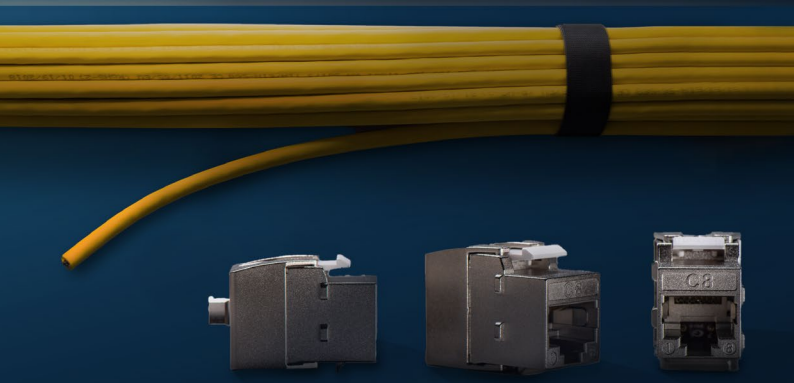
EN

DIGITUS®

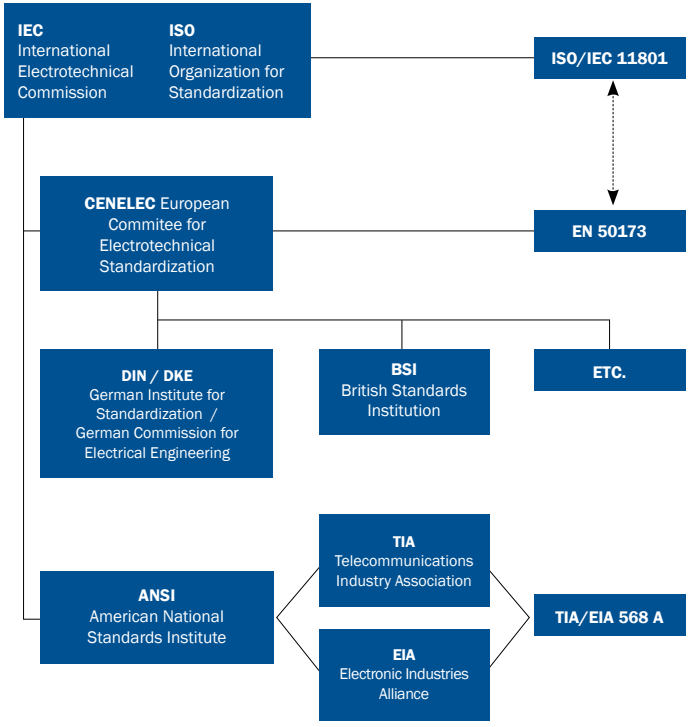
BASIC KNOWLEDGE

of copper and fibre optics



Index

Structure of standardization organization



Standards of structured cabling

ISO/IEC International Standards

ISO/IEC 11801:2017	Generic Cabling for Customer Premises
ISO/IEC 11801-1:2017	Part 1: General Requirements
ISO/IEC 11801-2: 2017	Part 2: Office Premises
ISO/IEC 11801-3: 2017	Part 3: Industrial Premises
ISO/IEC 11801-4: 2017	Part 4: Single-tenant Homes
ISO/IEC 11801-5: 2017	Part 5: Data Centers
ISO/IEC 11801-6: 2017	Part 6: Distributed Building Services

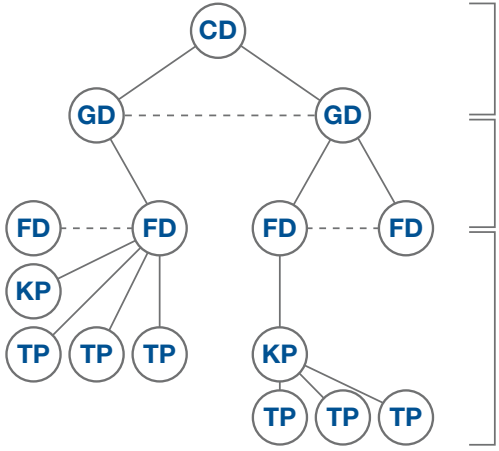
ANSI/TIA/EIA Standards

ANSI/TIA/EIA-568-C.0-2009	Generic Telecommunications Cabling for Customer Premises
ANSI/TIA/EIA-568-C.1-2009	Commercial Building Telecommunications Cabling Standard
ANSI/TIA/EIA-568-C.2-2009	Balanced Twisted-Pair Telecommunications Cabling and Components Standard

CENELEC EN Standards

EN 50173-1:2013	Information Technology	General Requirements
EN 50173-2:2008	Information Technology	Office Rooms
EN 50173-3:2009	Information Technology	Industrial Buildings
EN 50173-4:2008	Information Technology	Residential Buildings
EN 50173-5:2009	Information Technology	Data Centers
EN 50174-2:2010	Information Technology	Specification of a System and Quality Assurance
EN 50174-2:2010	Information Technology	Specification of a System and Quality Assurance
EN 50174-3:2009	Information Technology	Planning and Performing Outdoor Installation
EN 50600-1:2013	Information Technology	General Concepts (DC)
EN 50600-2-1:2014	Information Technology	Building Structure (DC)
EN 50346:2004	Information Technology	Testing Installed Cables

Layout of structured cabling



CD Campus Distribution

GD Building Distribution

FD Floor Distribution

KP Consolidation-Point

TP Telecommunication Outlet

Overview of valid standards of structured cabling

Structured cabling (horizontal cabling) is described in detail in the following standards:

Organization	Office Buildings	Data Centers	Industrial Buildings	Tenements
ISO International Organization for Standardization	ISO/IEC 11801-2:2017	ISO/IEC 11801-5:2017	ISO/IEC 11801-3:2017	ISO/IEC 11801-4:2017
CENELEC	EN 50173-2: 2007/ A1:2011	EN 50173-5 2007/ A1:2010	EN 50173-3:20077/ A1:2010	EN 50173-4/ A1:2010
TIA	ANSI/TIA-568-C.1 2012	TIA/EIA-942	TIA/EIA-1005	TIA/EIA-570-B

Categories and classes of structured cabling:

	100 MHz	250 MHz	500 MHz	600 MHz	1.000 MHz	2.000 MHz
TIA USA	TIA/EIA 568-C.1/2 CAT 5e	TIA/EIA 568-C.2/1 CAT 6	TIA/EIA 568-C.2-10 CAT 6_A		TIA/EIA 568-C.2-1 CAT 8	
ISO International	ISO/ IEC11801: 3rd Edition Class D	ISO/ IEC11801: 3rd Edition Class E	ISO/ IEC11801: 3rd Edition Class E_A	SO/ IEC11801: 3rd Edition Class F	ISO/ IEC11801: 3rd Edition Class I/II	ISO/ IEC11801: 3rd Edition Class F_A
CENELEC Europa	CENELEC EN50173-1 Class D	CENELEC EN50173-1 Class E	CENELEC EN50173-1 Class E_A	CENELEC EN50173-1 Class F	CENELEC EN50173-1 Class I/II	CENELEC EN50173-1 Class F_A
VDE DKE Deutschland	DKE DIN EN5017-1 Class D	DKE DIN EN5017-1 Class E		DKE DIN EN5017-1 Class F	DKE DIN EN5017-1 Class I/II	

Capacity/transmission property by category

Capacity/transmission property by category:

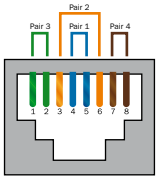
Class	Transmission rate	Category	Transfer rate
Class A	100 KHz	CAT 1	Telephony
Class B	1 MHz	CAT 2	128 Kbps
Class C	16 MHz	CAT 3	10 Mbps
Class D	100 MHz	CAT 5e	100 Mbps
Class E	250 MHz	CAT 6	1 Gbps
Class E_A	500 MHz	CAT 6_A	10 Gbps
Class F	600 MHz	CAT 7	10 Gbps
Class F_A	1000 MHz	CAT 7_A	10 Gbps
Class I/II	1600/2000 MHz	CAT 8.1 / CAT 8.2	25/40 Gbps

RJ45 connector face

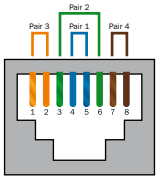
Telecommunications sockets and multimedia sockets for copper connection systems are designed as RJ45 connections for classes D, E, E_A and Category 8.1.

There are two different layout options:

T568A



T568B

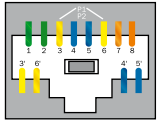


Alternative connector face

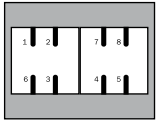
The maximum transmission properties of classes F, F_A and Category 8.2 can only be achieved with TERA®, GG45® and alternative connector faces like BKS MMCpro.

Those alternative connector faces are not compatible with RJ45 connector face. For integration adapter cables are necessary.

GG45®



TERA®



Type description of Twisted-Pair cables

Four-pair twisted pair cables are subdivided into the following types:

Type	Description
U/UTP	unshielded, twisted pair cable
F/UTP	shielded, twisted pair cable; foil shield around all pairs
SF/UTP	shielded, twisted pair cable; foil shield and braid shield around all pairs
U/FTP	shielded, twisted pair cable; foil shield around every pair, with ground wire
F/FTP	shielded, twisted pair cable; foil shield around all pairs and foil shield around every pair
S/FTP	shielded, twisted pair cable; braid shield around all pairs and foil shield around every pair

Cable structure of the twisted pair cable:

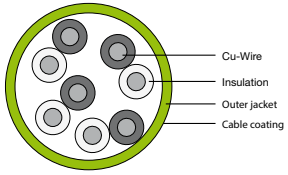
In accordance with EN 50173-1:2011, the twisted pair cables are specified as follows:	
XX/YTA	XX stands for the outer shield, the shielding of the cable U: no shield; F: foil shield; S: braid shield; SF: foil and braided shield
Y	one shield for two adapter pairs (four cores) U: no shield; F: foil shield; T: twisted; A: conductor count; P: pair (two cores); Q: quadruplet (4 cores)

Cable structure of Twisted-Pair cables

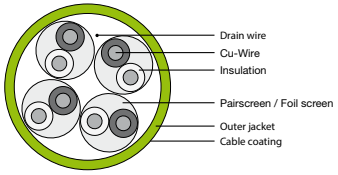
Unshielded cables are the most common. Shielded, twisted pair cables are primarily used in Germany, Austria, and Switzerland. Shielded cables have an overall shield and/or a pair shield. The additional shielding reduces interference, which can affect the transmission properties of the cable.

Cables in category 7 or higher only attain their performance and transmission properties when shielded.

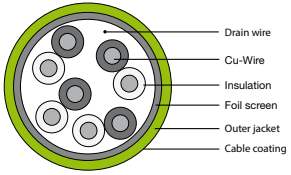
U/UTP



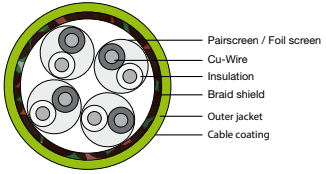
U/FTP



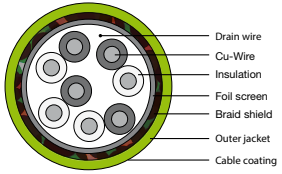
F/UTP



S/FTP



SF/UTP



Translation American Wire Gauge to metric system

AWG	Wire diameter (mm)	Wire cross section (mm2)
18	1,0237	0,8230
19	0,9116	0,6527
20	0,8118	0,5176
21	0,7229	0,4105
22	0,6438	0,3255
23	0,5733	0,2582
24	0,5106	0,2047
25	0,4547	0,1624
26	0,4049	0,1288
27	0,3606	0,1021
28	0,3211	0,0810

Bending radius for installation cables

Reference data bending radius for installation cable		
	Flexible multicore cable	
Diameter	Free movable	Installed
Ø 8 ... 12 mm	4 x Ø	3 x Ø
Ø 12 ... 20 mm	5 x Ø	4 x Ø
Copper cable acc. EN 50173		
During installation	5 x Ø	
After installation	4 x Ø	
Optical fiber cable		
Singlemode	min. 30 mm	
Multimode	15 ... 20 x Ø	

Category 6_A is not Category 6A

Channel
- Class E_A of ISO/IEC 11801 and EN 50173 Amendment 1
- Category 6A of IEA/TIA 568C.2-10

Permanent Link
- Class E_A of ISO/IEC 11801 and EN 50173 Amendment 2
- Category 6A of IEA/TIA 568C.2-10

Connector & Cable
- Category 6_A of ISO/IEC 11801 and EN 50173 Amendment 2
- Category 6A of IEA/TIA 568C.2-10

Frequency	NEXT / dB Channel	
MHz	ISO/IEC 11801 AM1	EIA/TIA 568C.2-10
	Class E_A	Category 6A
1	65	65
100	39,9	39,9
250	33,1	33,1
500	**27,9**	**26,1**

Category 6_A is not Category 6A

Frequency	NEXT / dB Permanent Link	
MHz	ISO/IEC 11801 AM2	EIA/TIA 568C.2-10
	Class E_A	Category 6A
1	65	65
100	41,8	41,8
250	35,3	35,3
500	**29,2**	**26,7**

Frequency	NEXT / dB Connector	
MHz	ISO/IEC 11801 AM2	EIA/TIA 568C.2-10
	Category 6_A	Category 6A
1	75	75
100	54	54
250	46	46
500	**37**	**34**

"High-voltage cables and lines, control and communication cables - cables and lines for general use in construction works relating to the fire behavior requirements EN 50575"

This regulation has existed for over 15 years, but has not imposed any requirements on copper and fiber optic cables so far. Of course, we are familiar with the CE marking that is used for active devices and components such as power strips, cameras and Ethernet switches.

The testing standards for all EU member states were now ratified and announced in the official journal of the EU (305/2011) in February 2016. The regulation itself entered into force on July 1, 2016, but it is granted coexistence until July 1, 2017.

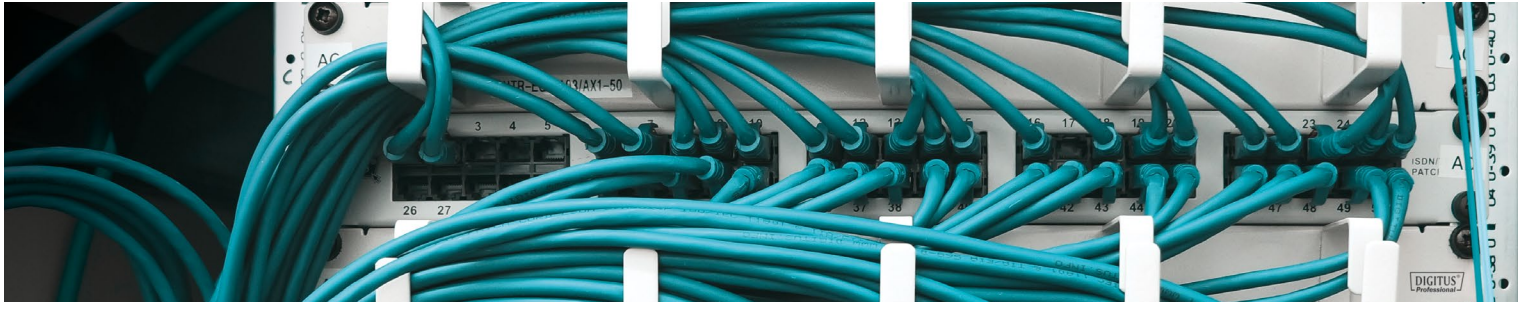
During this period, untested products can continue to be sold and installed - meanwhile, manufacturers are required to test the cables and classify them according to the new standard.

Until July 1, 2017, all products affected by the new regulation must then be checked and marked accordingly. The major change in the specifications is the replacement of the fire protection class IEC 60332 by a series of Euro classes (A_{ca} - F_{ca}). Where A_{ca} is the strongest and F_{ca} is the weakest flame retardant.

The E_{ca} and $B2_{ca}$ classes have come into focus because they contain most of the changes in terminology and the specification requirements.

The E_{ca} class corresponds to the existing IEC 60332-1. The class with the currently higher requirements for fire performance IEC 60332-3 lies between the new Euro classes $B2_{ca}$ and C_{ca}. However, it leans more towards the C_{ca} class. The task of the cable industry now is to rework the respective cables and has the goal of meeting the requirements of these new classes.

Class	A_{ca}	$B1_{ca}$	$B2_{ca}$	C_{ca}	D_{ca}	E_{ca}	F_{ca}
EN ISO 1716 **Combustion heat**	⬢						
EN 50399 **Heat release & smoke production**		⬢	⬢	⬢	⬢	⬢	⬢
EN 60332-1-2 **Vertical flame propagation**		⬢	⬢	⬢	⬢		
EN 61034-2 **Smoke density**		⬢	⬢	⬢	⬢		
EN 60754-2 **Acidity**		⬢	⬢	⬢	⬢		



The Construction Products Regulation only refers to the „permanently laid / installed infrastructure“, i.e. it contains no connection components or patch cables and no compact modules.

However, all pre-assembled solutions such as fibre optic / copper trunk cables that are considered to be „permanently installed“ are covered, after all these depend on the mass cable certification on which the assembly group was built.

A requirement of the Euro classes:

It is the responsibility of cabling system manufacturers to test the cables themselves or hire an external company to verify compliance with the standards.

This is detailed in EN 50575. Finally, a „notified body“ must be assigned to approve the test results. Products cannot be marked in accordance with the Euro class, or be considered as compliant without certification by the certification body.

But how does a certification body become a „notified body“? The application process for this status takes about two to three weeks.

Upon receipt of the „notified body“, status, the certification body will be able to evaluate the customer's test data (manufacturer, cabling system vendor, distributor) and subsequently issue a report and a certificate. It is expected that the certification can take up to three more weeks.

What impact does the Construction Products Regulation have on you, our customers – and DIGITUS® ?

The introduction of this regulation is a significant development and must be clearly understood by all parties operating in the structured cabling market. These changes to the product design as well as correct labelling and packaging are obligatory and must be adhered to by marketers.

It is expected that the requirement for new specifications will be understood by market participants within the coexistence period of the regulation. We have prepared extensively for the introduction of the new cable classes and have been distributing the Class E_{CA} and D_{CA} cables since Q2 2017 as planned. Upon request, higher quality classes are available.

The regulation: The CE directive for „permanently installed communication cables“

As of 1 July 2017, there has been a radical change in the cabling industry. Since this date, copper and fibre-optic patch cords must be CE marked according to the law.

The **CE logo** does not necessarily have to be on the cable, but still in the form of a sticker on the packaging materials e.g. the cardboard box and cable drum.

The standard EN 50575 includes power, telecommunication and signal cables for use in buildings.

The installation cables that are used, such as: **copper Cat.7 S/FTP AWG23/1 – glass fibre I-DQ (ZN) BH 4 G 50/125µ OM4** are affected by the standard, as they are installed „permanently“ in the building.

The product management team of DIGITUS® started to classify the cables according to the EN 50575 standard at an early stage. They now guarantee the delivery of goods with the CE logo and Euro classification. The accompanying documents, the so-called DoP (Declaration of Performance) documents provide information. If a cable has a CE logo, then the product also has a valid DoP.

This confirms the performance and the fire characteristics of the product. A laying cable with a CE logo without the associated DoP is not compliant! As the cables are classified, documented and certified by accredited testing centres, the European Union has made it possible to compare products with regard to fire characteristics by introducing this CE logo.

Long term-/System warranty

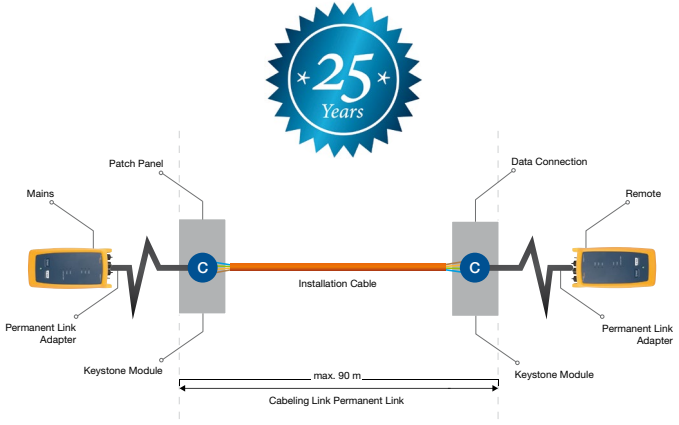
Long-term warranty on DIGITUS® cabling components

ASSMANN Electronic GmbH stands for quality and customer satisfaction. We can therefore offer a system guarantee for passive copper and fiber optic cabling systems of DIGITUS® .

System warranty for passive cabling systems
The ASSMANN system guarantee for DIGITUS® copper and fiber optic cabling systems:

Be carefree for the next 25 years guaranteed
The cabling infrastructure is a long-term strategic investment for any business.

ASSMANN's system guarantee for DIGITUS® Professional cabling systems ensures that your installation provides a lastingly robust foundation for your data infrastructure. That's why the 25-year guarantee agreement is geared to plant owners and operators.



Measurement Configuration Permanent Link

PoE - Power over Ethernet

Energization of end devices via the structured copper cabling

Power over Ethernet is a solution approach in which end devices that are attached via a copper data cable are provided with the necessary power. The key feature of the solution approach is: The necessary data and power transfer can be transported over one and the same data cable to the end device.

Active components up to 60/100 watts per data cable can be transmitted with the current IEEE 802.bt transmission standard. Having said this, the core issue is careful planning, installation and the actual operation of the structured cabling when using 60/100 watts Power over Ethernet – PoE.

The different Power over Ethernet – going by their development steps:

Power over Ethernet – PoE: IEEE 802.af (2003), power supply via 10Base-T/100Base-TX

The standard for power supply via data cables was adopted for the first time in 2003. The 4/5 and 7/8 wire pair is used for power supply, whereas the 1/2 and 3/6 wire pair is used for data transfer.

To begin with, a split allocation of the available wires for data and power supply took place. However, the wire pairs assigned to the data transfer can also optionally be used for the power supply. By definition, the power output of the active components amounts to 15.4 watts per port. End devices with lower power consumption can thus be operated safely and problem-free.

Power over Ethernet – PoE+: IEEE 802.at (2009), power supply via 1000Base-T

Application area
- IP camera (inclinable and swiveling, heated casing)
- IP telephone
- WLAN access points

Power over Ethernet – 4PPoE: IEEE 802.bt (2018), power supply up to 60/100 watts

Application area
- IP camera
- IP telephone
- WLAN access points
- Workstations
- LED lighting
- Access control
- Electric roller shutters
- Electric locking systems

PoE - Power over Ethernet

Compatibility	Backward Compatibility
10Base-T (10 MBit)	PoE IEEE 802.af (15,4 Watt)
100Base-TX (100 MBit)	PoE+ IEEE 802.at (30 Watt)
1000Base-T (1 Gigabit)	
2.5GBase-T (2.5 Gigabit)	
5GBase-T (5 Gigabit)	
10GBase-T (10 Gigabit	

Problems with PoE transmissions
Two problems can arise with the integration of PoE end device into an already existing and new network.

1. Warming/heating of the copper data cable
The construction of a structured data cable is not designed for transport (power from the power source to the end device). The actual intended use is the transmission of digital signals. Accordingly, the data cable used possibly may not be suitable for PoE use.

The following criteria strongly influence the warming:

Wire cross-section: The greater the wire cross-section, the less the warming.

Shielding: A cable that is not isolated releases warmth outwards to the sheath more quickly. A S/FTP (screen/foil) shield is ideal. Thus, the warming of the cable is insulated.

With cable warming, one talks, among other things, about the problem of power dissipation. Since the flowing power in the wire of a data cable is relatively high, the power dissipation increases in the cable.

Definition of power dissipation (P)
Power dissipation is described as the difference between recorded power (power input) and – in the desired form – emitted power (power output) of a device or process. Power dissipation is predominantly released as heat flux; it should be kept as small as possible.

The line loss when transmitting electrical energy depends directly on the line resistance (R), which in turn depends on the cable thickness, the material used as well as the flowing electrical current (I).

The calculation is as follows: **$P = R \times I^2$**

The power dissipation becomes greater:
- Higher power
- Longer transmission path
- Greater conductor resistance

The power dissipation is therefore the reason for the heat build-up in the cable. When using several PoE end devices with high power supply (4PPoE), the warming in the cabling network is exorbitantly high. Problems can then arise if data cables are tightly bundled and are not laid and installed in accordance with the installation regulations. In the worst case, the

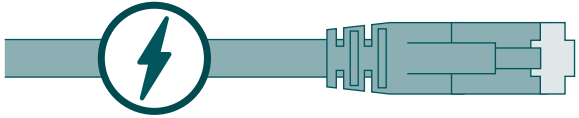
PoE - Power over Ethernet

warming in the cable is so great that the cable (sheath, insulation) literally melts and a short circuit occurs.

2. Abrasion and combustion under a load
RJ45 connectors and sockets were not originally developed for power transmission. They – like copper data cables – served to transmit digital signals. Despite further development and improvement of the connector face, problems exist in the form of abrasion and combustion, which occur under load when plugging in or out.

It is fundamentally recommended to switch off the voltage source before the RJ45 connection is plugged in or out.

The RJ45 plug and the RJ45 socket must be designed in such a way with respect to plug contact and contact spring that when plugging the RJ45 connection in and out, the initial contact is not the same as that on which the data and power transmission eventually take place. An electric arc occurs between the plug contact and the contact spring when plugging in or out. This leads to abrasion and combustion on the contact surfaces and the transmission resistance increases at the same time. In the worst case, the contact surfaces of the RJ45 plug and the RJ45 socket can be so badly damaged that data transfer is no longer possible.



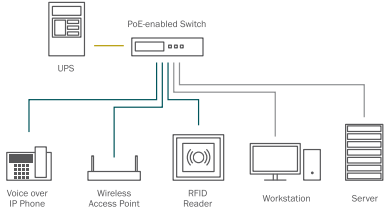
Recommendation when using PoE
Even if it is not standardized to ISO/IEC 11801 and EN 50173-1, we recommend a direct connection of the RJ45 plug to the data cable. The number of RJ45 sockets in the link from the power supply to the power device is thus reduced. In addition, the conductor cross-section remains on the same denominator due to the omission of the patch cord, which reduces the heat build-up.

Further recommendations are:
- Higher conductor cross-section (AWG22/1 or 23/1)
- Maximum shielding (S/FTP)
- Small cable bundles

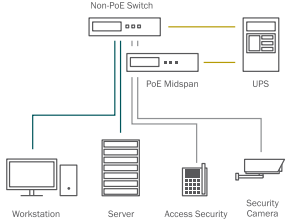
PoE - Power over Ethernet

Summary/Overview of the PoE standards					
Standard	**Norm**	**Classification**	**Energization**	**Power (PSE)**	**Power (PD)**
PoE	IEEE 802.af	Type 1	2 Pairs	15.4 Watt	12.95 Watt
PoE+	IEEE 802.at	Type 2	2 Pairs	30 Watt	25.5 Watt
4PPoE	IEEE 802.bt	Type 3	4 Pairs	60 Watt	51 Watt
4PPoE	IEEE 802.bt	Type 4	4 Pairs	90/100 Watt	72 Watt
*** PSE: Power Sourcing Equipment *** PD: Power Device ***					

ENDSPAN



MIDSPAN



Construction of fibers

The difference between Singlemode and Multimode
Fiber optic cables consist of either Multimode gradient fibers (identification “G”) or Singlemode fibers (identification “E”). When talking about the propagation of the light rays inside (mode) you can make the assessment that, to put it simply, Multimode fibers consist of several modes which are travelling at the same time, and Singlemode fibers it is only one. Both fiber classes cannot be mixed as there would be a high loss in light power.

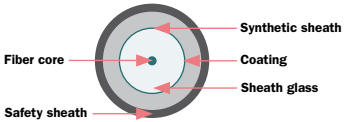
Core, mode field, cladding
The light travels in the inner area of a fiber. This inner area is called “core” (Multimode fibers) or “mode field” (Singlemode fibers). The outer area, called cladding (not to be confused with cable outer sheath), will ensure the following: The light should not exceed a certain angle of incidence. Furthermore it should make sure that the light will stay in the inner area and that light, which has left this area, cannot entry again. Otherwise there can be signal falsification.

Core- and cladding diameter
Core/mode field and cladding do have a different index of refraction, which means that the light is reflected on the border between both areas (so called total reflection). This makes sure that as much light as possible can be transferred inside of the core/mode field. In Europe we are talking mainly of 50 µ core diameter of Multimode fibers. Singlemode fibers have a core diameter of 9 µ. Depending on the fiber manufacturer it can also be between 9-10 µ. The diameter of the cladding always is 125 µ. With this the description of the fiber is build like on the following sample of a Singlemode fiber: “9/125 µ“.

Performance classes
The ISO/IEC 11801 as well as the DIN EN 50173 are dividing the fiber optic cables into different performance classes. Multimode fibers are divided into four classes from OM1 to OM4. The Singlemode fiber class is called OS2.

LED/VCSEL/Laser
Light-emitting diodes (LED) are used mainly for transmission rates up to 100 MBit/s. For higher transmission rates like Gigabit and 10 Gigabit Ethernet (10 GBit/s) Lasers have to be used. Depending on the wave length there can be used price attractive semi-conductor chip lasers, so called VSEL – vertical cavity surface emitting laser – (850 nm), but for higher wave lengths (e.g. 1310 nm or 1550 nm) there have to be used classical lasers.

Measuring of cabling routes
For the measuring of your fiber optic cabling you should use the suitable light source type, which will also be used later in operation. A false light source can tamper the measuring results.



Coding for indoor fiber optic cables according VDE DIN 0888

Code	Description
J-	Indoor Cable
V	Tight buffer
H	Loose buffer, unfilled
W	Loose buffer, filled
Y	PVC-cable jacket
H	Jacket of halogen free material
n	Fiber number
E	Singlemode fiber
G	Multimode fiber
n	Core diameter (µm)
n	Jacket diameter (µm)
n	Damping coefficient (dB/km)
B	Wavelength = 850 nm
F	Wavelength = 1300 nm
H	Wavelength = 1550 nm
n	Bandwidth (MHz x km) resp. Dispersion (ps/(km x nm)

Coding for outdoor fiber optic cables according VDE DIN 0888

Code	Description
A-	Outdoor cable
H	Loose buffer, unfilled
W	Loose buffer, filled
B	Bundle fiber, unfilled
D	Bundle fiber, filled
s	Metallic element in the cable soul
F	Gel filling
Q	Swelling flies
2Y	PE-Jacket
(L)2Y	Multi coated cable jacket
(ZN)2Y	PE-Jacket with non-metallic strain relief
(L) (ZN)2Y	Multi coated cable jacket with non-metallic strain relief
B	Cable armoring
B2Y	Cable armoring PE jacket
n	Number of fibers per bundle
E	Singlemode fiber
G	Multimode fiber
n	Core diameter (µm)
n	Jacket diameter (µm)
n	Damping coefficient (dB/km)
B	Wavelength = 850 nm
F	Wavelength = 1300 nm
H	Wavelength = 1550 nm
n	Bandwidth (MHz x km) resp. Dispersion (ps/(km x nm)
LG	Stranding of layers

Fiber optic color code according IEC 60603

Number of optical fiber or patch cord	Color of optical fiber or patch cord	Number of optical fiber or patch cord	Color of optical fiber or patch cord
1	red	7	brown
2	green	8	purple
3	blue	9	turquoise
4	yellow	10	black
5	white	11	orange
6	grey	12	pink

Number of optical fiber or patch cord	FOTAG Code	Number of optical fiber or patch cord	FOTAG Code
1	blue	7	red
2	orange	8	black
3	green	9	yellow
4	brown	10	purple
5	grey	11	pink
6	white	12	turquoise

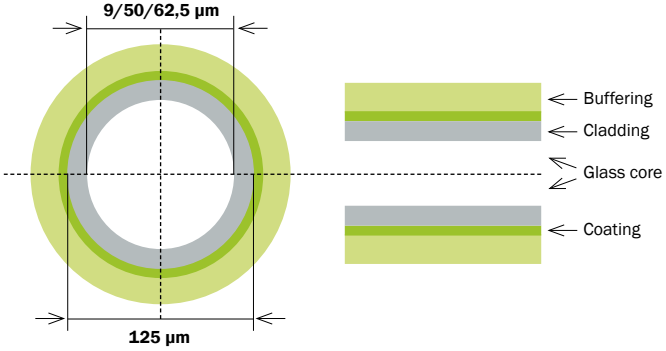
Performance for Ethernet according IEEE 802.3 over fiber optic

Application	Standard	Speed
10Base-FL	IEEE 802.3	10 Mbit/s
100Base-FX	IEEE 802.3u	100 Mbit/s
1000Base-SX 1000Base-LX	IEEE 802.3z	1 Gbit/s
10GBase-SR 10GBase-SR 10GBase-LX4 10GBase-LR 10GBase-LW 10GBase-ER 10GBase-EW	wavelength coding IEEE 802.3ae	10 Gbit/s
40GBase-SR4 40GBase-LR4 40GBase-ER4	IEEE 802.3ae	40 Gbit/s
100GBase-SR	IEEE 802.3ae	100 Gbit/s

Wavelength	Coding
L = 1310 nm	R = 64B/66B coding (10 GBit)
S = 850 nm	W = 64B/66B coding (10 GBit)
E = 1550 nm	X = 8B/10B coding (1 GBit)

Classification for fiber optic according EN 50173-1 (2002)

Class	Fiber	FOTAG-Code
OM1	G 62,5/125 µm	orange
OM2	G 50/125 µm	orange
OM3	G 50/125 µm	aqua
OM4	G 50/125 µm	violet
OM5	G 50/125 µm	lime
OS1/OS2	E 09/125 µm	yellow



Classification for fiber optic link according EN 50173-1 (2002)

Channel	Maximal channel attenuation (dB)			
	Multimode		Singlemode	
	850 nm	1.300 nm	1.310 nm	1.550 nm
OF 300	2,55	1,95	1,80	1,80
OF 500	3,25	2,25	2,00	2,00
OF 2000	8,50	4,50	3,50	3,50
OF 300 ≙ optical fiber link distance 300 meters				

	OM1 (62,5/125 µm)	OM2 (50/125 µm)	OM3 (50/125 µm)	OM4 (50/125 µm)	OM5 (50/125 µm)	OS2 (9/125 µm)
10Base-F	2.000 m	2.000 m	2.000 m	2.000 m	-	n./a.
100Base-FX	2.000 m	2.000 m	2.000 m	2.000 m	-	n./a.
1000Base-SX	275 m	550 m	900 m	1.100 m	-	n./a.
1000Base-LX	550 m	550 m	550 m	550 m	-	5.000 m
10GBase-SR	35 m	82 m	300 m	550 m	800 m	n./a.
10GBase-LR	n./a.	n./a.	n./a.	n./a.	n./a.	10.000 m
10GBase-ER	n./a.	n./a.	n./a.	n./a.	n./a.	40.000 m
40GBase-SR	n./a.	n./a.	100 m	150 m	200 m	n./a.
100GBase-SR	Wide Band 850 nm - 950 nm				150 m	n./a.

For transmission from 40GBase-SR multi fiber connectors (MPO) are used.

OM5

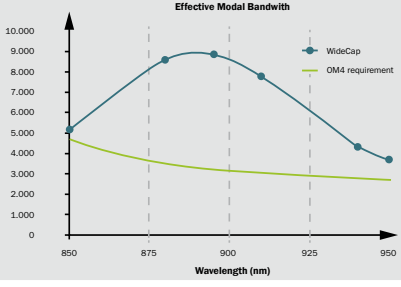
Until now there have been multimode fiber types OM1 with 62 µm and OM2; OM3 and OM4 with 50 µm. All of these provide transmission in the wavelength range of 850 nm. This limitation of range and transmission speed is now being revolutionized by the OM5 fiber, which is referred to as a Wideband Multimode fiber. Until now, parallel optical transmission has been used to transmit a higher data rate.

In this modality, multiple fibers are used to transmit the data simultaneously. This fragmentation of the data is now being optimized further. OM3 and OM4 fibers have been produced for the transmission window of 850 nm. With the OM5 fiber, the range from 850-950 nm wavelengths is now being produced in such a way as to extend the transmission to 4 wavelengths.

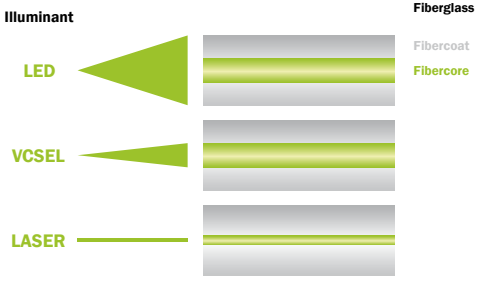
Thus, per wavelength up to 25 Gbps can be transmitted and 100 Gbps over one fiber, and at a distance of 150 m. Since the fiber is also compatible with OM3 and OM4, it can transmit data up to 200 m in the 850 nm waveband.

Characteristic	Condition	Specification	Unit
Fiber diameter		50 +/- 2,5	µm
Cladding diameter		125 +/- 0,8	µm
Damping	850 nm	≤ 2,4	dB/km
	953 nm	≤ 1,7	dB/km
	1.300 nm	≤ 0,6	dB/km
Overfilled modal bandwidth	850 nm	≥ 3.500	MHz × km
	953 nm	≥ 1.850	MHz × km
	1.300 nm	≥ 500	MHz × km
Effective modal bandwidth	850 nm	≥ 4.700	MHz × km
	953 nm	≥ 2.470	MHz × km
40 Gb/s multi-wavelength transceivers	850 nm-950 nm	150	m
40 & 100 Gigabit Ethernet	850 nm	200	m
100 BASE-SR	850 nm	600	m
1000 BASE-SX	850 nm	1.100	m

Optical transmission windows:



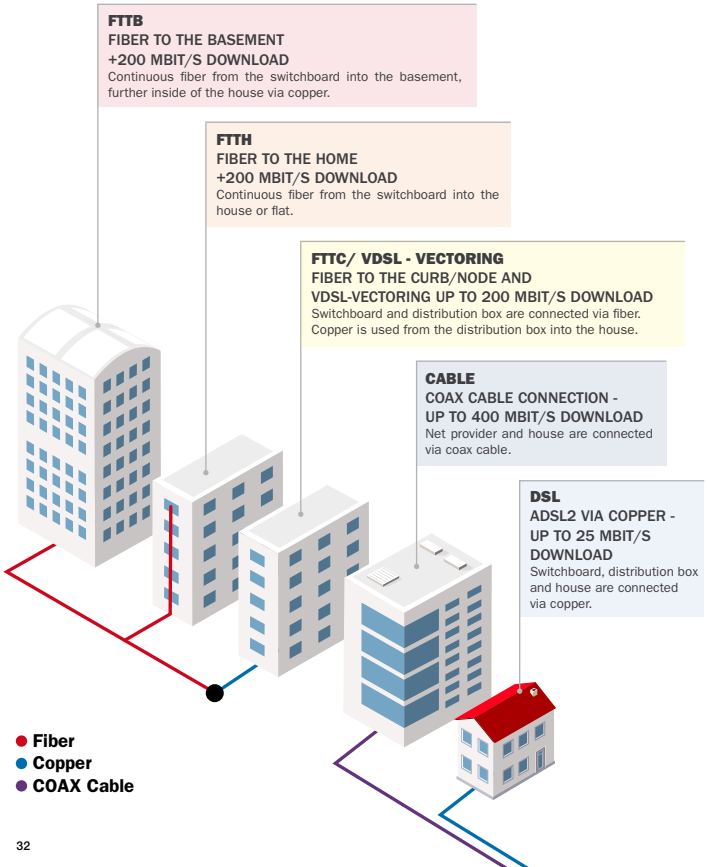
Optical transmission windows



Source	Fiber	Wavelength	Typical application
LED OM5	G 62,5/125 µm G 50/125 µm	850 nm	up to 100 Mbit/s
VCSEL OM3	G 50/125µm	850 nm or 1310 nm	up to 10 Gbit/s
LASER OS2	E 09/125µm	1310 nm or 1550 nm	typical above 10 Gbit/s

VCSEL - Vertical Cavity Surface Emitting

FTTx (Fiber to the x)



FTTx (Fiber to the x)

FTTH (Fiber to the Home)
Definition for a fiber connection from the Telekom provider to the end-user with maximum speed.

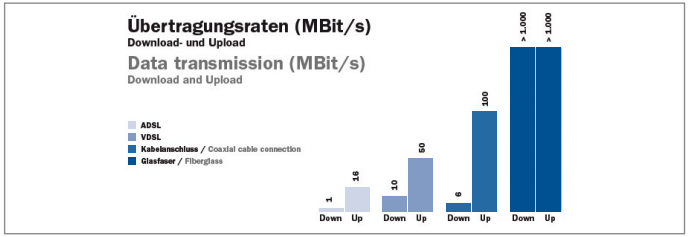
FTTB (Fiber to the Basement)
The fiber optic cable will be installed up into the basement, within the house copper will be used.

FTTC and VDSL-Vectoring (Fiber to the Curb)
The fiber optic cable will be installed up to the curb. The cables will be used from the Telekom provider up to the local cable distribution box and copper cables will be used on the remaining parts up to the end-user.

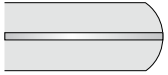
The **vectoring technology** reduces the **crosstalk** between close-by metallic connection cables. Therefore, the transmission rate of especially unshielded cable bulks of usual telephone networks and with many VDSL users can be increased distinctly.

CABLE
The coax cable is installed from the network provider via distribution boxes up to the house. The connection to the Router/Modem also uses coax cable. Partially, the connection from the network provider to the distribution box is made by fiber cables. From the distribution box to the house then connection will be made via coax cable.

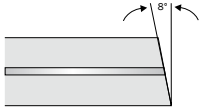
DSL
The classic way of the connection from households with the network provider is done via copper cables. A copper cable is used from the network provider to the switchboard, then up to the distribution box and into the house.



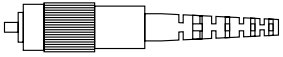
UPC ≙ ultra physical contact



APC ≙ angled physical contact

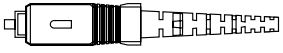


SC Connector



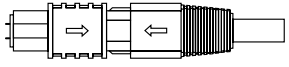
ST Connector

LC Connector

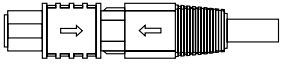


E-2000® / LSH Connector

MPO Connector (Male)

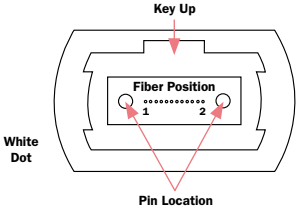


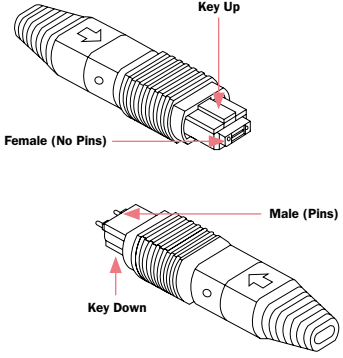
MPO Connector (Female)



Structure of a MPO/MTP connector

A MPO/MTP plug is equipped on one side with a raise. The position of this raise defines the termination “Key up” or “Key down”. The fiber holes of each plug are numbered from left to right as P1 (position 1), P2, etc. Furthermore there is a white dot on each plug on the side of position 1 to make a determination possible when the cable is already installed. A MPO/MTP plug is available as male or female version. The female version does not include pins on the plug in comparsion to the male version which has pins. Below image will show you the base structure of a MPO/MTP plug:





Connection methods A, B & C

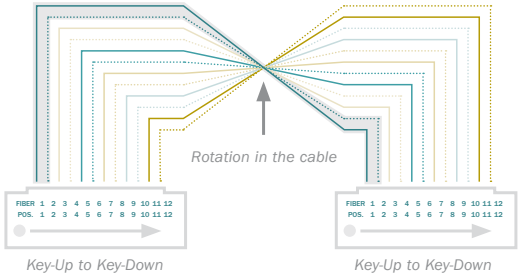
The TIA norm defines two types of fiber optic duplex patch cords, equipped with LC- or SC plugs, to complete an end-to-end fiber optic connection: An A-to-A patch cord is a crossed version and an A-to-B patch cord is a straight version. On base of these types there are three methods to connect polarities in the MPO/MTP area.

A-TO-A PATCH CABLE

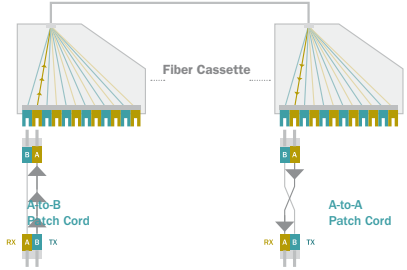
A-TO-B PATCH CABLE

Structure of a MPO/MTP connector

Method A
Method A is the most common. It uses a straight patch cord (A-to-B) on one end which is connected through a cassette (LC to MPO or SC to MPO, depending on the requirement), a straight MPO/MTP Key up to Key down backbone cable and a crossover patch cord (A-to-A) on the other side.

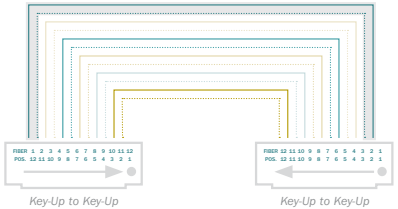


Application example:

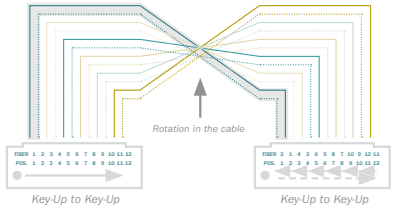


Structure of a MPO/MTP connector

Method B
Method B has a crossover in the cassette. The MPO plug is in Key up position on both ends, which means that the fiber position 1 is position 12 on the other side. Thus position 12 of one side is position 1 on the other side. With this method only A-to-B patch cords are used.



Methode C
Methode C is the most complex. There is a pair-wise crossover happening in the backbone cable. The backbone cable is pair wise turned, which means P1, P2 to P2, P1 and P3, P4 to P4, P3 etc. On both sides A-to-B patch cords are used. The cassette uses MPO/MTP Key up to Key down.



IP protection types
1st code number

1st code number	Protection against foreign bodies entering	Symbol
0	**Not protected**	
1	**Protected against foreign bodies Ø 50 mm and bigger** Protection against touching dangerous parts with the back of the hand	
2	**Protected against foreign bodies Ø 12.5 mm and 80 mm long** The structured test item must be a sufficient distance from dangerous parts	
3	**Protected against foreign bodies Ø 2.5 mm and bigger** Protection against touching dangerous parts with a tool (The touch probe of 2.5 mm diameter must not be able to enter)	
4	**Protected against foreign bodies Ø 1.0 mm and bigger** (The touch probe of 1.0 mm diameter must not be able to enter)	
5	**Dust-protected** Protection against touching dangerous parts with a wire (The touch probe of 1.0 mm diameter must not be able to enter)	
6	**Dust-proof** Protection against touching dangerous parts with a wire (The touch probe of 1.0 mm diameter must not be able to enter)	

Example IP 44:
1st code number = 4 (protection against foreign bodies bigger than 1 mm Ø)
2nd code number = 4 (protection against splash water from all directions)

IP protection types
2nd code number

2nd code number	Protection against water entering with damaging effects	Symbol
0	**Not protected**	
1	**Protected against dripping water** Definition: Drops falling vertically must not have any damaging effects	
2	**Protected against dripping water up to 60° to the vertical** Definition: Drops falling vertically must not have any damaging effects if the housing is angled up to 15° on both sides of the vertical	
3	**Protected against spray water up to 60° to the vertical** Definition: Water that is sprayed at an angle of up to 60° on both sides of the vertical must not have any damaging effects	
4	**Protected against splash water from all directions** Definition: Water that splashes against the housing from all directions must not have any damaging effects	
5	**Protected against water jet from all directions** Definition: Water that is directed as a jet against the housing from all directions must not have any damaging effects	
6	**Protected against strong water jet** Definition: Water that is directed as a strong jet against the housing from all directions must not have any damaging effects	
7	**Protected against the effects when submerged temporarily under specified pressure and time conditions** Definition: Water must not enter in an amount which causes damaging effects if the housing is temporarily submerged in water under standardised pressure and time conditions	
8	**Protected against the effects when submerged long-term under specified pressure for a defined period of time** Definition: Water must not enter in an amount which causes damaging effects if the housing is submerged long-term under water, under conditions which must be agreed on between manufacturer and user. The conditions must, however, be more difficult than those for code numer 7.	

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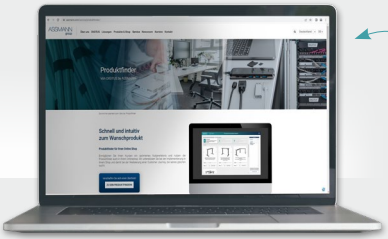

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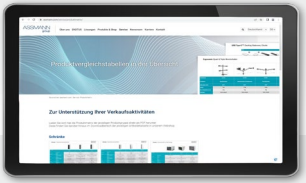

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