

*White paper*

*Remote Powering*

## Next generation Power over Ethernet



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### Bibliography

1. PoE requirements IEEE 802.3af – 2003
2. PoE requirements IEEE 802.3at – 2009
3. 4PPoE requirements IEEE 802.3bt Draft 1.5 – Nov 2015
4. IEEE Std. 802.3 – 2012 IEEE Standard for Ethernet The IEEE is a registered trademark of “The Institute of Electrical and Electronics Engineers, Inc., USA”.
5. ISO/IEC 11801 – Information technology – Generic cabling for customer premises
6. EN 50173 Row – Information technology – Generic cabling systems
7. EN 50173-6 Information technology – Generic cabling systems – part 6: Shared facility services
8. IEC 60603-7 Connectors for electronic equipment– part 7: Detail specifications for unshielded free and fixed plug connectors, 8-pole
9. ISO/IEC TR 29125 Information technology – Telecommunications cabling requirements for remote powering of terminal equipment
10. CLC TR 50174-99-1 Information technology – Cabling installation – part 2: Installation planning and installation practices in buildings; supplement 1: Remote power supply
11. IEC 60512-99-001 Connectors for electronic equipment – Tests and measurements – part 99-001: Inspection schedule for connectors for insertion and removal under electrical load – inspection 99a: Connectors for application in twisted pair communication cabling with remote power supply
12. EN 60950 Information technology equipment – Safety – part 1: General requirements
13. HDBaseT is a connection standard of the HDBasetT Alliance for the distribution of uncompressed ultra-high-definition multimedia content for home and commercial applications.

# 1. Introduction

Networks in enterprises are growing further and are becoming more versatile and complex.

Wireless Access Points (WAPs), safety network cameras, building automation and control systems as well as voice over IP telephony (VoIP) are now vital network components.

The more network devices are added, the more the cabling infrastructure must be designed for this growth. This makes the option of the remote powering of terminal equipment all the more attractive.

In recent years, Power over Ethernet (PoE) has established itself as the key technology enabling network administrators, installers and system integrators to handle the integrated supply of terminal equipment with energy and data via structured cabling.

The first PoE standard IEEE 802.3af created in 2003 was already designed for powering of terminal equipment with up to 12.95 Watt. The fast-growing need for PoE applications with higher performance made it necessary to renew these standards.

The PoE Plus (PoE+) standard IEEE 802.3at with up to 25.5 Watt on terminal equipment was adopted in 2009. Industry's need for remote powering at higher levels has been growing ever since.

The current new standard IEEE 802.3bt takes this into account and now supplies terminal equipment with up to 90 Watt.

As expected, the manufacturers of terminal equipment and PoE supply units already offer non-standardized solutions providing more performance (up to 100 Watt).

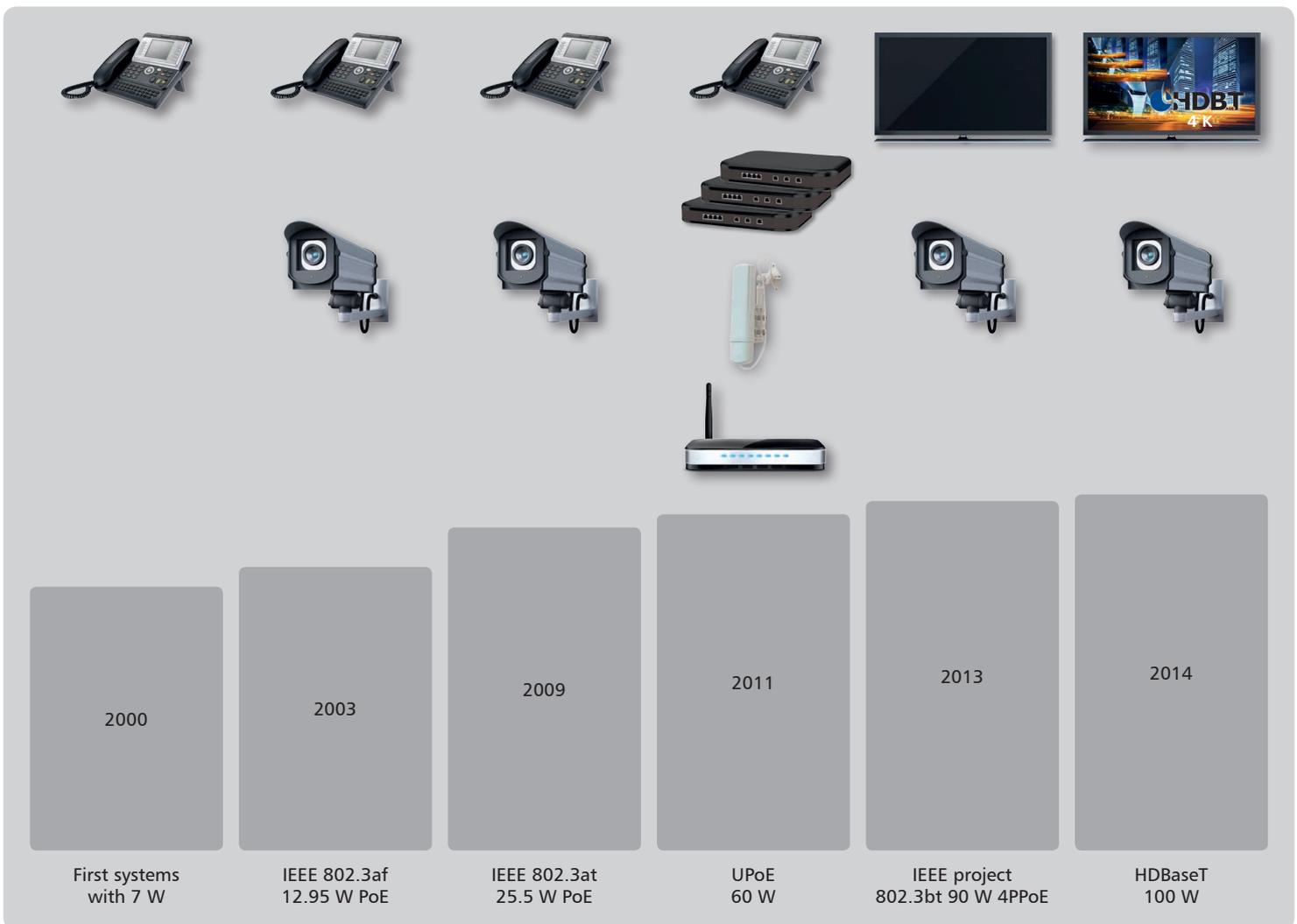


Fig. 1: Development of the PoE standard

## 2. PoE basic principles

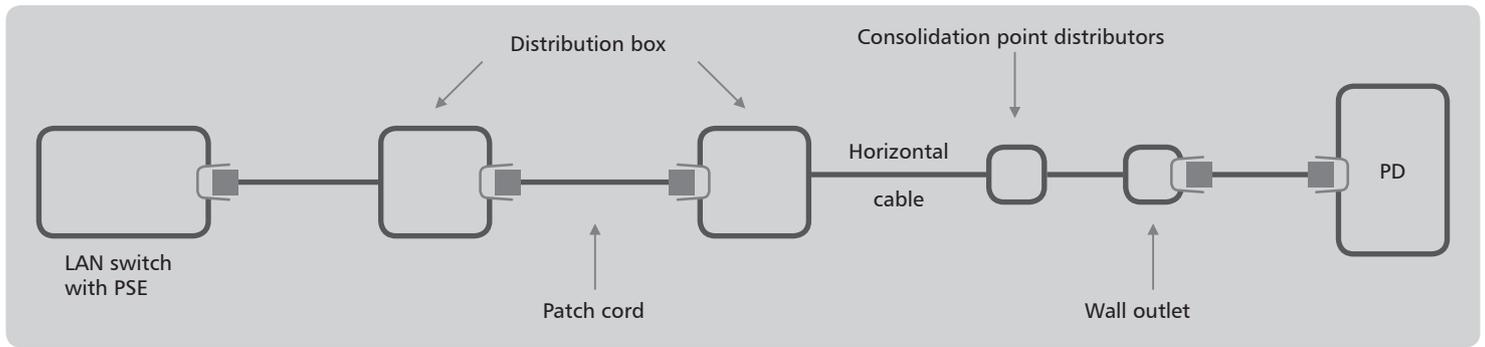
PoE describes a system for the safe transfer of electrical power together with data to terminal equipment via the structured class C, D, E, E<sub>A</sub> and F<sub>A</sub> cabling. PoE is designed in such a way that the power and data transfer do not influence one another.

For this, the PoE converts the mains voltage (230 V AC) to a safe low voltage and transfers this via the structured

cabling to the PoE-suitable terminal equipment. Some power gets lost in the leads during this process. In accordance with the IEEE 802.3af standard, up to 15.4 Watt of power is supplied so that terminal equipment can be supplied with up to 12.95 Watt. This means up to 16% loss on the transmission path.

The PoE system consists of a supply unit (power sourcing equipment PSE), which

supplies the power and the powered terminal equipment (“powered device or PD”). The PSE exists as the solution integrated into the data distributor (switches), which is then described as “end span”. If data distributors are used without integrated PSE, the PSE supply to the PD terminal equipment can be connected by way of so-called “mid-span”.

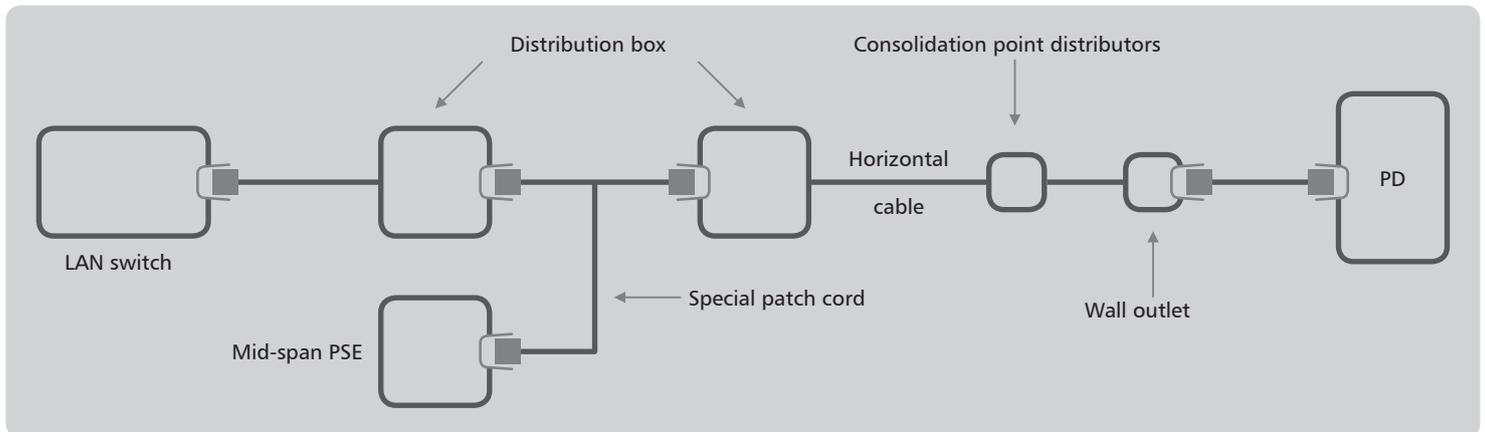


**Fig. 2: PoE supply with PSE integrated into the data distributors**

A “mid-span” PSE supply operated between data distributors (switch) and thermal equipment (PD) supplies the

terminal equipment without interruption of the data signals.

Mid-span PoE is generally described as PoE injectors and is used as a separate supply.



**Fig. 3: PoE supply with mid-span PSE**

The terminal equipment (PDs) are the consumers in the PoE system and supplied by direct current (DC). Many PDs (terminal equipment) are fitted with PoE splitters enabling the separation of supply and data cables and therefore the forwarding of data to other devices.

In Voice over IP (VoIP) telephone applications, WIFI wireless LAN applications or in IP camera applications, PoE systems can save up to 50% in cabling costs as the separate laying of supply lines can be dispensed with.

The normal UPSs (uninterrupted power supply) in many networks enables via PoE systems the permanent supply of the terminal equipment in the event of power failures.

### 3. PoE standards at a glance

IEEE standard	PoE (802.3af-2003)	PoE Plus (802.3at-2009)	4-pair PoE (802.3bt proposal)
Output voltage (V DC)	36 – 57	42.5 – 57	42.5 – 57 (estimate)
Output voltage, operation (mA DC)	350	600	2 x 1,000 (estimate)
Output voltage, start mode (mA DC)	400	400	still open
Capacity of the (PSE) supply (Watt)	max. 15.4	max. 30	45, 60, 75, 90
Capacity of the terminal equipment (PD) (Watt)	max. 12.95	max. 25.5	40, 51, 62, 71
PSE class	1, 2, 3	4	5, 6, 7, 8
Supported terminal equipment (PD type)	1	1 and 2	1, 2, 3, 4
Used pair of wires	2	2	2 and 4

**Table 1: Comparison of the existing and proposed PoE standards**

The IEEE 802.3af standard established in 2003 delivers up to 15.4 Watt to the PSE and uses two of the four pairs of wires of a structured cabling system. As however some power is lost through the resistivity, the PD (terminal equipment) retains only a maximum 12.95 Watt according to the standard. This is however still sufficient to supply a great deal of typical PoE terminal equipment such as VoIP telephones, WLAN access points, IP cameras, digital

clocks, time recording devices, access control and door intercom systems.

The IEEE standard for PoE Plus 802.3at of 2009 provides the PSE with up to 30 Watt and so is able to supply the PoE terminal equipment (PDs) with up to 25.5 Watt via two pairs of wires of a structured cabling system.

The wide distribution of PoE terminal equipment drives device manufacturers

to demand even more of the structured cabling used so that more new PoE applications can be developed. The new infrastructure must therefore transfer even more power and data so that efficiency can increase. With devices such as WLAN access points in accordance with IEEE 802.11ac, even GigaBit Ethernet performance can be surpassed.

PoE is also already used in 10 GigaBit Ethernet applications.

Sector	Application	Typical power requirement
Health care	Nurse call	50 W (>30 W)
Retail trade	Vending machines	30 – 60 W
Banks	Cash dispensers	45 W
Building automation	Ventilation flap, access control	40 – 50 W
Company IT	Thin client PC's virtual desktop terminals	50 W
Hospitality industry	PoE switches	45 – 60 W
Building security	Pan-tilt cameras	30 – 60 W
Industry	Brushless motors and motor controls	> 30 W
Miscellaneous	Digital signature	> 30 W
Building technology	LED lighting	25 – 100 W
Miscellaneous	Multichannel WLAN access	> 30 W

**Table 2: Newly emerging PoE applications**

The market demands on PoE systems are developing faster than the standards as table 2 shows. Current PoE devices

already require more than PoE Plus with 25.5 W can provide.

The applications mentioned here can very easily benefit from the new PoE standard.

IEEE 802.3 in 2013 formed a “study group” in 2013 for the standardization of PoE via four pairs of wires in response to these market demands. The study group gave rise to the task force for the new standard IEEE 802.3bt. The new standard will supply up to 71 Watt to

the PoE terminal equipment (PD) and therefore also improve performance efficiency. The standard enables a pair-to-pair unbalance of up to 5% whereby already installed classes E and EA and FA cabling can be used.

The new standard will also integrate already existing, manufacturer-specific PoE solutions. Some manufacturers already provide solutions for the emerging high-power PoE applications such as Universal PoE (UPoE) with a capacity of 60 Watt on the PSE port.

## 4. PoE via four pairs of wires (4PPoE)

The new IEEE 802.3bt standard enables manufacturers of PoE devices to create solutions that perform more efficiently and provide more power transferring up to 10 GigaBit of Ethernet data. Fig. 4 shows a PoE system from the 802.3at-2009 standard. There is therefore the possibility to supply the PD according

to alternative A via so-called phantom power on the same pairs of wires, which also transfer the data.

Alternative B uses the free pairs of wires not used for 10 and 100 Megabit Ethernet to transfer the power.

The IEEE802.3bt standard will enable the

simultaneous use of alternative A and B therefore doubling the range of services. The so-called 4-pair PoE (4PPoE) through the use of all four pairs of wires reduces the loss of performance over the transfer path compared with the former 2 pair PoE irrespective of the cabling class used by up to 50%.

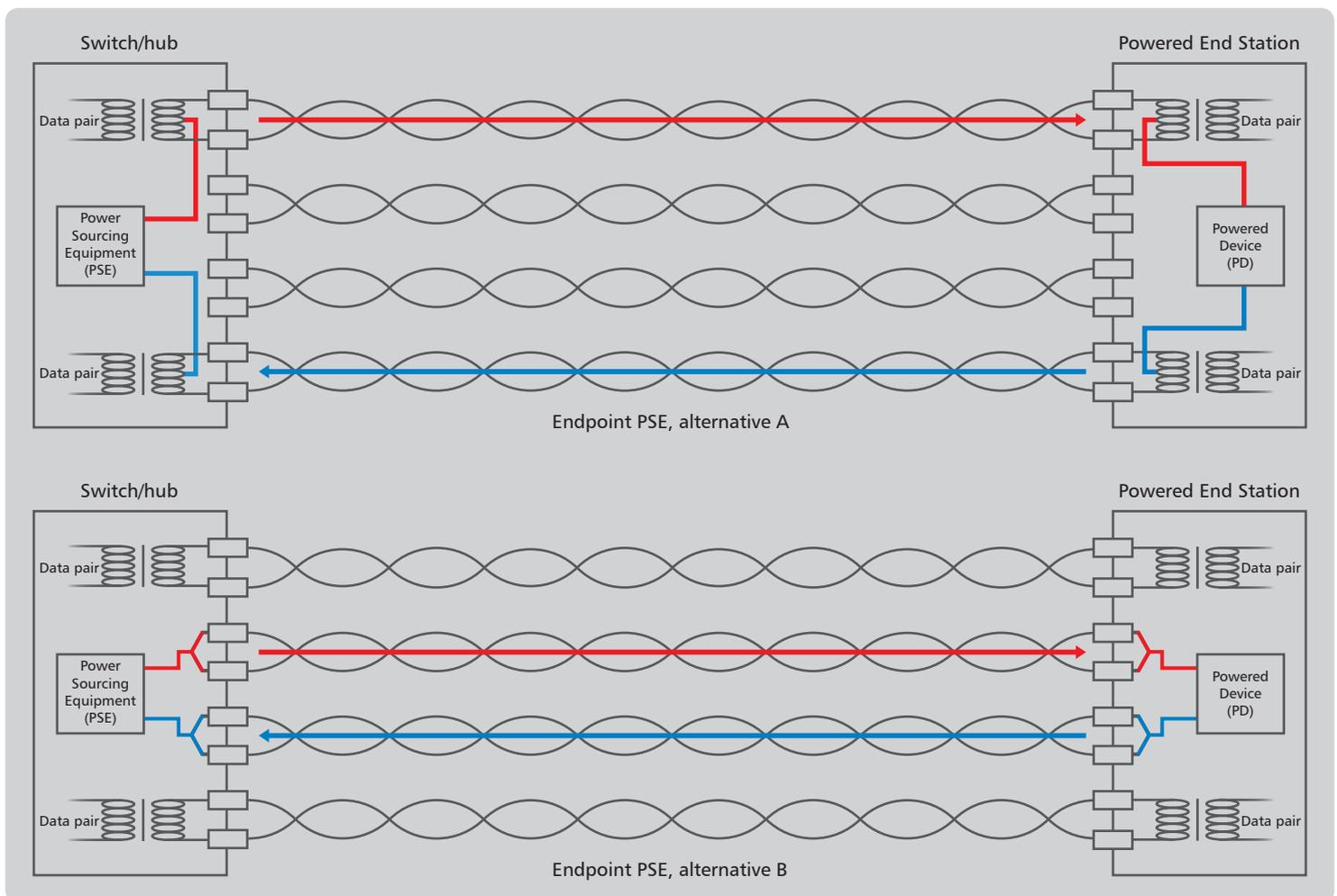


Fig. 4: Alternatives A and B in accordance with IEEE 802.3at-2009

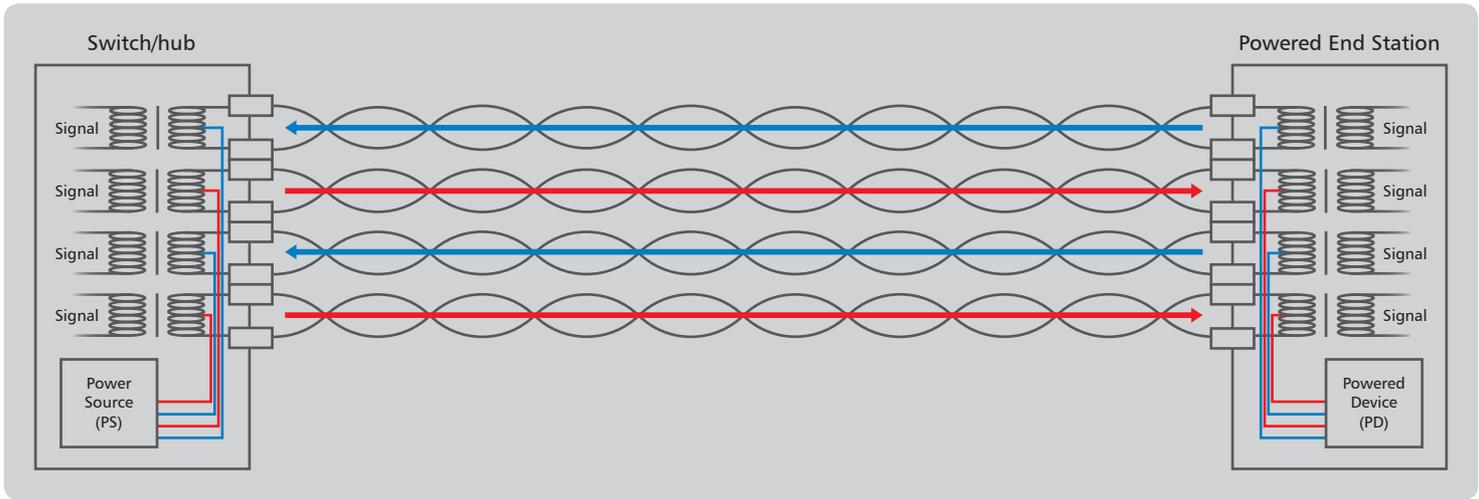


Fig. 5: 4PPoE

Fig. 5 shows how in the future, 4PPoE will provide the PoE terminal equipment (PD) with power via all four pairs of wires from the PSE supply that are typically already integrated into the data

distributor (switch).

In considering whether a four-pair PoE network is a good idea for a given installation, network administrators have

to consider several variables. This includes the overall network and transfer path requirements, effects on the thermal environmental conditions, capacity limits from cabling routes and supply strategies.

## 5. Networks and transmission channels

The network and channel design requirements for a 4PPoE are the same as for PoE and PoE Plus. Regarding the channel topology, 4PPoE uses the existing four pairs of wires with a channel length up to 100 m. Further information regarding the various topologies is

contained in the ISO/IEC 11801 and EN 50173 standards for the structured cabling.

Regarding the current orientation of the IEEE802.3bt 4PPoE standard, the cabling must fulfil at least class D over a

length of 100 m and contain four pairs. It is pointed out that class D cabling only offers the minimum performance level. We recommend using class E<sub>A</sub> cabling using certified cat. 6<sub>A</sub> connection technology with cat. 7 or cat. 7<sub>A</sub> cable.

## 6. Connection points in the room

In the current office environment, most network connections are placed near the workplaces in dado ducts and floor tanks. The increasing capacity of PoE terminal equipment leads to increasing distribution enabling more and more applications. Current PoE-capable devices are for example, motorized IP monitoring cameras, video telephones, HD displays, LED lights and small, intelligent devices for building automation such as microcontrollers, sensors and actuators.

The new 4PPoE enables among other things the following applications:

- Vending machines
- Video conference systems and guest facilities
- IP security systems for monitoring in security areas
- Industrial controls and IP sensors
- Digital signature systems
- Multichannel wireless access points for Gigabit transfer
- LED room lighting with scene control

These devices are no longer compulsorily connected to terminal outlets in walls,

tables or floor outlets (TOs). The connections for these devices are being increasingly found in the ceiling such as

WLAN access points or LED lighting, near doors, on presentation walls and outside buildings on outside walls. These unconventional connection sites lead to new requirements as additional cabling capacities, new cabling routes as well as fire protection and safety requirements.

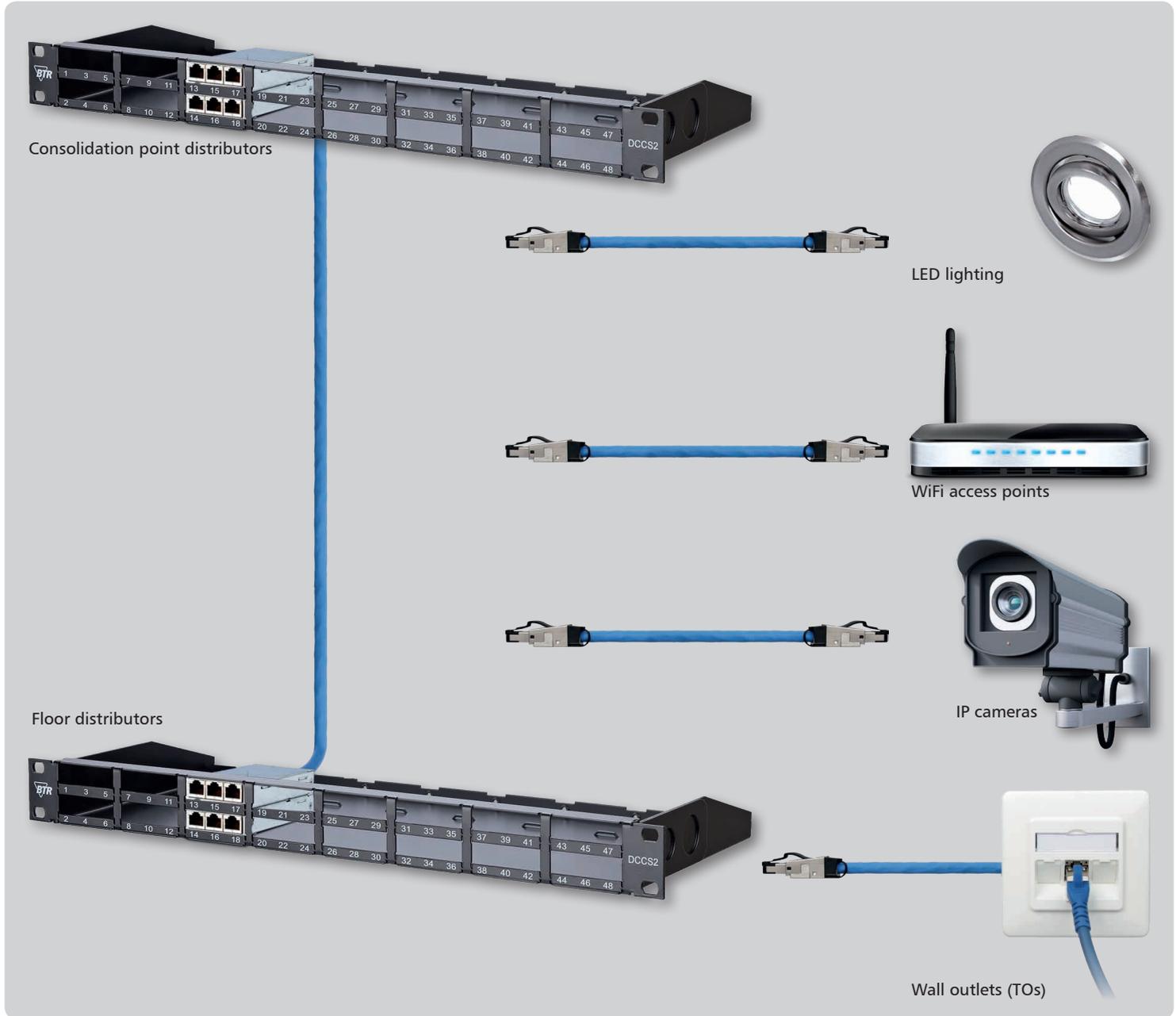
This requires early installation planning so that the structured cabling is available for all connection points.

## 7. Cabling with consolidation point distributors

The use of consolidation points lends itself to this. The cabling systems specially designed for the pre-cabling of floor

distributors to the consolidation point distributors such as DCCS2 from METZ CONNECT offer a flexible infrastructure

that meets the new requirements. Fig. 6 shows what such a solution could look like.



**Fig. 6: Cabling with consolidation point distributors for PoE applications**

The consolidation point cabling creates the connections between the floor distributors and the consolidation point outlets to be optionally placed in the rooms. The connection to the terminal equipment takes place by way of further

fixed or flexible leads to the wall outlets (TOs) or/but directly to the wall or in terminal equipment fitted directly in the wall or the ceiling. For this, as well as the classic patch cords, installation cables can now also be laid, which are

fitted on both ends with field-terminable RJ45 connectors. The EN 50173-6:2013 standard for distributed building services describes the requirements.

## 8. Thermal load

The increasing supply of PoE terminal equipment with more and more power via the structured cabling due to the also increasing loss of capacity leads to the heating of the cable. In order to prevent

additional costs of heat dissipation and a reduction of the shelf life of cables and connection technology, careful planning including the thermal load of the cabling is necessary.

Fig. 7 shows the worst case scenario of the current load in mA per pair of wires and temperature increase in °C in a cable bundle of 100.

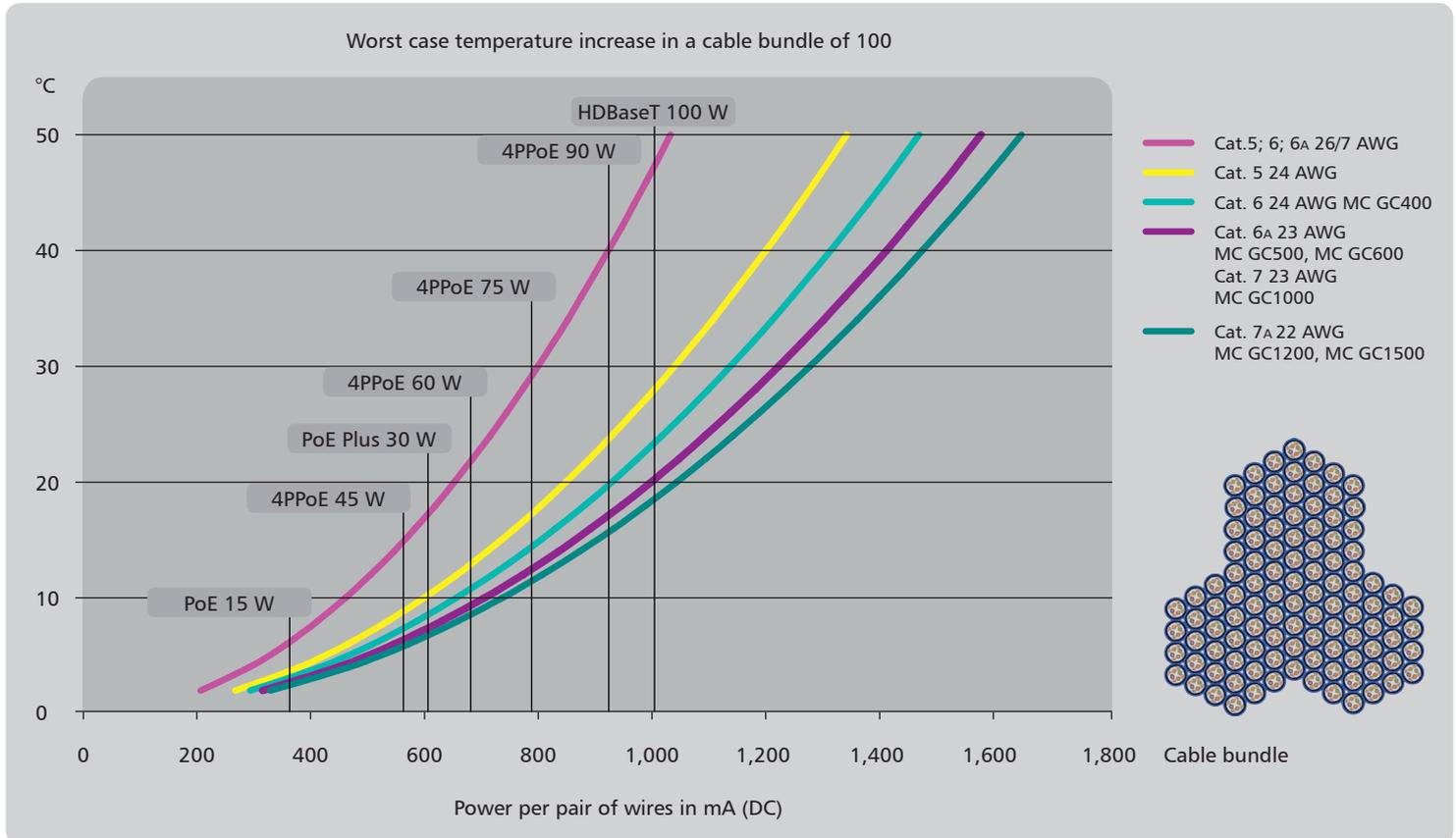


Fig. 7: Effect of direct current on the cable temperature

As fig. 7 shows, the heating up of the patch cord bundle is greatest with conductor diameters of 0.4 mm (AWG26) and smaller. Cat. 7<sub>A</sub> cables with conductors of 0.63 mm (AWG22) heat up considerably less.

Depending on the installation conditions, the heat generated in the cable is spread to the surroundings. Depending on how the cables are laid in mesh cable trays, cable trays that are three quarters closed or in closed cable and dado ducts or in pipes, the heat created can more or less be dissipated effectively.

The ISO/IEC TR 29125 and the current CLC TR 50174-99-1 standard for "Remote Powering" provide information on planning the installation.

The IEEE 802.3pt 4PPoE standard assumes a permissible maximum temperature increase of 10° C in the case of load on all four pairs of wires. Typical cabling is designed for a temperature range of -20° C to +60° C whereby the environmental temperature may not exceed +50° C. The use of a higher category cable (cat. 7<sub>A</sub> AWG22) can, due to the reduced conductor resistance and improved heat dissipation of the cable

shield significantly reduce the heating up of the cable. We recommend the use in cabling designed for 4PPoE (90W) or even HDBaseT with up to 100 W, cable of cat. 7 and cat. 7<sub>A</sub> with a conductor of 0.63 mm (AWG22).

A further effect of the cable heating, due to the increasing conductor resistance is the increase in insertion loss. This may have an effect on the maximum length of the cabling and also requires consideration of the design in accordance with ISO/IEC 11801 and EN 50173.

## 9. Layout of the cabling and connection technology

When transferring power via data cables and connection technology, the effect on the plug connections must also be considered. In accordance with connector standard IEC 60603-7, the contacts are designed for currents up to 1,500 mA at 20° C. In the case of an environmental temperature of 60° C, this is reduced according to the standard to 1,000 mA per contact.

IEEE 802.3bt provides for a current load of 925 mA per pair of wires. In the case of symmetric design of the pairs of wires, the current is distributed evenly over both wires of up to 462.5 mA. All contacts in the RJ45 connector (in accordance with IEC 60603-7) will in the case of 4PPoE with a capacity of 90W PSE each be subject to a load of

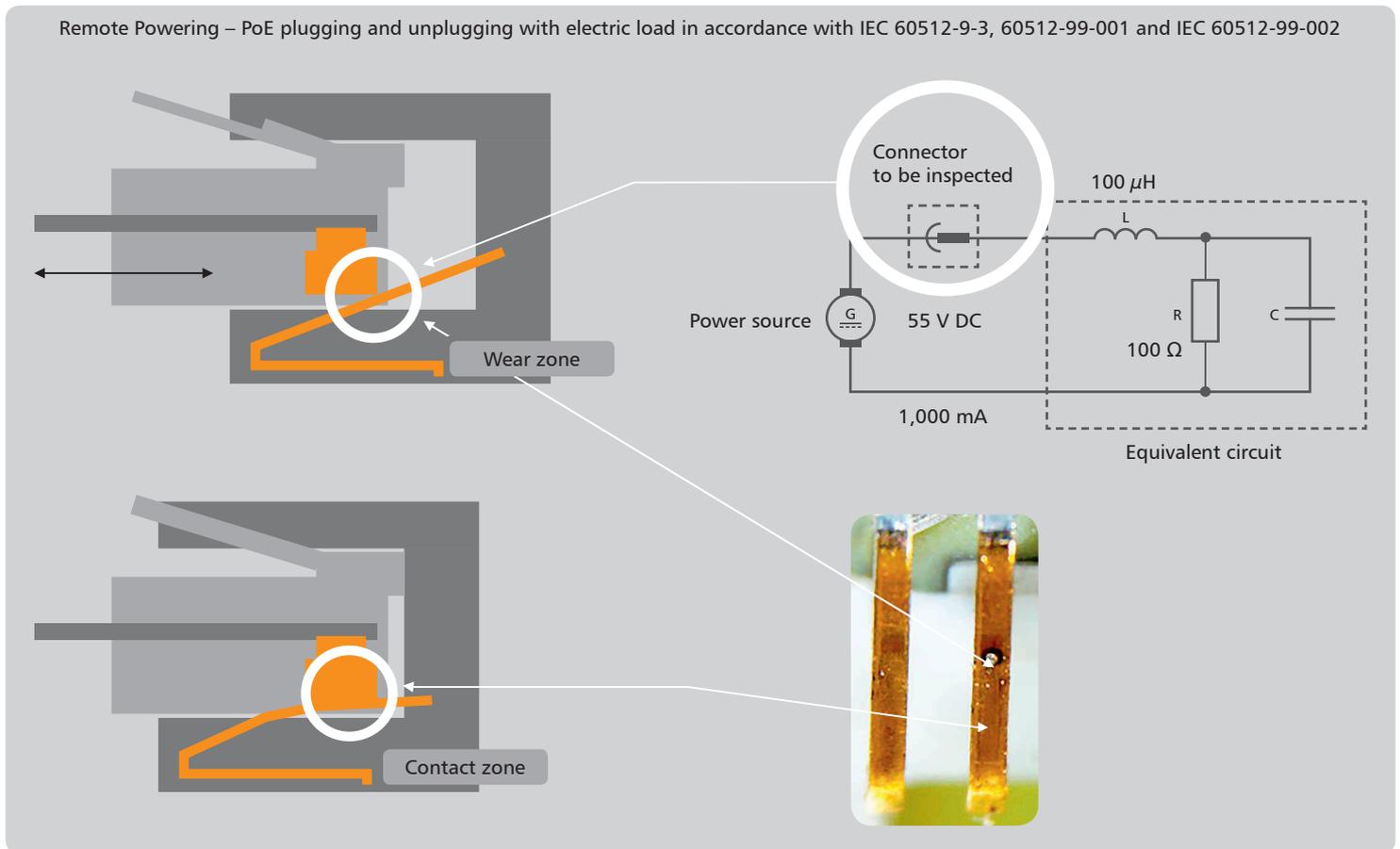
462.5 mA. In the case of environmental temperatures up to 60° C, the connectors will have sufficient reserve in this case. In the case of interruption to an individual conductor, the current will however be doubled (925 mA) in the remaining second conductor of a pair of wires. METZ CONNECT connectors will also justify this load.

As well as the current load with connectors unplugged/plugged in, one should however also take a look at the load when plugging in and unplugging the connectors.

The IEEE 802.3 standards for PoE, PoE Plus and 4PPoE already envisage solutions for this. If PDs (PoE terminal equipment) are plugged in, this will take

place in a de-energized state as the PSE when separating the connection to the PD will shut off the power immediately. The plugging in procedure is therefore power-free and will not stress the plug connection.

When unplugging the terminal equipment, the operating current however flows from up to 462 mA per contact. Due to the also inductive character of a cable route, unplugging may create small sparks in the contact zone around the connector that may lead to wear on the connector. Depending on the construction of the contacts, this wear is in the area where the plug connection should carry out its function properly when plugged in.



**Fig. 8: Maintaining connectors under load**

Fig. 8 shows here how this is solved in the case of METZ CONNECT connectors.

Here, the contact zone is separated from the wear zone considerably increasing

the connectors' shelf life.

## 10. 4PPoE in accordance with IEEE 802.3bt, draft

Draft 1.5 of IEEE 802.3bt is currently available. In this, the PoE supplies (PSE) and terminal equipment (PDs) are now classified in nine classes and four types.

Devices of type 1 correspond at least to the PoE standard IEEE 802.3af. Type 2 devices support PoE Plus. Future type 3 and 4 devices are designed in accordance

with IEEE 802.3bt for 4PPoE but also supply type 1 and 2 devices.

IEEE 802.3 standard	af (PoE)	af (PoE)	af (PoE)	af (PoE)	at (PoEplus)	bt* (4PPoE)	bt* (4PPoE)	bt* (4PPoE)	bt* (4PPoE)
PSE/PD class	0	1	2	3	4	5	6	7	8
PSE/PD type	1	1	1	1	2	3	3	4	4
Output of PSE (W)	15.4	4	7	15.4	30	45	60	75	90
Output on PD (W)	12.95	3.84	6.49	12.95	25.5	40	51	62	71
PSE voltage (V DC)	44	44	44	44	50	50	50	52	52
Current per pair of wires (mA)	350	91	160	350	600	550	682	777	925
Number of pairs (under current)	2	2	2	2	2	4	4	4	4

**Table 3: Future PoE types and classes (\*still in consultation)**

The transfer of power takes place in the case of devices type 1 and 2 via two pairs of wires. PoE devices type 3 and 4 are supplied via four pairs of wires.

## 11. Recommendations

- The new 4PPoE standard supplies terminal equipment with an output of up to 90 Watt and data rates up to 10 GBit Ethernet via four-pair cabling.
- The requirements of EN 60950 for safety extra-low voltage (SELV) are fulfilled.
- For operation with structured cabling in accordance with ISO/IEC 11801, at least class D is required.
- Based on the heating up of the cable at a higher PoE capacity, cables of category 7 or 7<sub>A</sub> are recommended.
- The combination of PoE supply with UPS (uninterrupted power supply) enables the largely uninterrupted operation of the PoE terminal equipment.
- As unplugging the connectors under load may lead to premature wear, it is recommended that only connection technology qualified for PoE/4PPoE (certified in accordance with IEC 60512-99-001) be used.

The further work on the 4PPoE standard IEEE 802.3bt is essentially driven by the increasing number of applications, which as well as data supply are also increasingly supplied with power.

Our work on standardization committees for connection components and cabling systems should help to make structured cabling fit for the requirements of the future.

This white paper should provide information and details on PoE technology and the forthcoming amendments and extensions.

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