection attempts, disconnections),
- provides cryptographic keys for secure wireless trade.

According to IEEE 802.1X when the Ethernet cable connected to the PoE module or PoE receiver is connected to the PSE, if nothing happens until the authorization by the server, the PoE switch sends a message to the server that does or does not support 802.1X compatibility. Once the acknowledgment is sent by a PSE, RJ45 port is opened and the system performs the security exchange.

For trade between the "server clients" and the 802.1X server type, and although the standard[9] does not specify the protocol to use, RADIUS or Diameter[10] protocols can be used.

In addition, GDPR solutions[11] ("privacy by design") that guarantee the protection of data by design are preferred.

3.4 Design and sizing rules for a PoE installation

General design principles

PoE installations range from targeted use (e.g. IP video-protection) to a functional installation from BMS.

Generally, in order to design a PoE installation, it is appropriate in terms of power budget to:

1. Identify the equipment or terminal points to supply.
2. Identify the equipment that can be powered by PoE. Parts of installations that cannot be made in PoE will be done in a traditional way.
3. Distinguish between PoE receivers, non-PoE receivers that can be powered from PoE modules, PoE connection points.

[8] *IEEE Std 802.1X: IEEE Standard for Local and Metropolitan Area Networks-Port-Based Network Access Control.*
[9] *See Country-specific guide*
[10] *Diameter is a Peer-to-Peer (P2P) protocol, where a peer can function either as a client or a server. Diameter protocol uses a Uniform Resource Identifier (URI) according to scheme AAA (Authentication, Authorization and Accounting) or scheme AAAS (Authentication, Authorization and Accounting with Secure Transport).*
[11] *GDPR: see https://ec.europa.eu/info/law/law-topic/data-protection/reform/rules-business-and-organisations_en)*

4. Consider the number of PoE modules per use: lighting, HVAC, sensors, blinds, shutters,... To select modules according to the characteristics defined in chapter 4.
5. Consider the total number of circuits for the building. Several methods can be applied downstream of an RJ45 port to the board: either this RJ45 port feeds a PoE receiver (or a non-PoE receiver a PoE module), or it feeds a PoE chaining unit.

Each equipment connected to the same PoE module will work the same way. The grouping of the receivers can be made physically by association of receivers on the same module. This optimizes the number of modules. This grouping can also be done in software afterwards.
Two possibilities of design can be considered: from the switch it is possible to mix the uses on a circuit coming from the same RJ45 port or to design the installation in a more traditional way by assigning each port to a dedicated use: lighting, HVAC, blinds, ...
It is pertinent to note that the installation may be subject to binding (statutory) regulations, as is the case with public buildings.

6. Divide the number of circuits by level, by sector, ... and from there, to deduce the distribution of the cabinets containing the PES and the fixed link lengths
7. Calculate the number of PES (PoE switches) according to the type of envisaged switches, and possible PoE interfaces. Select the switches according to the characteristics defined in chapter 4.

During the power balance, and for PoE chaining, it is advisable not to load the circuits to 90 W. For example, the calculation can be done with a 60W chaining which will allow the possibility to extend the circuit (if required) from an RJ45 port by connecting one or more new module(s) or PoE receiver(s) on the last PoE module. For any new module added a new IP address will be handled by the switch.

8. If they exist, to dimension the production from renewable energies and the DC bus which supplies the PoE switches. Production by photovoltaic system connected to the public distribution network with storage shall comply with national regulations and technical standards[12].

9. Identify the parts of PoE installation outdoors in order to place surge protective devices (SPDs) at the points of penetrations in the building, in addition to SPDs protecting power installations in switchboards and SPDs protecting network operator input and telecommunications installations.

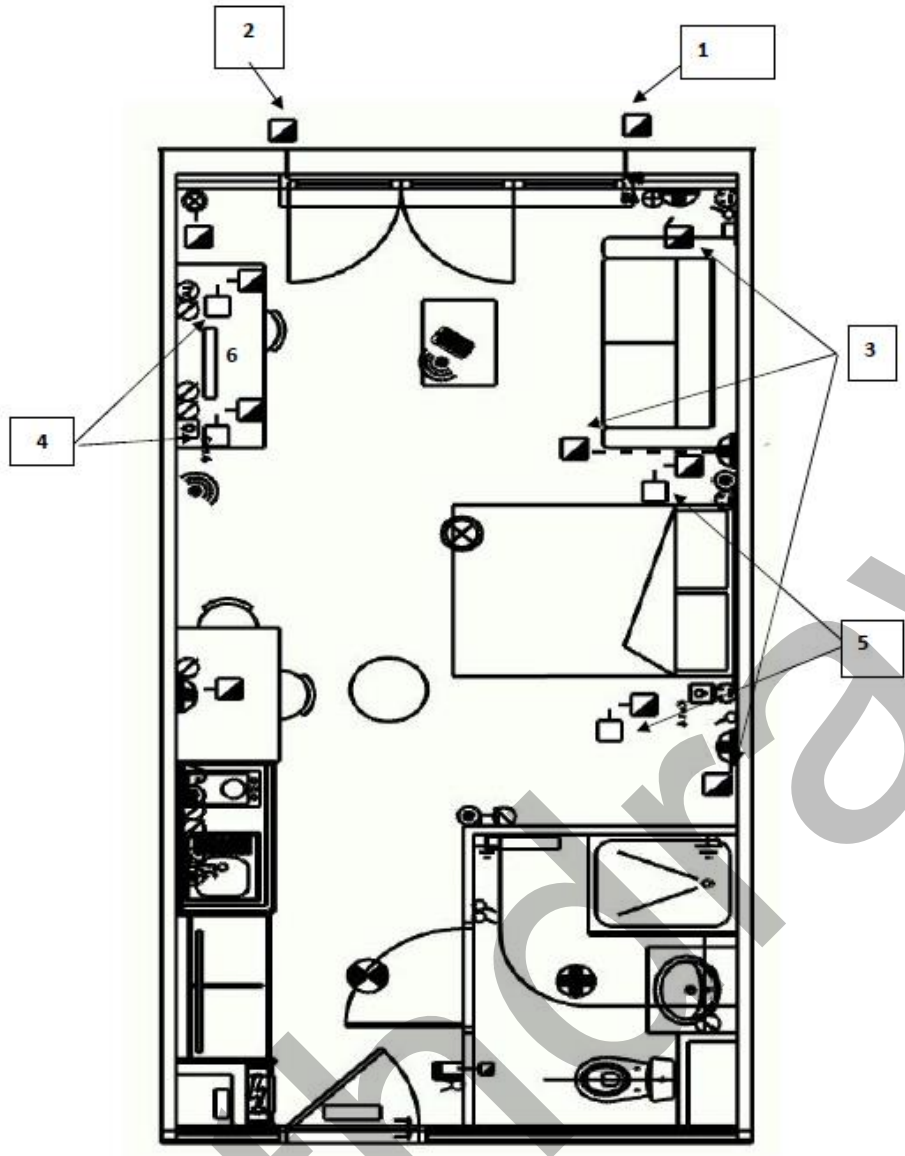
3.5 Examples of applications

The installations described below are some examples of installations that can be implemented using PoE. These are different types of installations, residential and non-residential, where PoE systems have been installed.

The first example shows a hotel room. It features several different switches, and a distribution in six plugs to provide energy to different devices.

The second example shows a PoE installation in a residential setting. In every room, there are different RJ45 sockets to enable remote access and management of the installation.

[12] HD 60364-7-712 for photovoltaic installations



	PoE module		PoE switch
	WIFI hotspot		PoE HVAC controller
	PoE lighting 12V		PoE lighting
1	PoE module shutter	**4**	PoE module for connection (e.g. USB connection)
2	PoE module store	**5**	PoE piloted module
3	PoE module lighting	**6**	Single-cable TV

Figure 11: PoE installation in a hotel room

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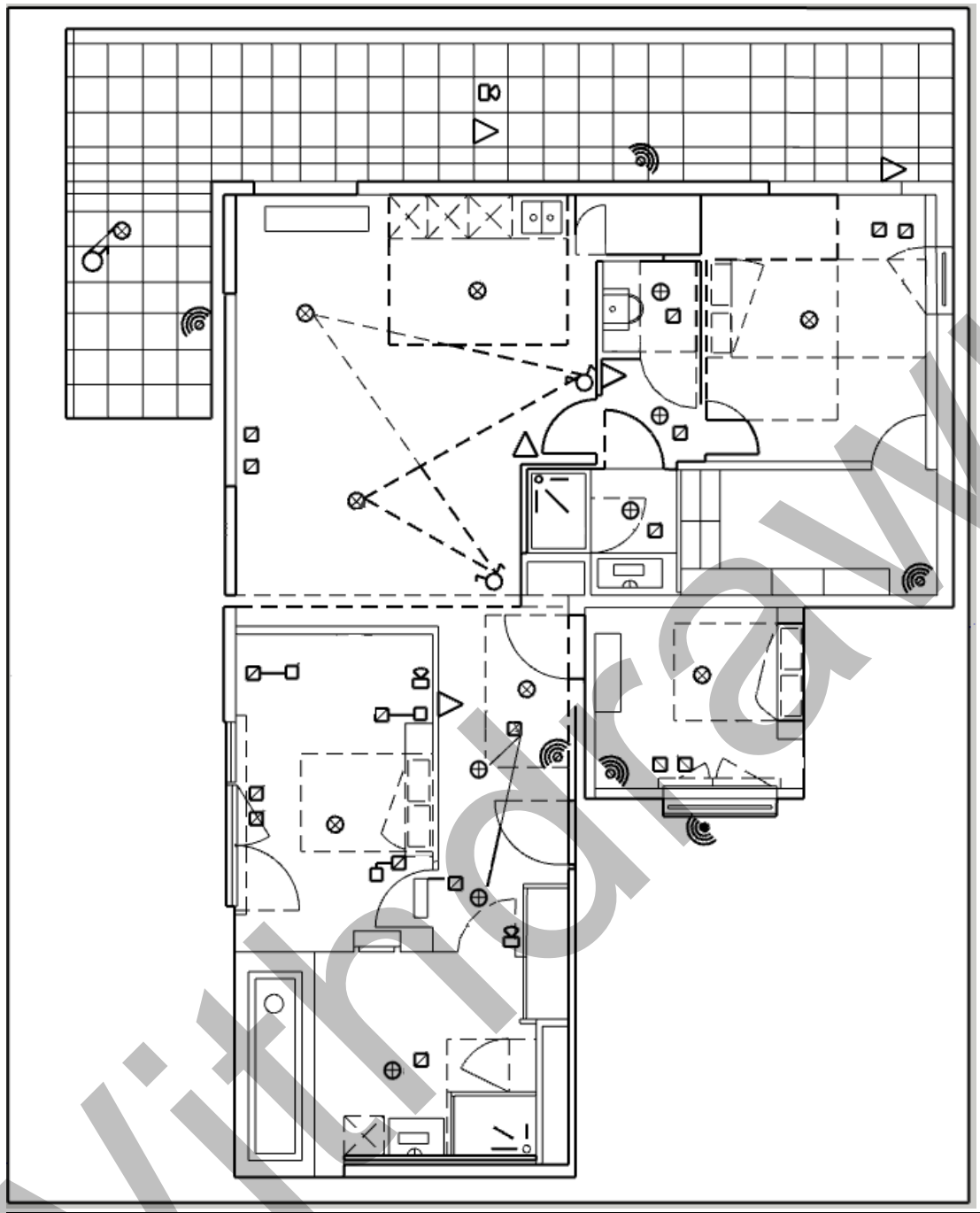

	PoE module		PoE sensor
	WIFI hotspot		PoE camera
	Non-PoE lighting		heat pump
	PoE lighting		switchboard
1	PoE module shutter	**4**	PoE module for connection (e.g. USB connection)
2	PoE module store	**5**	PoE piloted module
3	PoE module lighting	**6**	Single-cable TV

Figure 12: PoE installation in a house

4. Choice of material / equipment

This chapter is mainly dedicated to the description of the materials constituting the PoE installation.

The equipment must be marked 'CE'.

The equipment concerned must comply with the LV[13] Directive and the EMC Directive[14].

The equipment must be chosen in accordance with the environment of the location in which they are intended to be installed (IP, IK, ...).

For Power over Ethernet installations, in accordance with IEEE 802.3, the PoE hardware constituting the source installation (PSE) up to and including the terminal equipment (PSE, PoE modules, receivers intended to be connected to these devices, modules, PoE interfaces) shall be designed according to the rules of SELV in accordance with IEC 62368-1.

The electrical equipment constituting the PoE installation must comply with the latest version of the current IEEE 802.3 standard.

The choice of user equipment connected to the PoE installation complying with the latest version of the IEEE802.3 standard must be preferred.

As of the publication date of this repository, the latest version of the IEEE 802.3 standard is IEEE 802.3bt.

It is also important to prioritize solutions with configurable hardware via graphic interfaces and programming systems with open interfaces.

The criteria above are essential to ensure the independence of the electrical installer / integrator and his customer.

Any program (except the security keys of the PoE modules) must be accessible from a freely accessible database.

Installation of Class I devices is strictly prohibited in any PoE installation.

All equipment of the PoE installation must be designed in order not to propagate fire, hazardous smoke, and without any halogenic materials in order to contribute to fire safety.

[13] Directive 2014 / 35.EU

[14] Directive (Directive 2014/30 / EU) for the placing on the market of equipment

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4.1 PoE receivers

A PoE receiver must comply with the IEEE 802.3 standard by design and have at least one RJ45 port. These receivers must also comply with their reference standard (e.g. for luminaires manufactured in a factory by compliance with the standard EN 60598-1 "Luminaires - Part 1: general requirements and tests").

With disparities in functionality, performance and power, PoE receivers can also comply with IEEE 802.3at, or IEEE 802.3af, or IEEE 802.3bt standards. In this framework, we recommend installing PoE receivers that meet the IEEE 802.3bt standard.

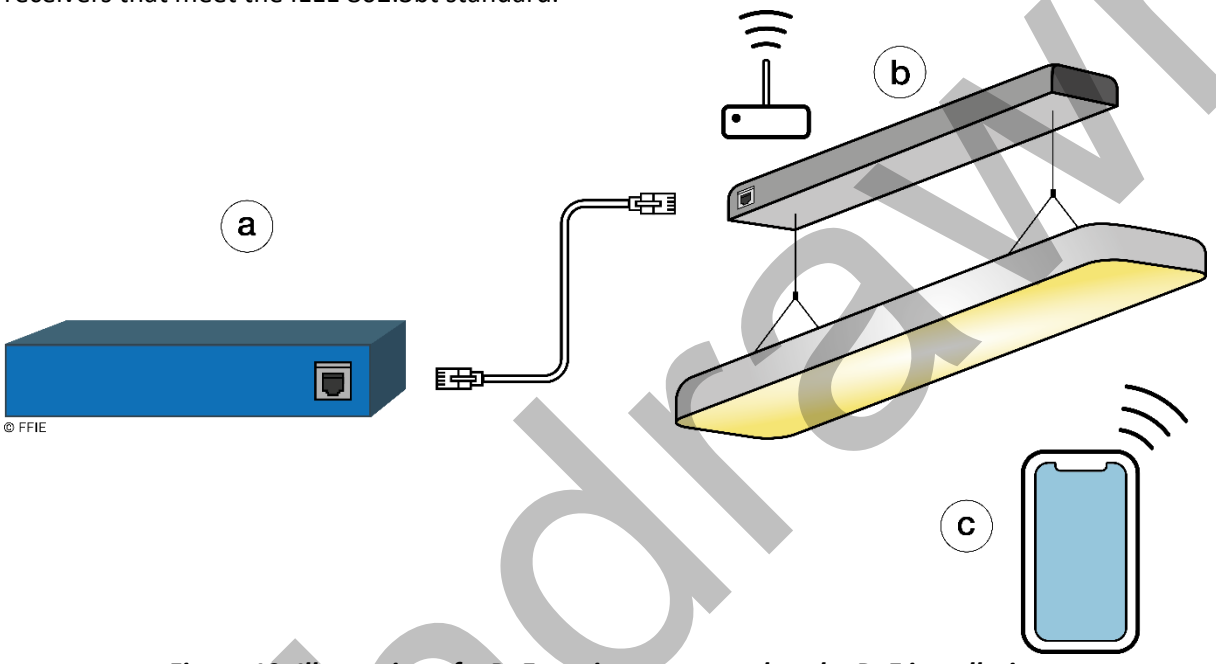

Figure 13: Illustration of a PoE receiver connected to the PoE installation

a: PSE

b: PoE receiver

c: smart-phone remote control

4.2Non-PoE receivers

A non-PoE receiver can be integrated into a PoE installation if all these pre-conditions are met:

- It requires a DC power supply
- Its voltage is less or equal to 57V DC[15].
- Its power is less than 90W.
- Its receiver can be powered and controlled by the installation in PoE by being connected downstream of a PoE module

[15] If the non-PoE receiver has a lower supplying voltage, the voltage could be adapted to the receiver to avoid any overvoltage that could damage the receiver

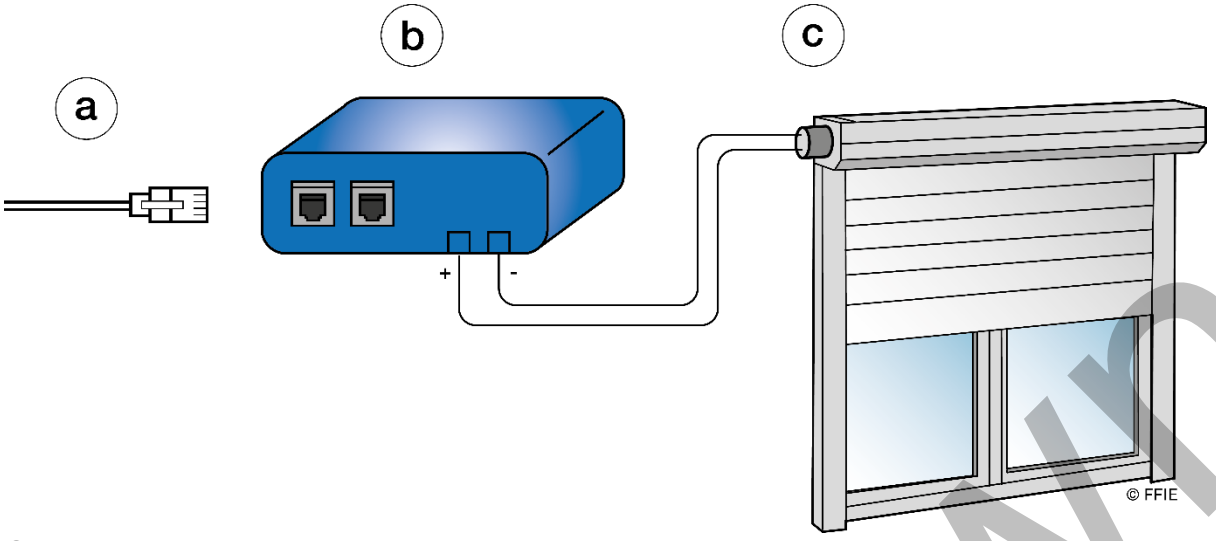

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Figure 14: Illustration of a non-PoE receiver connected downstream of a PoE module

a: ethernet cable
b: PoE module
c: non-PoE receiver

Among the PoE receivers are for example luminaires, HVAC control equipment, blinds, sensors (temperature, light, indoor / outdoor brightness (exact term), density of people), etc.

Recommendation: for the case of non-PoE luminaires we advise not to order LED drivers from your suppliers but the sources only (provided they meet the above characteristics). This will allow the PoE Module to act as the driver. ***Please note****: A preliminary test on the equipment may be necessary.*

4.3 PoE modules

PoE modules must have the following characteristics:

- CE-marked.
- Designed according to IEEE 802.3.bt standard.
- For equipment with a transformation function, be equipped with a galvanic protection ensuring SELV (marked with the symbol below – Figure 15) or with the word “SELV”), and comply with standard EN 61558-2-6 "Safety of transformers, inductors, power supplies and similar products for voltages up to 1100 V Part 2-6: special rules and tests for safety transformers and power supplies incorporating safety transformers ",

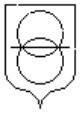

Figure 15: Symbol for SELV Equipment

- Be Class III (marked with the symbol ),
- Be equipped with certified electronic components.

These five criteria are essential to provide adequate safety measures for the users.

In addition, for SELV lighting converters, the lamp converters must comply with standard EN 61347-2-2 "Lamp control gear - Part 2-2: special requirements for dc-supplied electronic step-down converters or lamp for incandescent lamps" and converters for LEDs in accordance with EN 61347-2-13" Lamp control gear - Part 2-13: special requirements for electronic control devices supplied with DC or AC power for LED modules "and EN 62384 "DC or AC powered electronic equipment for LED modules - Performance requirements".

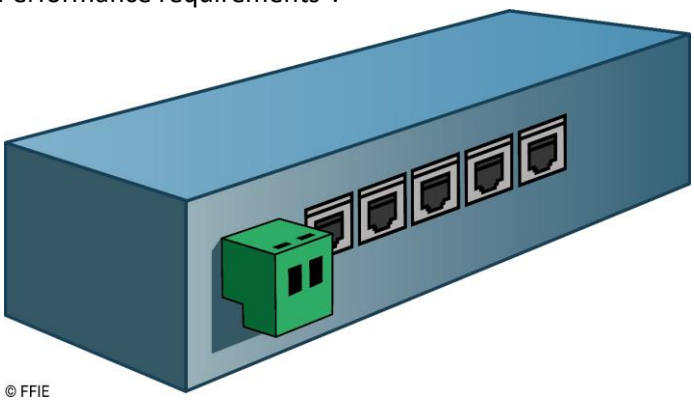

Figure 16: Illustration of a PoE module

Each module must be associated, by construction, with one or more dedicated functions; for example, HVAC, blind control, lighting, ...
Each module must have:

- At least one RJ45 port (input) for connection to the source. The presence of two ports can be used to connect the modules in series as specified by the manufacturer.
- At the output, one or more RJ45 port(s), or connections allowing the connection of blinds, lighting, ... The presence of several lighting connections downstream of a module allows for example, to control a lighting ramp from the same module.
- The modules must have individual IP and MAC addresses.

In order to equip the installation with connection points other than the RJ45 connection points, it is necessary to have conversion modules (e.g. RJ45-USB).

In order to build a complete Building Management System, namely managing PoE installations and so-called traditional installations, it is necessary to install modules making it possible to carry out data collection, measurement and control, by the use of for example, tori.

The presence of a recognition chip on modules and cable ends allows easy pairing.

It should be ensured for each non-PoE receiver reference that the module upstream of the receiver is set (or adapted) to operate with this receiver.

In practice, preliminary tests in workshops of the PoE Module / Receiver connections are desirable and in particular, where there is a lack of specifications or prior study of compatibility between materials attested by test report.

Any proposal for equivalent equipment from a designer, architect or contractor must be preceded by tests.

These tests must cover all the functionalities required by contract; for example, for a luminaire, these functionalities may cover the luminous intensity, the color temperature, the angle of the light beam in the case of a motorized luminaire, etc.

PoE splitters can be distinguished from modules. They allow to separate power and data from the same PoE Ethernet cable. The PoE splitter has two outputs: one for data and one for power.

4.4 Control devices

Control of the different receivers of a building or the infrastructure can be done by any/all the methods mentioned below:

- Connection to the server via a graphic interface: mobile phone, tablet, computer, screen of control.
- On radio or piezo command.
- On motion or presence detector.
- On wired controls.
- Other.

The choice of these devices is to be considered according to the needs of the building or infrastructure operator and according to the recommendations by the manufacturers of the modules, receivers and/or PoE switches.

To allow flexibility for rooms (e.g. in the case of an open space), the first two options mentioned above are preferred solutions.

4.5 Cables

Figure 17: Illustration of an Ethernet cable category 6a

What kind of cable?

The cables to use are 4-pair Ethernet cables, taking into account the following characteristics.

Which category?

To guarantee the optimal data transmission speed, cables for Power over Ethernet installations including category 6 or higher Ethernet cables: category 6a, 7, 7a, 8.1, 8.2. **Ideally Ethernet cable category 6a should be used as a minimum.** In fact, the Ethernet cable of category 6a (planned up to 500 MHz) complies with 10GBASE- T (10 GigaBit Ethernet).

The use of cables below category 6, for instance Category 5e Ethernet cables, 5e Category cables, telephone cables should not be used. As is the case for terminal links: manufactured PoE systems or patch cords.

For the power delivery, the Joule effect has to be taken into consideration in relation to the choice of the category.

Cable section

Another criterion to take into account is the nominal cross-sectional area of the Ethernet cable. This cross-sectional area is expressed in accordance with the AWG standard. AWG is an abbreviation of **'American Wire Gauge'**.

It is a cross-sectional area measurement according to the number of strands composing the cable. The table below is a gauge and section correspondence table.

Gauge (AWG)	**Matching Cross-Sectional Area (mm²)**
AWG 26	0.13
AWG 24	0.20
AWG 22	0.32

Table 3: Gauge to Section Table

Warning: the higher the Gauge Value (AWG) is, the lower the cross-sectional area will be. The decrease in gauge can allow greater power delivery with less heating. The decrease in gauge has no impact on the speed of data transmission.

To meet the requirements of the “100W PoE” (Actually 99 W maximum at the PSE level) we recommend using AWG24 cables. And in any case, the cables must be at least AWG26.

Cable reference standards

Ethernet cables complying with IEC 61156 standard series "Symmetrical and quad-balanced multi-core cables for digital transmissions" or EN 50288 "Multi-element metallic cables used for analogue and digital transmissions and controls” can withstand a maximum operating voltage of 100 V. The insulation resistance must be greater than 5000 MΩ/km according to IEC 61156.

Gauge (AWG)	**Maximum current by couple of pairs (A)**
AWG 26	1
AWG 24	2
AWG 22	3

Table 4: UL 486E gauge to maximum current correspondence table (indicative[16])

Currents associated with PoE cables

According to the IEEE 802.3bt all pairs of the Ethernet cable are used in power and data. The current per pair is a maximum of 960 mA (480 mA per conductor).

[16] One RJ45 AWG 24 cable must be able to pass up to 120W on 4 pairs.

Voltage in the circuits of the PoE installation

There is a difference between voltage at the output of PSE and voltage at the PoE receivers. The limit set by the IEEE is 48 V within the limit of 90 m. To obtain this value the PSE injects a voltage higher than 48V but which, according to IEEE 802.3.bt standard, must be lower than 57V DC.

Cable reference temperature

Cables complying with the IEC 61156 or EN 50288 series of standards must operate at temperatures ≤ **60 ° C.**

The temperature rise due to cable losses is often limited to 10 ° C or even 15 ° C in documents dealing with PoE ++.

It is not allowed to use cables with conductors made of Copper Clad Aluminum (CCA), as the increase in temperature due to the circulation of the current will be much greater for these cables due to the resistance of the conductor being higher.

PoE Ethernet Cable Insulators: Conductors and Outer Sheath (External envelope for cables)

The choice of materials will determine the permissible temperature values at the insulation and duct levels. Cable insulators have to be CPR-compliant.

Cable Euroclass (Fire Safety PoE Cables)

To help protect people, property, pets and livestock, the cables to use are Ethernet cables that meet the following euroclasses:

$C_{ca\ d1,\ s1,\ a1}$ in residential buildings

And

$C_{ca\ d1,\ s1,\ a1}$ or $D_{ca\ d2,\ s2,\ a2}$ in other types of buildings.

Euroclass Ethernet cables $Cca_{\ d1,\ s1,\ a1}$ shall be used in residential buildings.

The equipment allowing the routing of these cables will be chosen in particular according to their characteristics regarding the non-flame propagating (as stated by the manufacturer according to the tests of the standards specific to the products concerned) and primarily without halogen or with a reduced halogenic content[17]. In addition, there can be more stringent national regulations to take into account.

Special cases

For outdoor uses, where the cables may be exposed to extreme temperatures, or humidity, special Ethernet cables suited to these conditions must be chosen.

For cables placed outdoors and directly clipped, according to IEC 60364, the selected Ethernet cables are special cables that have received UV treatment.

[17] Halogen-free materials certified by manufacturers or metal-wrapped materials help to achieve this goal.

For such cases:

- Cable buried under ducts
- Cables under external gutters,

It is advisable to use Ethernet cables in high density polyethylene (HD) or medium density (MD). This is common for installations within parks and gardens, pool lighting, architectural lighting on the facade, inter-building links, ...

Level of performance in housing

In order not to degrade the performance levels of residential cabling systems, the quality of the connectors must be chosen according to the desired level of performance. These levels of performance are also related to the care taken in the realization of the pre-wiring of the housing. To achieve the desired performance levels, it is recommended to use the cables and connectors shown below.

Main technical characteristics of the associated wiring				
Cable (4 Pairs)	Connector	Frequency Band	Ethernet Flow (in theory)	Radio Frequencies TV/SAT
F / UTP including 1 pair with screen shielding TV (2)	RJ45 Cat6 screened (4)	250 MHz including 1 pair shifted at 2200 MHz	1 Gbit / s	2.2 GHz on the pair Screened TV
x / FTP (3) 4 pairs with screen shield. With x = S or F or SF	RJ45 Cat6A shunted (5)	500 MHz including 1 pair sheared at 2200 MHz	10 Gbit / s	2.2 GHz on the pair Screened TV

The cables and connectors mentioned must meet the following normative documents:

(2) EN 50441-3

(3) EN 50441-3

(4) EN 60603-7-5 or EN 60603-7-81

(5) EN 60603-7-5 or EN 60603-7-71 or EN 60603-7-81

F: Foiled (shielded screen)

U: Unshielded

TP: Twisted Pair

S: Shielded (braid shield)

SF: Braid + screen

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4.6 Connection devices

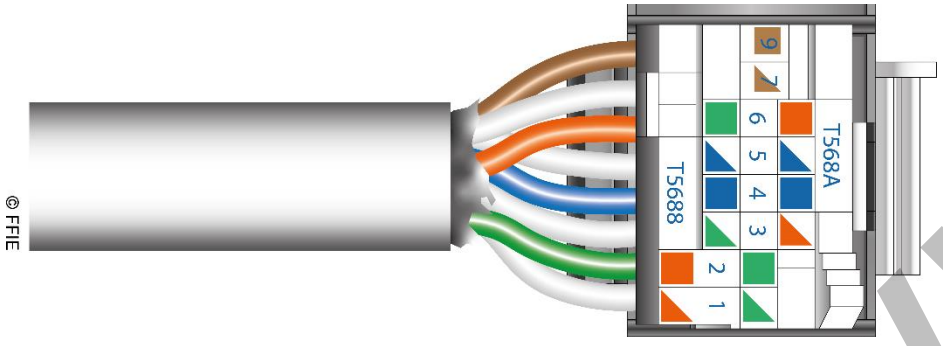

Figure 18: Illustration of an RJ45 connector (PoE board connection)

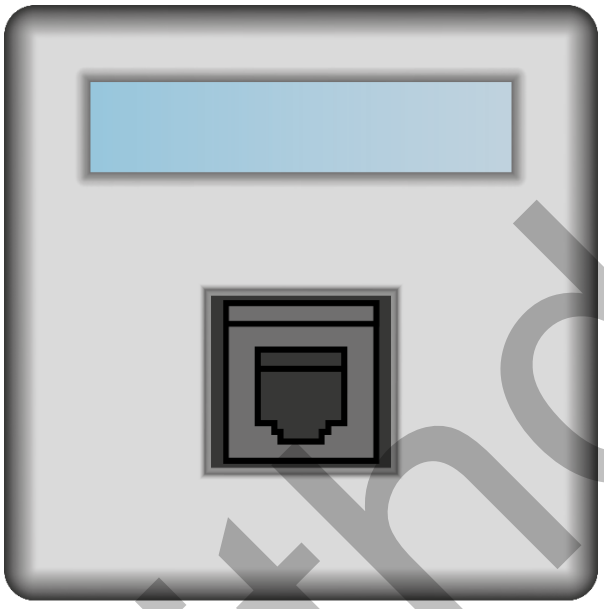

Figure 19: Illustration of RJ45 socket base (PoE wall connection point)

The connection devices to be used are RJ45 sockets adapted to PoE. These outlets have been tested to withstand up to 70 disconnected connections (under load). However, disconnecting an RJ45 (under load) is not recommended.
RJ45 must comply with:

- EN 50173-1;
- ISO/CEI 11801 éd. 1.0 2017-11
- CEI 60603-7-41/51
- EN 50173EIA/TIA 568 A/BPoE (IEEE 802.3af), PoEP (IEEE 802.3at), 4PPoE (IEEE 802.3bt)
- CEI 60512-00-001/002
- C90-485-1

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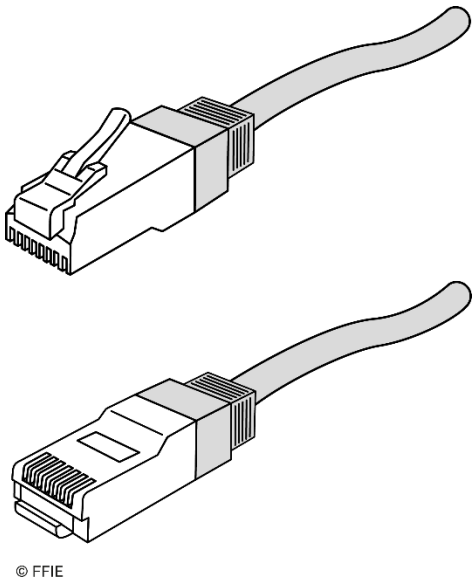

Figure 20: Illustration of RJ45 plugs

In the case of the use of cords for the installation, it is advisable to use cords where the assembly RJ45 connectors and ethernet cable has been certified by the manufacturer.

It is advisable to have tools adapted to terminate male RJ45 connectors (especially for powers greater than 30W).

Connections in USB, HDMI, micro-USB, ... are possible behind a module that converts the PoE into another standard. For example, a PoE / USBc module can recharge downstream connected equipment while transmitting data. The output connection of this module is no longer considered a PoE installation. For example, the output voltage at the connection point may therefore be less than 44 V DC, (for example 12 V DC, 20 V DC, ... at the connection point; in addition, SELV must always be ensured).

Since PoE connection point pedestals (socles) must not have any conductive parts that are accessible in normal use, it is recommended to install outlet socket pedestals with a cover, for terminal socket pedestals. Likewise, the pedestal “hub cap” with a minimum degree of protection of IP2X, must be able to keep any conducting part out of reach.

For RJ45 plugs it is recommended to have plugs equipped with Snagless latches, in order to ensure the durability of the connection.

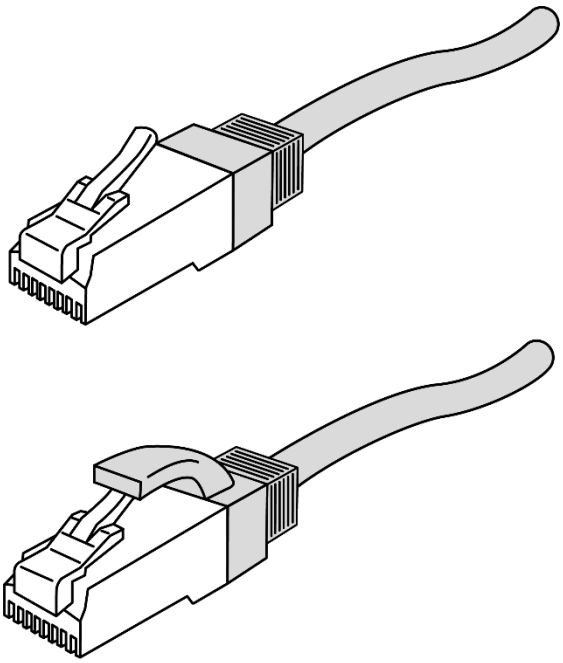

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Figure 21: Illustration of the RJ45 plug without Snagless latch (top) and with a Snagless latch (bottom)

Drain wires are not connected to the earthing of the installation, due to the protection against electric shock by means of a SELV system. Cutting the drains wires to the finish on the patch panel also helps to avoid antenna effects.

4.7 PoE Power Supplies

PoE switches are compatible with non-PoE switches, but PoE installations cannot operate on non-PoE switches.

PoE hardware that meets the IEEE 802.3af or IEEE 802.3at standard operates on IEEE 802.3 bt installations.

Isolation transformer

Compared to a standard switch that only manages the data, the PoE switch also manages the power.). The equipment connected to it (see chapter 4 - equipment) does not need an external power supply.

The PoE Switch is also called PSE Endspan (or PSE End-Span) especially for technological applications. The difference between the MIDSPAN PoE and the ENDSPAN PoE.

Our advice
↰ Favor modular switches: easier to replace in case of module failure, more secure to ensure continuity of service, more suitable to complete the installation. ↰ Focus on DIN rail switches for PoE installations to co-exist with traditional installations. ↰ Adapt the size of the switches to the needs of your customers but anticipate the evolution of needs by providing free ports in sufficient number. ↰ Favor separate power supplies to the switches. ↰ Think about the redundancy of the power supplies. ↰ Opt for the supply of switches from a DC Bus powered by renewable energy solutions such as photovoltaic, wind, hydraulic, hydrogen, ... or a combination of these solutions. ↰ Favor AC / DC fanless power supplies, by construction, as they generate less noise, they can be integrated more easily in places of work. In addition, this solution does not necessarily require the establishment of an air conditioning system. ↰ To change the switchboards, provide for a 20% reserve percentage.

Regarding the power, each PoE switch must be selected according to:

- The maximum power supplied to connected equipment on an RJ45 port.
- The power that the switch can provide to all RJ45 ports (the term "PoE budget" can be used to refer to this notion and is the total power).
- The average power per RJ45 port.

The choice of a switch is also based on the total power it can provide the equipment that is to be connected. It is important to provide a power reserve from the beginning of the project.
Regarding environmental factors, it is important to define the characteristics of the switches according to the respective environmental conditions of the premises or locations in which they will be installed. Thus, the maximum temperature levels at which the switches and the elements of the installation connected to or connected to it (subject to prior information) and the ambient temperature during normal operation will be considered. Upstream of the switches, it may be necessary to provide a UPS. PoE switches can be interconnected by fiber optics

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4.8 PoE surge arresters

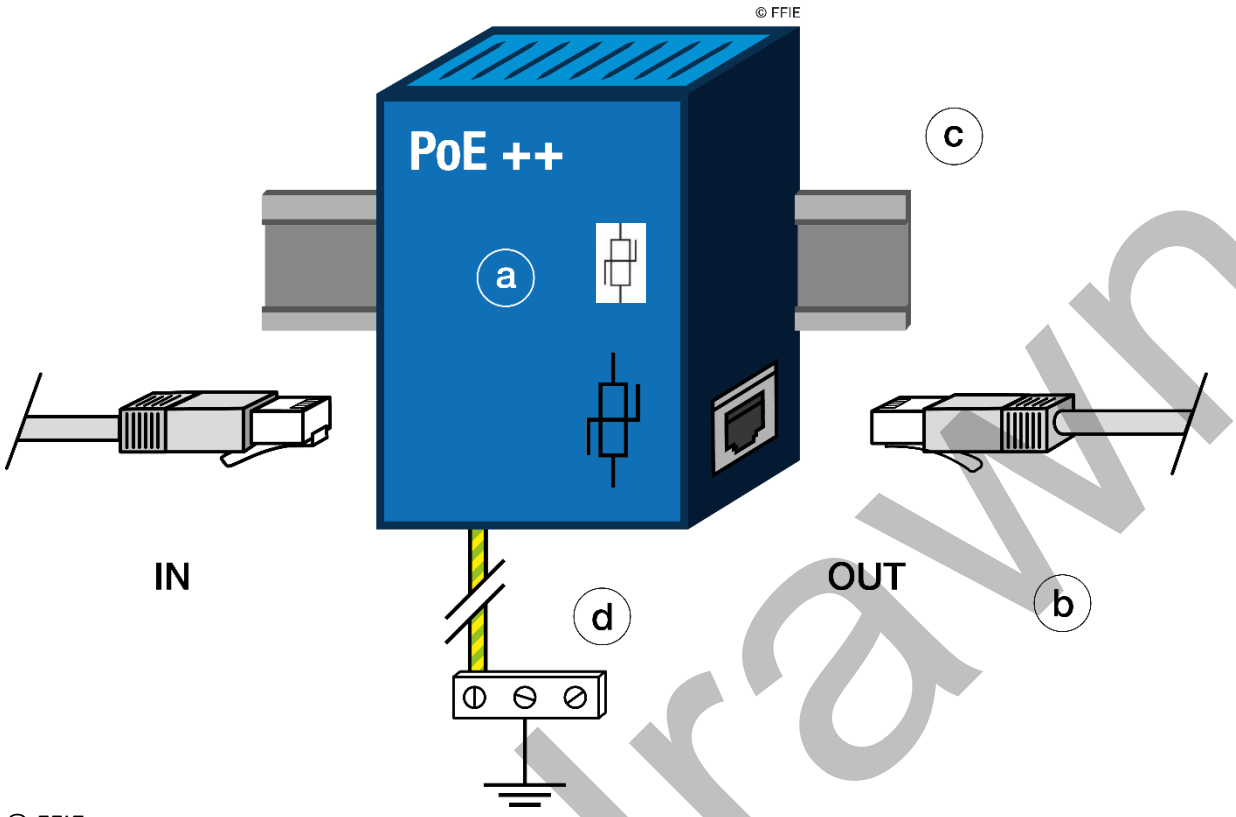

Figure 22: Example of a PoE surge arrester in situation

a: PoE SPD
b: RJ45
c: rail DIN
d: Earthing connection

Warning: these are surge arresters installed directly on the PoE installation. These surge arresters are complementary with surge arresters installed upstream of the PSE.

PoE Surge Protective Device (PoE SPD) does not affect the SELV because the earthing is done through an electronic component (digital ground). This is not a direct grounding/earthing.

PoE SPDs must be chosen according to the standard EN 61643-21 "Low-voltage surge arresters - Part 21: Surge arresters connected to signal and telecommunication networks - Operating requirements and test methods" and IEEE 802.3af / IEEE 802.3at / IEEE 802.3bt. Compliance with UL497 B is a supplement.

Particular attention will be given to the continuity of the link between the upstream and downstream PoE, and therefore particularly to the pinout. One of the possible pinouts is (1-2) (3-6) (4-5) (7-8).

The surge arresters are to be chosen according to parameters such as the protection level Up (to be compared with the rated impulse withstand voltage Uw of the equipment to be protected), according to the shock current (I_{imp}) and the discharge current (I_n).

Coordination between PoE SPD and other Surge Protective Devices of the installation have to be ensured as per the recommendations of manufacturers.

The parameters of a PoE SPD are the following.

	Parameter designation	Example values
A	Rated line voltage	48 Vdc
Up	Protection level	@ In (8 / 20µs) Up 70 V
I_{imp}	Shock current	Test 10 / 350µs x 2 - category D1 500 A
$In_{L/L}$	Nominal Discharge Current Line / Line	Test 8 / 20µs x 10 - Category C2 500 A
$In_{L/PE}$	Discharge Current Line / Earth	Test 8 / 20µs x 10 - Category C2 2000 A
Uc	Operating maximum DC Voltage. The maximum voltage Uc in the arrester must be greater than or equal to the value indicated in the Table below.	60 Vdc
IL	Current max. line	2000 mA IL
D	Maximum Data Rate.	1000 Mbps
F	Maximum frequency	f> 100 MHz
P	Insertion loss	<1 dB

Table 5: Parameters of a PoE surge arrester - example

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4.9 Electrical switchboard

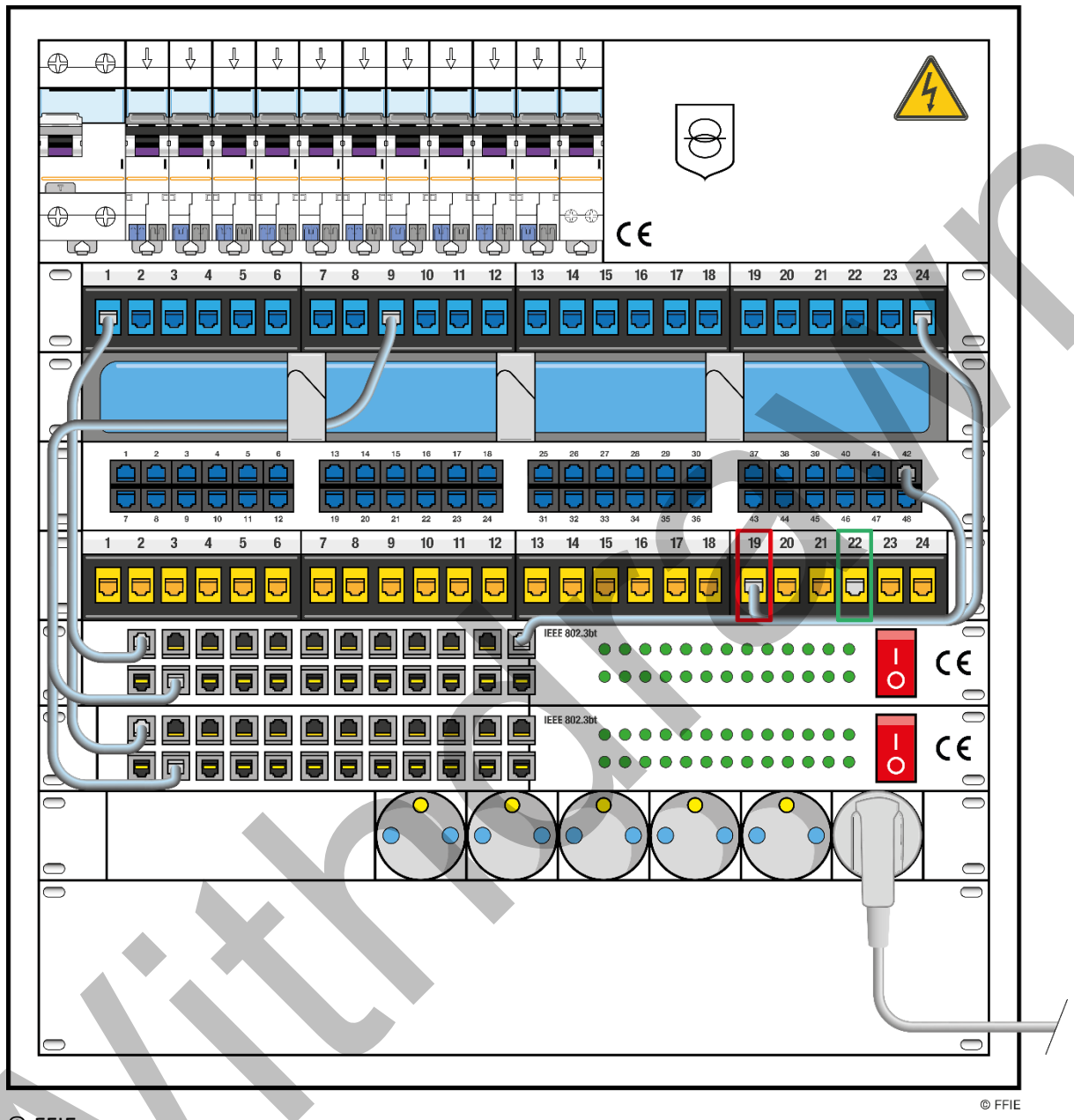

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Figure 23: Example of PoE switchboard

Each electrical switchboard powering PoE installations consists of an enclosure to accommodate PoE switches, and their AC / DC power supplies, (if they are not embedded into the switches).

Each switchboard has a lockable door with a key or tool.

With the door open, insulating protections shall prevent any contact with the active parts.

The envelopes are adapted to the conditions of external influence at the point of installation.

In cases where the cabinets are not visible and are placed in ducts (sheaths), particular care will be taken to choose cabinets whose depth is compatible with complete integration into the duct. A distance of at least 70 mm of clearance must be left on the front of the cabinet.

Each switchboard is powered by a dedicated duct, with dedicated electrical protection, ensuring overcurrent protection, against over-voltages and against indirect contacts. The switchboard must provide protection against direct contact. The upstream protections of the PSE of a cabinet and the safety converters of these PSEs can be found in the cabinet (panel or rack). The power supply of the cabinet can be doubled or equipped with an Uninterruptible Power Supply (UPS) in case of regulatory obligation or by necessity of operation. In the case of multiple power supplies (e.g. Renewable Energy Source and network), a security statement indicating presence of multiple power supplies with the electrical safety logo, (as shown below), must be placed on the front of the panel.

WARNING: Electrical hazard
Multiple power supplies

Each switch supplying the PoE installation is powered by a safety transformer protected against overcurrent and surge protection. Equipment powered from a 16A 2P + T power outlet must be protected by a residual current device with a maximum sensitivity of 30 mA Type A or F.

Each switchboard must be properly ventilated.

As a minimum level of protection against external influences, all the elements of the installation must be IP2X or IPXXB in the installations located within the technical electrical rooms or technical ducts (sheaths).

It is advisable to choose DIN rail switches especially for PoE installations in the existing, but also in new installations in order to gather both technologies in the same envelopes of the traditional installation parts and the PoE installation parts.

The conductive elements of the enclosure (switchboard) must be grounded for the parts upstream of the PoE switches.

Shallow (thin) switches will be favored to facilitate the integration of PoE cabinets in ducts, and to a depth compatible with ducts.

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Construction Products Regulation (CPR) applied to the cables and conductors

CPR is a European regulation that has applied since July 2017 to many building products including permanently installed cables in construction work (Building or Civil Engineering).

Any cable or conductor now must be certified according to a Euroclass and must bear the CE marking, the declaration of performance, etc.

Ethernet cables on the market have a Euroclass with Dca or Cca fire reaction.

Note that the risk of emission of hazardous smoke in case of fire is reduced with Ethernet cables that are halogen-free.

It is necessary to ensure the correct application of this Regulation.

5. Self-assessment and control

This chapter covers aspects that need consideration when constructing a PoE installation.

5.1 Material selection

1. PSE are PoE switches (this does exclude the use of non-PoE switches).
2. Presence of CE marking on all products.
3. Electrical equipment to construction class III; class I equipment is forbidden.
4. Power source equipment (PSE and injectors) for PoE installations will comply with the requirements for SELV systems.
5. Active equipment is compliant with IEEE 802.3bt standard, or with previous versions of this standard: IEEE 802.3af or IEEE 802.3at; as indicated by the presence of the product marking or mentioned in the manufacturer's manual for each piece of equipment, (excluding the non-PoE receivers).
6. The AC / DC converter must be compliant with standard EN 61558-1 “Safety of power transformers, power supply units and similar” and EN 61558-2-6:2010 Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V -- Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers.
7. All Ethernet cables must be euroclass Cca $_{s1, d1, a1}$ or Dca $_{s1, d1, a1}$; for PoE installations the use of Cca cables s1, d1, a1 is recommended except in residential premises where it is required. Additional national measures will also have to be taken into consideration.
8. All Ethernet cables must be AWG 24 to AWG 26. The term "Gauge" measured in AWG is the American equivalent of the cross-sections. The larger the AWG, the smaller the section.
9. All Ethernet cables and power cords used must be a minimum of category 6a.
10. All Ethernet cables of manufactured systems integrated in the PoE installation between PoE switch and receiver must be made of cables of a minimum category of 6a. The only category 6 Ethernet cables can be accepted on terminal PoE systems (e.g. camera with its own Ethernet cable) and with short links.
11. All trunking system components used for cables must be flame retardant.
12. All wall penetrations must be capped with plaster, or plaster with glass wool or rock wool.

13. Rigid Ethernet cables cannot be used for patching or direct connection of fixed installation parts to the switch(es).
14. Consideration of environmental factors is to be taken in case of risk to people, domestic or farm animals and property. The same for presence of Ethernet cables suitable for use outdoors, underground or exposed to external environmental influences (example: external influence AN3 according to HD 60-364 UV exposures) according to indications of the cable manufacturers.
15. Adapted connections for PoE: all connectors must be PoE certified by their respective manufacturers. For example, RJ45 connectors are designed for PoE applications.
16. All the used connectors must comply with the applicable standards.
17. The electrical equipment contained in each switchboard must be designed to provide protection against direct contact. Alternatively, each switchboard has to be protected with a door and locked with a key or tool.
18. On the blueprint the cable links between PSE and receivers must be 90 m long maximum.
19. Switchboards must be chosen according to the external influences of their environment, and with the minimum degree of protection IP2X or IPXXB (according to IEC 60529).
20. Switchboards with conductive parts (class I) must be grounded/earthed.
21. All equipment of the PoE installation is designed with halogen-free materials, for adequate fire protective characteristics.

5.2 Installation

1. PoE installation must comply with EN 50174-2 in force for other types of installation.
2. In case of mixed-use buildings (for example residential and tertiary buildings), compliance must be ensured with the most stringent applicable standard.
3. No part between the AC / DC power supply supplying the switches and receivers should be earthed. Only shielding of Ethernet cables can be earthed. Same rule if the switches are powered directly by a DC production facility.
4. In case of power supply by photovoltaic installations with DC injection on the PoE installation, or in case of AC injection upstream of the PSE, PV installations shall comply with part 7-712 of HD 60364 or national transposition.
5. Each cable group (concentric strand) must consist of a maximum of 24 cables. In case of a flat formation, identical provisions apply.
6. There must be no right angles in the visible parts of the cable.
7. The bending radius are respected with an imaginary circle where the bending radius is at least equal to 12 times the outer diameter of the cable.
8. The distance between strands must be greater than or equal to 3 x D (D being the diameter of the strand) with a minimum of 100 mm over the entire length from the switch(s) to the receiver(s).
9. Between a PoE installation and a traditional power installation there must be a default distance of 200 mm, or adapt according to national rules.
10. No PoE connection points should be installed in zones 0, 1 and 2 of rooms containing a bath or shower, hot tubs or balneotherapy, according to HD 60364 part 7. The conventional voltage limit is 12V DC in zones 0 and 1.
11. Regarding the risk of overvoltage, SPD Type 2 or SPD Type 1 + Type 2 upstream of the PoE switchboard should be present.
12. Each PSE must be protected against overvoltage by an SPD.
13. Each part of PoE installation coming out of the building must be protected by a PoE SPD (minimum protection downstream of the switch) in accordance with the standard RJ45.

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14. When an RCD (residual current device) protects the switch, such RCD must be of type A or type F.
15. When the switch is supplied by a socket outlet, the circuit supplying the socket outlet has to be protected by an RCD with a maximum rated residual operating current of 30 mA.
16. Emergency lighting managed by a PoE installation has to meet national regulation requirements.

In certain types of buildings, special national rules apply.

5.3 Tests

Security tests

1. Measure lack of electrical continuity on each part of the PoE installation (be careful not to make an insulation resistance test, because you may damage or destroy PoE equipment).
2. Verify continuity of the conductive parts upstream of the PSE (e.g. switchboard).
3. Optional: Verify absence of hot spots by infrared thermography all along entire length of the cable run, and all connected electrical equipment, while the circuit is energized.

Functional tests

1. Check LED light on each RJ45 switchboard connector.
2. Test the installations located between the PSE and the PoE / non-PoE receivers as follows: verify connection of the 8 conductors to the final RJ45, measure cable resistivity and verify category of cable used.
3. Perform functional tests related to each piece of equipment, such as: camera, sound system, lighting, BMS, etc ...
4. Make resistive imbalance test:
    a. Measure resistive imbalance in each pair
    b. Measure resistive imbalance between two pairs.

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6. Installation and commissioning

In addition to the general provisions described in Chapter 3 and the hardware selection criteria described in Chapter 4, the following rules apply:

6.1 Installation rules for cabling and PoE modules

Any part of the installation located upstream of a PSE must comply with the European and/or national regulations in effect for the type of building concerned and the general rules of the low voltage installations standards in effect.

For the PSE, the installation rules are described below. They do not replace the regulatory provisions in effect for each type of building.

The basis of the PoE installation is to realize a communication network and an IP infrastructure. In order to carry out wiring of PoE installations, the following provisions should be applied: EN 50174-2 «- Information- Wiring technology installation -Part 2: Planning and installation practices inside buildings ».

The rules for the PoE installation are independent of the Earthing system upstream of the PSE.

The overall architecture of the cabling is a star wiring configuration from the PSE.

In addition, the standard EN 50173-1 "Information technology - Generic cabling systems - Part 1: General requirements" lists the products and wiring diagrams.

PoE installations are to comply with the rules of protection against the interactions between the control circuits / communication networks concerning the interaction between the power networks and the communication networks. Professionals are also advised to equip the installation with anti-harmonic filters.

Once the wiring has been completed, connect:

- PoE receivers or PoE interfaces to the switches.
- Terminal objects at PoE receivers.
- Possibly electrical equipment or objects connected to RJ45 sockets.

The preferred installation mode is a lay-up mode. Any laying in strands is allowed but the number of cables per strand must be limited due to the potential of excess heat building up.

For this reason, the maximum number of cables per strand (or layer) is limited to 24 for a maximum length from the PSE of 90 m. This arrangement is also valid for the ribbon wiring mode.

The maximum number of 24 cables in a strand within the limit of 90 m allows under normal environmental conditions (of which external T ° of maximum 20 ° C) and in single mode of apparent and correctly ventilated laying at the same time to ensure adequate transmission of data (in the absence of external disturbance) while having a temperature rise in the center of the strand that does not affect the safety of people and goods.

This length takes into account a length of 80 m of fixed wiring, and 5m of patch cords on each side.

It is however recommended to limit the number of cables per strand or ribbon wiring to 19.

The cables are fixed every 200 mm to the cable trays / slabs and every 500 mm in plenum with a length of reserve allowing a connection to a remote location.

PoE modules are fixed to the fixed parts of the building with the exception of modules placed in false ceilings (lighting type, sensors, sound, video protection, ...) or partitions (conversion module PoE / USB for example).

These conditions for limiting the number of cables per strand are based on an apparent laying mode in an outdoor ambient temperature of 20 °C, which ensures that the temperature of 60 °C in the center of the sheet is not reached in normal service (according to IEEE 802.3bt).

The cables can run under fasteners, ducts, conduits, cable trays or slab paths.
In case of more severe temperature conditions or laying mode, the reduction of the number of cables per strand (or layer) may be necessary.

A security statement may be placed at the patch bay.
"Ensure connection-disconnection without load"

	U/UTP	F/UTP, SF/UTP	U/FTP, F/FTP, S/FTP
Category 5e	0,49 to 0,52 mm 9,5 Ω/100m	0,51 to 0,53 mm 9,0 Ω/100m	No typical design
Category 6	0,52 to 0,55 mm 9,0 Ω/100m	0,53 to 0,55 mm 8,5 Ω/100m	0,54 to 0,56 mm 8,0 Ω/100m
Category 6_A	0,54 to 0,56 mm 8,0 Ω/100m	0,55 to 0,57 mm 7,5 Ω/100m	0,55 to 0,57 mm 7,5 Ω/100m
Category 7	No typical design	No typical design	0,55 to 0,57 mm 7,5 Ω/100m
Category 7_A	No typical design	No typical design	0,58 to 0,60 mm 6,8 Ω/100m
Category 8.1 (ffs.)	No typical design	0,61 to 0,64 mm 6,5 Ω/100m (ffs.)	0,61 to 0,64 mm 6,5 Ω/100m (ffs.)
Category 8.2 (ffs.)	No typical design	No typical design	0,61 to 0,64 mm 6,5 Ω/100m (ffs.)

Table 6: Diameter and linear resistance of Ethernet cables and function of Ethernet cable types and their categories (values given for information only)

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The distance to the power cables of 200 mm minimum over the entire length from the switch(es) to the receiver(s).
Each cable is laid with a bending radius of at least 12 times the outer diameter of the cable.

In the case of particular environmental conditions, for example for buried or outdoor installation cables, the cables to be used are Ethernet cables to be suitable for the conditions of external influences and allowed for that specific use according to the manufacturers' recommendations.

For example, for a buried or underground laying mode, the cables to be used are Ethernet cables of category 6a minimum in High Density Polyethylene (HDPE) or Medium Density Polyethylene (MDPE). These cables, although provide good moisture protection have the disadvantage of being flame propagators. They can be found (and accessed) in technical rooms but are prohibited elsewhere inside the building and are not to be used inside residential buildings. Thus, in the case where the cable buried underground or outdoor leads to a building, it will be placed systematically in a flame-retardant sheath, which is in turn plugged with flame-retardant material at the point of entry of the building. The cable will be connected at the point of entry (to the building) to a category 6a Ethernet cable for the indoor circuit. Different types of cables are needed for outdoor or indoor uses.

Another example, for installation in an area exposed to UV light, the Ethernet cables will be a minimum of category 6a and will be shielded from the effects of UV light, as per the manufacturers' instructions.

Cable drains must not be grounded. On the other hand, the Ethernet cable shield can be grounded without altering the SELV, if they are not in contact with drain wires by design. It should also be ensured that the contact of the strips with the metal braids at the RJ45 sockets does not diminish the class III nature of the installation.

It will also be ensured that no strip (earthed) is in contact with conductive parts of the constituent elements of the installation placed downstream of the switch SELV supplies (for example a strip placed in contact with a base connection socket RJ 45).

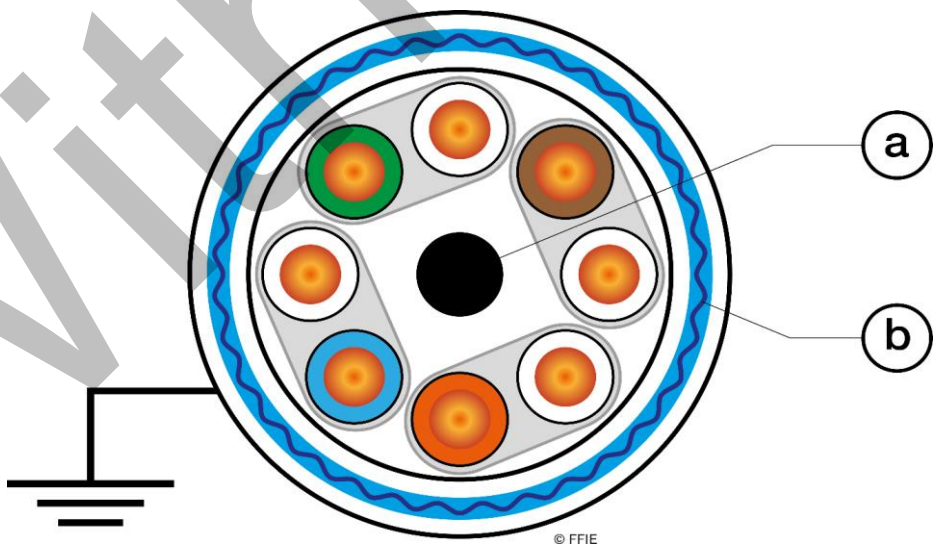

Figure 24: diagram of an Ethernet cable

a: drain

b: cable shield

On the cable run from the patch panel to the receivers, there is no need to access the connections. However, it is recommended to avoid multiplying the connections in order to limit the weakening of the signal strength.

The terminal parts of the cables to be connected must be marked for easy pairing and / or equipped with a tag, flash code, chip ... for means of identification.

6.2 Installation rules for PoE power supplies (PSE)

The sources (PSE) powering the switches are installed in cabinets, paintings or bays. They must be located upstream of an isolation transformer, as the entire PoE installation downstream must be SELV. The power supply of these switches is protected against leakage current.

Each switch, if it is powered from a socket outlet, that is protected upstream by overcurrent protection (e.g. D-curve circuit-breaker) and a 30 mA Residual Current Device of either type A or F. Protection provided for each switch aims to contribute to the continuity of service, and minimized inconvenience in the event of a fault. The choice of PSE with redundancy also contributes in this endeavor. Downstream of the switch (DC side) no electrical protection is required as DC protection is provided by switches and / or PoE modules.

For the dimension of switches see chapter 4.

6.3 Installation rules relating to overvoltage protections

Every building equipped with a PoE installation, must be protected against over-voltages of atmospheric origin via a Type 1, Type 2, or Type 1 + Type 2 SPD installed at the origin of installation or close to the origin.
Upstream of the PSE, this protection is supplemented by the installation of SPD:

- Type 2 in case of presence of a Type 1 upstream
  or
- Type 3 in case of presence of a Type 2 upstream.

Downstream of the PSE, the protection can be completed for each circuit by a communication SPD for PoE application with shielded RJ45 connectors. This SPD complies with standard IEC 61643-21 "Low-voltage surge arresters - Part 21: Surge protective devices connected to telecommunications and signaling networks - Performance requirements and testing methods" and IEEE 802.3bt. The implementation of PoE SPD protects the receivers downstream of the PSE.

Such protection must be implemented for any receiver connected to the PoE installation and located outside the building. The parameters for choosing such equipment are described in Chapter 4 of this reference document.

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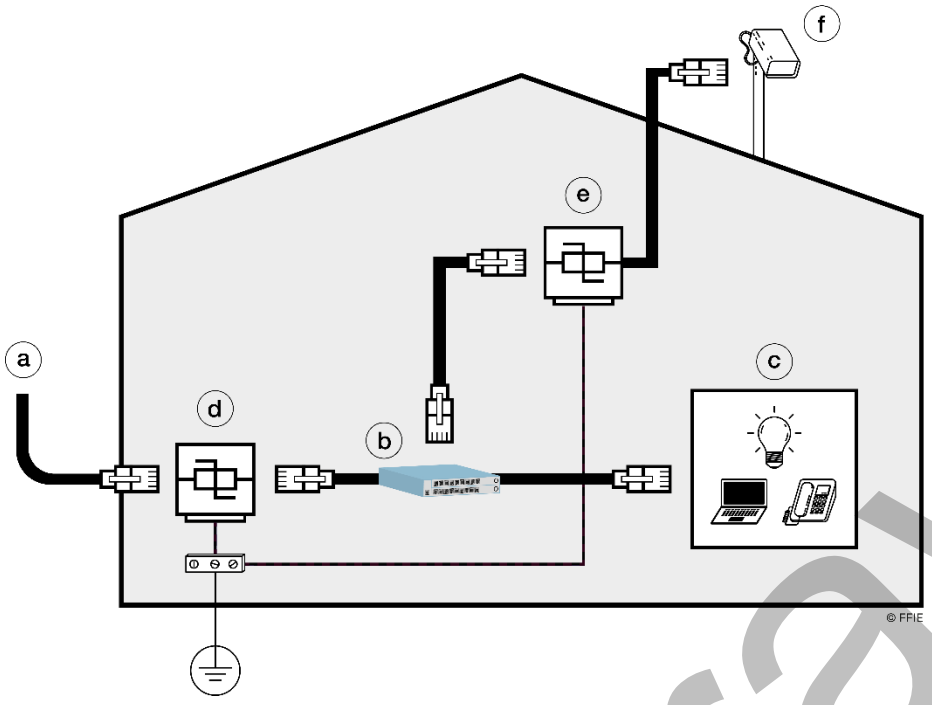

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Figure 25: Example of protection against atmospheric over-voltages in a PoE installation

a. External network
b. PSE
c. PoE receiver/module
d. Communication surge arrester
e. PoE surge arrester
f. PoE camera

The protection integrated into the PSEs is not taken into account in the context of this standard.

6.4 Connecting the RJ45 sockets

There are two types of connection for these sockets. The type A and type B connections are distinguished (independently of the PoE). Type B is the most used in housing/domestic sector and A in the commercial/industrial sector. The fundamental concept is to make a connection of type A or type B at both ends of each connection of the PoE installation. The entire installation must be done with the same type of wiring.

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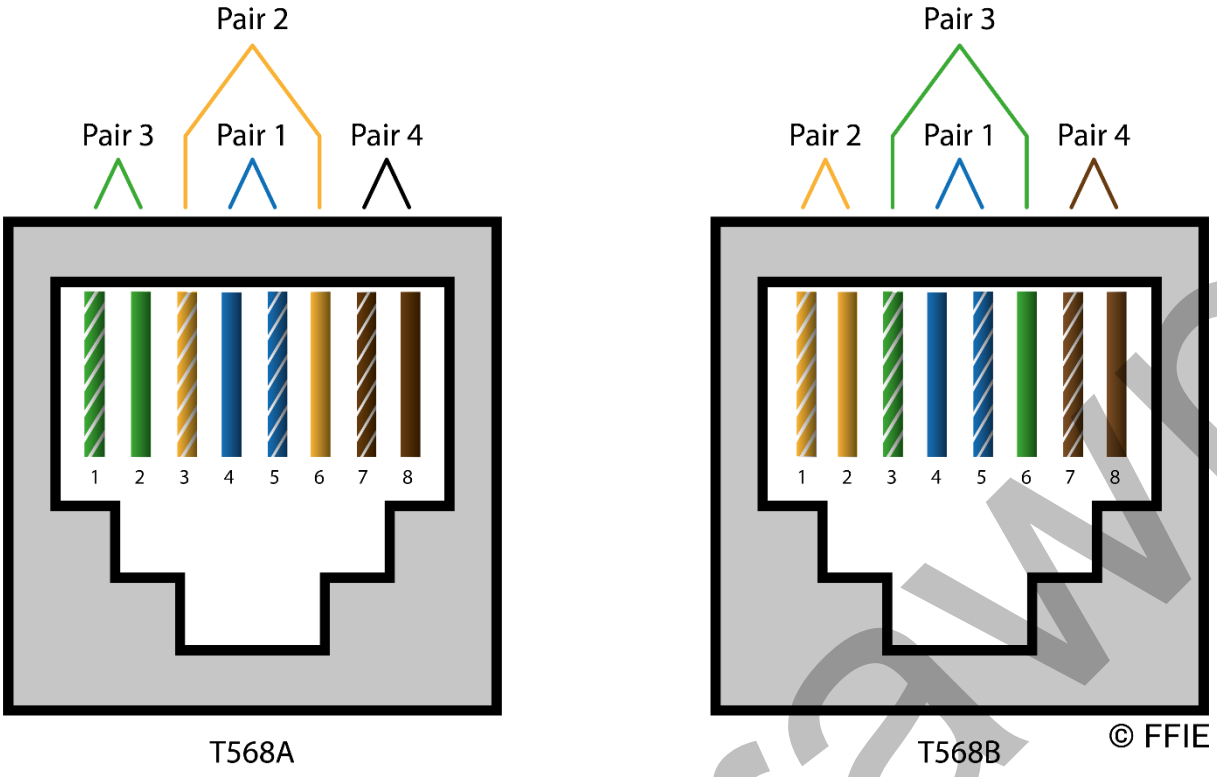

Figure 26: Type A connection and Type B connection

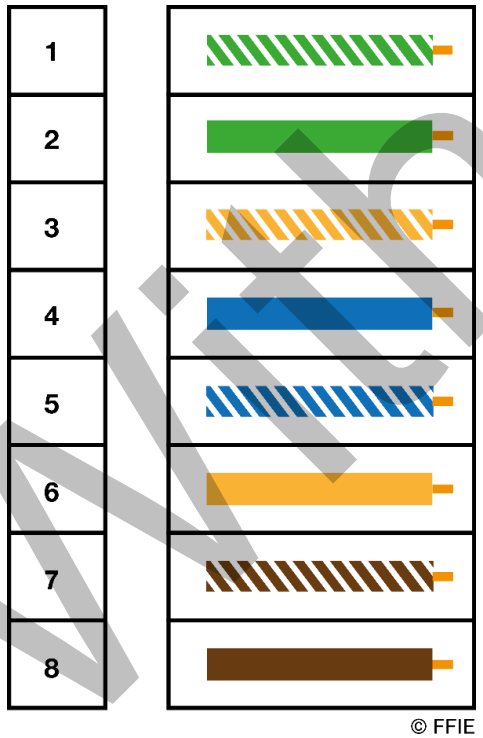

Table 7: Type A connection - color detail by contact

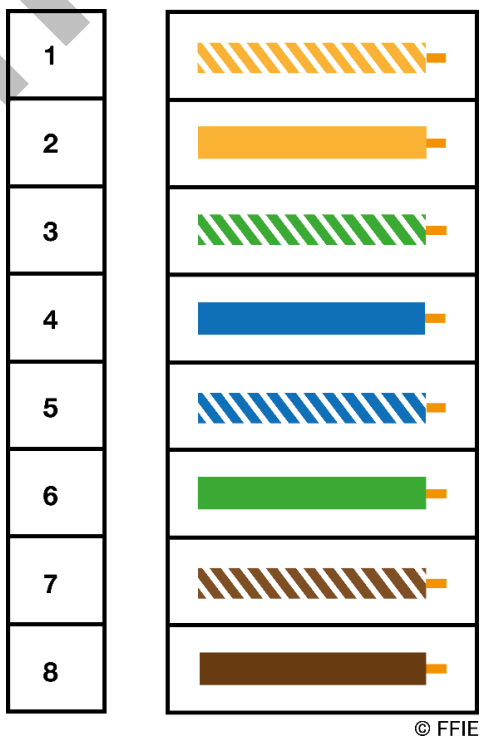

Table 8: Type B connection - color details by contact

In practice the switch detects if it is a connection of type A or type B.

For unused cable cores, it is strongly recommended to equip them with a cap securely fixed to the connector so that the contacts are not damaged while waiting for the connection

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6.5 Management of the emergency lighting

The installation of security lighting, the specific national regulations have to be respected.

Pending the appearance on the market of autonomous blocks in PoE, it is necessary to apply the regulatory provisions by relaying the backup blocks from the switches or from the lighting modules.

Figure 29 gives an example of relaying. Another solution is to consider the loss of power in all the equipment of the installation (bay protection circuit breaker, optocoupled output or TOR switches, monitoring bay transformers, ...) relaying by a contactor placed downstream of the protection of the security lighting device.

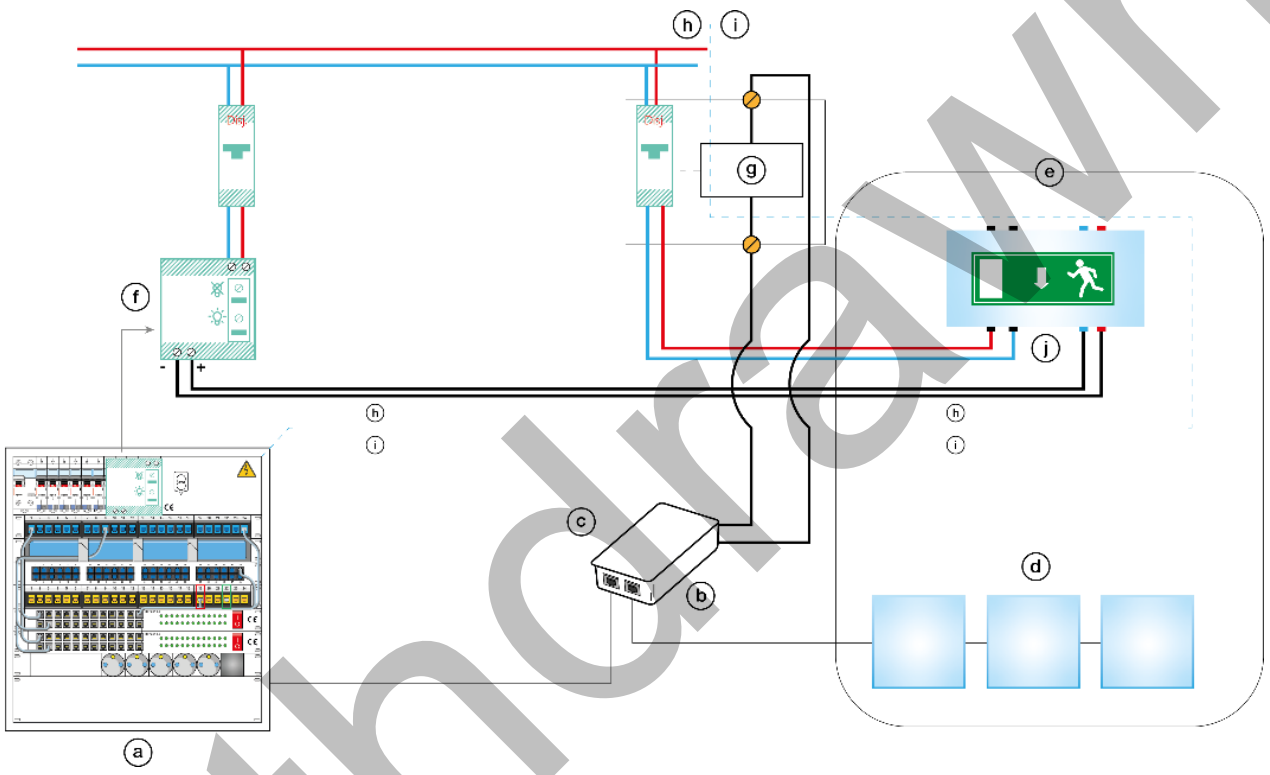

Figure 27: Schematic diagram of safety lighting in PoE

a: PoE Switchboard

b: PSE

c: PoE Module

d: device

e: technical room or area

f: emergency lighting

g: emergency lighting command

h: low-voltage distribution

i: SELV distribution

j: emergency lighting bloc

Note that the autonomous safety lighting units must comply with the EN 60598-2-22 standard or any other standard or equivalent technical specification of another State belonging to the European Economic Area. To date, central source emergency lighting solutions for Power over Ethernet electrical installations are under study. In the same way, the security lighting solutions of a PoE installation with autonomous SATI blocks are under study.

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6.6 Parameterization and commissioning rules

Once the PSEs are installed, and the cables have been connected to the PSE, the commissioning has to take place step by step and not at the end of the construction process.

The cable-module or PoE cable-receiver pairing must be done as modules and receivers are installed.

Tip: devices to associate the terminal part of the cable and equipment by scanning a flashcode on each of the two parts to connect exist and allow you to save valuable time.

Parameterization and commissioning for the majority of receivers to connect to a dedicated application, usually a WEB interface, for programming (example: WEB server in the case of IP cameras). The process for a PoE-based BMS is identical to that of a smaller PoE installation. This WEB interface can be located directly in the switch, on the local server, or on a remote server (Cloud).

Then, depending on the specifications or the clarifications provided by the client, it is necessary to apply the parameters to each receiver or to each PoE module on the graphical user interface. Below are examples of configuration via a user interface.

For a PoE-based BMS, the installation and commissioning process is the same.

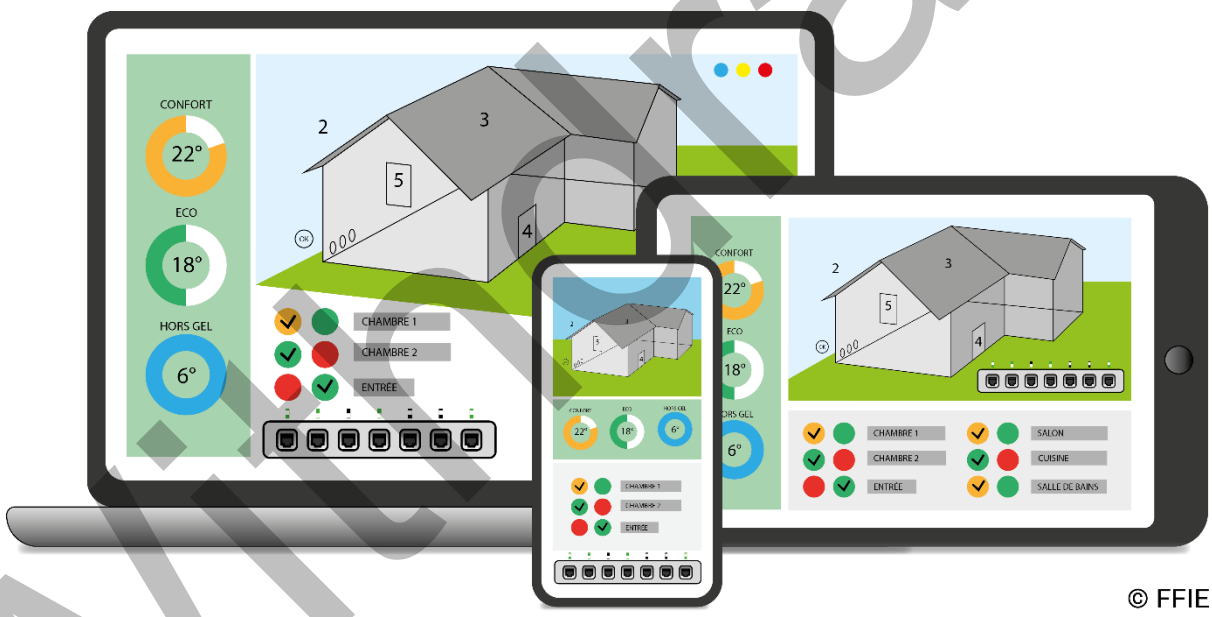

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Figure 28: Example of a graphical web interface

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7. Maintenance

A maintenance contract must be established for any new PoE installation.

This contract will take into account, in particular, the functional aspects related to the installation and the BMS, if connected.

The following 4 maintenance levels also have to be considered:

- Corrective
- Systematic
- Conditional
- Preventative

Preventive maintenance operations must be provided for visual verification of the absence of intentional earthing on the visible parts of the installation at the level of the outputs of the PSEs that can cause the SELV installation to reach dangerous potentials.

Among the maintenance operations to be carried out are:

- State / condition of the connections.
- Equipotential bonding on the conductive parts of switchboards.
- Visual status of protections (overcurrent & overvoltages) upstream of PoE switches.
- Verification of the integrity of the SELV downstream of the PoE switches.
- Checking functionality integrity.
- Etc.

Operations can be practiced remotely, for example, the reconfiguration of a switch, the commissioning of uses downstream of a switch, the control of the status of remote protections, ...

It is important to note that the operations carried out remotely are not a source of electrical or non-electrical risk to people, domestic animals and / or livestock and property.

8. Related services

The services related with a PoE installation are numerous, particularly because of the convergence of data and power on the same network. Below is a non-exhaustive enumeration of services that offer opportunities associated with a PoE installation.

Those services must be achieved within the framework of the regulations. This is for example the collection of data from third parties, the recognition of users, behavioral analysis, ...

- Collect data in compliance with GDPR
- Measure and compare (sensor grouping hygrometry, temperature, movement / presence, ...)
- Alarm
- Management of Energy Consumption.
- Product data sheets
- Internet of Things (IoT)

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- Technical Building Management / Energy management of the building and its uses (the management of traditional uses via the PoE installation must be taken into account)
- Building Automation
- Video surveillance and associated applications
- Access control
- Lighting control
- Sound systems
- Energy and Energetic Regulation
- Sleeping Management
- Assisted living facilities applications
- Voice assistant
- Lighting facades with lighting scenarios/features (example: chain of stores with lighting scenario depending on commercial events or times of the year)
- Separate or simultaneous remote installations
- Reduction of instantaneous consumption of appliances connected to a PoE installation

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9. Abbreviations – Definitions

AWG: American Wire Gauge

BMES: Building Energy Management System

BMS: Building Management System

BOS: Building Operating System

Chaining (PoE Chaining): installation part that consists of connection of several PoE modules or PoE receivers in order to distribute the power available on an Ethernet cable from PSE

Cloud: set of networked servers to store digital data

DECT: Digital Enhanced Cordless Telecommunications

DHCP*:* Dynamic Host Configuration Protocol, this protocol allows to dynamically assign IP addresses.

EMC: electro-magnetic compliance

GDPR: General Data Protection Regulation

HVAC: Heating, Ventilation, Air Conditioning

IEEE: Institute of Electrical and Electronics Engineers

IEEE 802.3af: IEEE standard for IP networks with PoE supply <15W

IEEE 802.3at: IEEE standard for IP networks with PoE supply <30W

IEEE 802.3bt: IEEE standard for networks IP with PoE supply <100W

Installation in PoE (or installation in Power over Ethernet): DC installation for the transmission of digital information and power over twisted pair cabling; installation consisting of one or more PSE, PoE receivers, twisted pair cables, connectors (for example RJ45), ...

IP: Internet Protocol

LAN (LAN Ethernet): Local Area Network

LSZH: Low Smoke Emission and Zero Halogen.

MAC (or MAC Address or MAC address): Media Access Control, physical address on a network adapter or a network interface

PELV: Protective Extra-Low Voltage

PoE: Power over Ethernet

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PoE Device (PD): device designed in accordance with IEEE 802.3

PoE driver: See PoE module

PoE ENDSPAN (or END-SPAN): configuration of PoE installation where receivers are directly powered from a PoE power source (PSE-ENDSPAN)

PoE Interface (PI): power interface located between a PSE and a PoE receiver. The term "PoE Repeater" can also be used

PoE MIDSPAN (or MID-SPAN): configuration of PoE installation where an additional PoE power source (the PSE -MIDSPAN) is connected between the receivers and a non-PoE switch

PoE module *(*or PoE Driver): interface compliant with the IEEE 802.3 standard designed to be installed between a PSE and one or more non-PoE receivers, allowing the supply and exchange of data with one or more non-PoE receivers, and which can include related functions

These functions include the possibility of chaining PoE modules together, radio communication to control devices, integration of relays, ...
Some modules are designed to allow the connection of more than one non-PoE receivers

PTZ: Pan Tilt Zoom (Camera)

UPS: Uninterruptible Power Supply

PoE Receiver: receiver powered by Power over Ethernet directly, or via a connector (e.g. RJ45) from a PSE. The terms "Powered Device" can also be used (PD). A PoE receiver is intended to consume energy without producing it. For example, this receiver can be a LED driver, a LED light, a control unit for rolling window shutters / blinds, sensor, ...

PPMS: Security Plan Layout of Individual

PSE: Power Sourcing Equipment, power supply for PoE installation.

SELV: Safety Extra-Low Voltage

SPD: Surge Protection Device

RADIUS: Remote Authentication Dial-In User Service Authentication protocol.

WLAN: Wireless Local Area Network

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10. List of applicable standards and regulations

Equipment standards

- *IEC 60512-9-3: "Connectors for electronic equipment - Tests and measurements Part 9-3: Endurance 121 tests - Test 9c: Mechanical operation (engaging / separating) with electrical load"*
- *IEC60512-99-001" Connectors for electronic equipment - Tests and measurements - Part 99- 001: "Test schedule for Engaging and Separating connectors under electrical load - Test 99a: 119 Connectors used in twisted pair communication cabling with remote power"*
- *EN 60950-1: "Information processing equipment - safety - part 1: general requirements"*
- *EN 62368-1: "Equipment for audio / video, information and communication technologies - Part 1: safety requirements"*

Standards for the cabling of communication networks

EN 50174:" Information technology - Installation of cabling systems "

- *Part 1: Installation Specification and Quality Assurance*
- *Part 2: Planning and Installation Practices Inside Buildings*

Other standards

- *ISO / IEC 11801: "Information Technology Series"*
- *Standards for Information Technology*
- *IEEE 802.3af "Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA / CD) Access Method and Physical Layer Specifications - Data Terminal Equipment (DTE) Power Via Media Dependent Interface (MDI)"*
- *IEEE 802.3at "Standard for Information Technology - Local and Metropolitan Area Networks-- Specific requirements-- Part 3: CSMA / CD Access Method and physical Layer Specifications Amendment 3: Data Terminal Equipment (DTE) Power over the Media Dependent Interface (MDI) Enhancements"*
- *IEEE 802.3.bt IEEE Standard for Information Technology - Amendment 2: Power over Ethernet over 4 Pairs, and subsequent amendments*
- *IEEE 802.1X: IEEE Standard for Local and Metropolitan Area Networks-Port-Based Network Access Control.*
- *IEEE 802.11: Wireless Local Area Network*
- *EN 60598-1: "Luminaires - Part 1: General requirements and tests - Luminaires - Part 1: General requirements and tests", and its amendment 1*
- *EN 60950-1: "Processing equipment" information - security - part 1: general requirements"*
- *EN 61643-21 and its amendment 1: "Low-voltage surge arresters - Part 21: surge arresters connected to signal and telecommunication networks - Operating requirements and test methods"*
- *IEC 62368-1: "Audio technology equipment / video, information and communication - Part 1: Security requirements"*
- *EN 50539-11 and its amendment A1 of January 2017 (C61-739-11 / A1):*
- *"Low voltage arresters - Surge arresters for specific applications including direct current - Part 11: Requirements and tests for surge arresters connected to photovoltaic installations"*
- *ISO / IEC 11801-1: 201X: Information technology - Generic Cabling for customer premises - 125 General requirements 126*
- *IEC 60512-99-001: Connectors for electronic equipment - Tests and Measurements - Part 99- 127 001: Test 99a: 128 Connectors Used in Twisted Pair Connectors ation cabling with remote power 129*
- *IEC 60512-9-3: "Connectors for electronic equipment - Tests and measurements Part 9-3: 130 Endurance tests - Test 9c: Mechanical operation (engaging / separating) with electrical load 131"*

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- *ISO / IEC 14763-2: 201X, "Information technology - Implementation and operation of customer 132 premises cabling - Part 2: Planning and installation (to undergo revision)"*
- *EN 50173-1 "Information technology - Generic cabling systems - Part 1: General requirements» List Products and wiring diagrams".*

11. PoE installation in 10 main points

Power Over Ethernet (PoE) is a technology that can carry DC power in very low safety voltage (SELV) over an Ethernet cable while retaining the capacity to transmit digital data. PoE allows to deliver power and digital data from a DC source to terminal equipment. Thus, uses and installations can be managed, and controlled while being powered via an Ethernet network.

Being an electrical contractor, in order to realize a PoE installation, the main points[18] to respect are the following ones:

1. **Calculate the maximum power demand** on the equipment to be supplied with PoE or able to be supplied with PoE: e.g. cameras, WIFI devices, lighting, heating/cooling control devices, motorization, ... Voltage level for each of them must be lower than 57 V DC (or lower voltage levels for example in rooms containing a bath or a shower), of maximum power 90 W per port, and in conformity with the IEEE 802.3 standard, marked CE, SELV for power supplies and Class III for other equipment. Non-PoE devices are powered from a switch via modules that meet these characteristics. I identify any connection points (RJ45 sockets-outlets for example) that must be powered between 44 and 57 V DC included, or with less voltage with suitable modules (e.g. PoE / USB). I choose the equipment according to those criteria.

2. Perform a sizing of the installation in terms of performance of the installation

3. Determine the number of switches (PSE) and their positions. Choose PoE switches powered by safety transformers. Downstream of the switches, provide the protection measure by Safety Extra Low Voltage (SELV) up to the receiver or connection point included.

   Perform a **risk analysis regarding IT security**. Results of this risk analysis determine the **recommendations** and **technological** appropriate **choices**, by adapting the level of IT security to the type of clients. Regarding the hardware, choose RADIUS "client" type switches, that is to say compatible with a RADIUS type server. Secure the hardware via their respective MAC address. Ensure the computer security of the installation by observing the basic rules described in 3.3 and prefer GDPR solutions "Privacy by design" which guarantee the protection of data by design.

4. For the installation, use cables at least category 6a or higher, AWG 24 to 26 Ethernet cables, and provide Ethernet cables of euroclass $Cca_{s1, d1, a1}$. and $Dca_{s2, d2, a2}$. Distance from any receiver (PoE or non-PoE) to their source must be less than or equal to 90 m. This distance takes into account terminal links. For applications outside of buildings, buried or subjected to UV exposure take special precautions to protect the cables. Risk of flame propagation of

[18] I*t is important to take this chapter as a synthesis and as a reminder and to respect the l all of the provisions that are found in this reference system for performing Power over Ethernet installations.*

polyethylene cables required for underground installations must be taken into account (fireproofing, non-propagating flame shield, no use in living units, etc.).

5. Installation of communication networks shall comply with the provisions of standard EN 50174-2. The wiring is made of strands or plies, the number of cables per strand or ply does not exceed 24. A maximum of 19 cables is recommended. For each cable, the radius of curvature is at least equal to 12 times the external diameter of the cable. The strands of cables are spaced apart by 0.3 × D, where D is the external diameter of the strand. PoE installations should be spaced from other types of installations.

6. The switches or modules are connected via connection devices (RJ45) adapted to the PoE, particularly in terms of the number of disconnected connections. As a precaution, no pedestal with a PoE connection should be installed in volumes 0, 1 and 2 of the rooms containing a bath or shower, as well as in swimming pool installations. The quality of the connection of the 4-pair cables at each end point will be particularly verified as well as the type of connection for the entire installation (type A or type B).

7. Commissioning is done as each module or receiver is paired with each Ethernet cable termination. Solutions with a graphical interface allowing commissioning, testing and operation are preferred.

8. Perform a self-control and an acceptance test of the installation according to the framework of chapter 6 "Control and self-checking".

9. Suggested additional / associated services: energy management, usage management, lighting control, continuous improvement, maintenance, and other services.

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