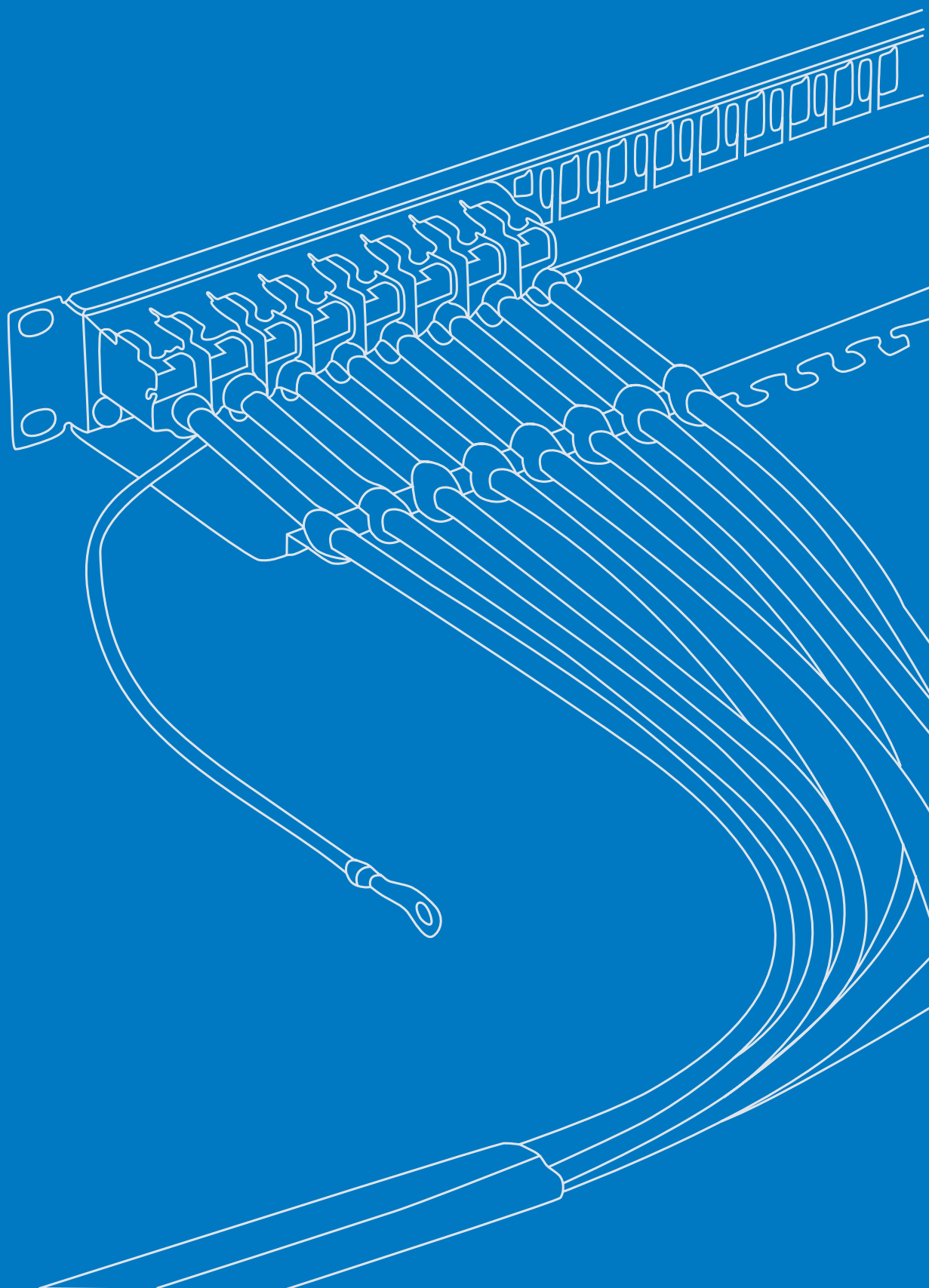
BASIC KNOWLEDGE COMPACT



GENERAL

The history of data communications is closely linked to the developments in cabling and connecting hardware. High performance data networks and local area networks (LANs) cannot perform well without appropriate cables and excellent connectors.

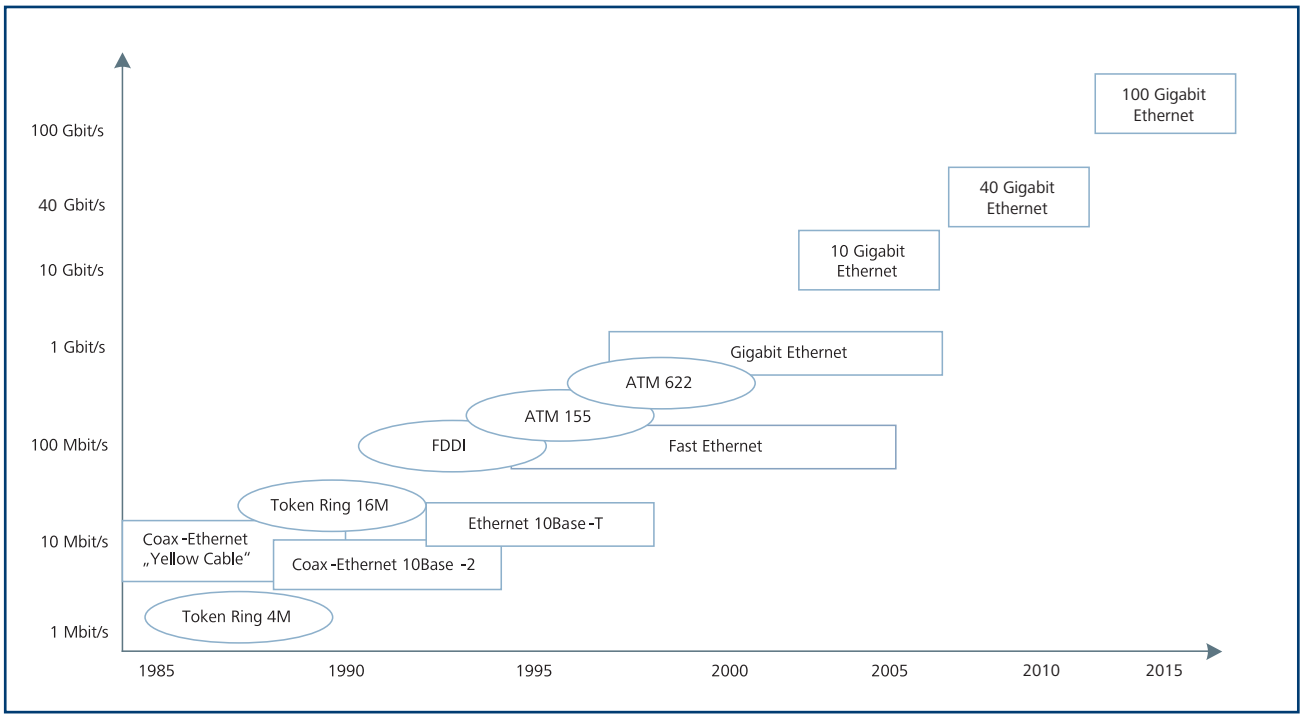
When we take a look at high-speed data networks like 40 Gigabit and 100 Gigabit Ethernet, it's hard to imagine that data networks descended from telephone networks. Telegärtner has set quite some trends from the early beginnings.

The Ethernet version 10Base-2 was running over coaxial cable. With Telegärtner's uninterruptable EAD outlets, computers could be added or removed while the network was running. Soon, the screened version scEAD followed, and even 2010 there are still some coaxial networks with EAD/scEAD outlets in use.

EAD/scEAD

TAE Outlet

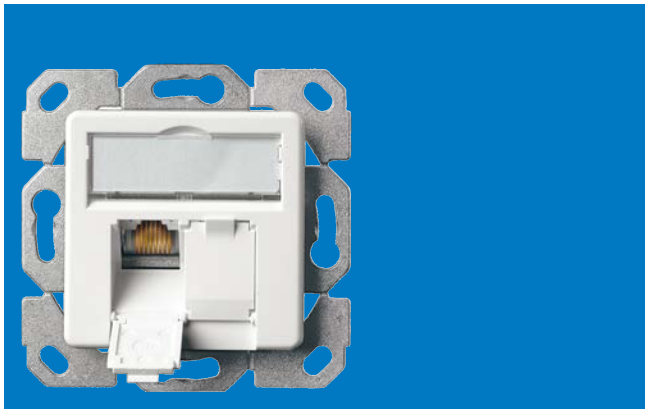
The evolution of Ethernet still continues, leading to ever-higher data rates. 10 Gbps over a 100 meter link of copper cable and 25/40 Gbps over up to 30 meters are possible, and 25 Gbps over 50 meters look quite promising.



Evolution of LAN technologies: Ethernet has become the dominant technology for local area networks (LANs). Most common are Fast Ethernet with 100 Mbps and Gigabit Ethernet with 1 Gbps. For high speed networks, 10 Gigabit Ethernet offers 10 Gbps, and 40 and 100 Gigabit Ethernet will soon offer even higher data rates.

COPPER NETWORKS

Structured Cabling



Example for a RJ45 outlet by Telegärtner

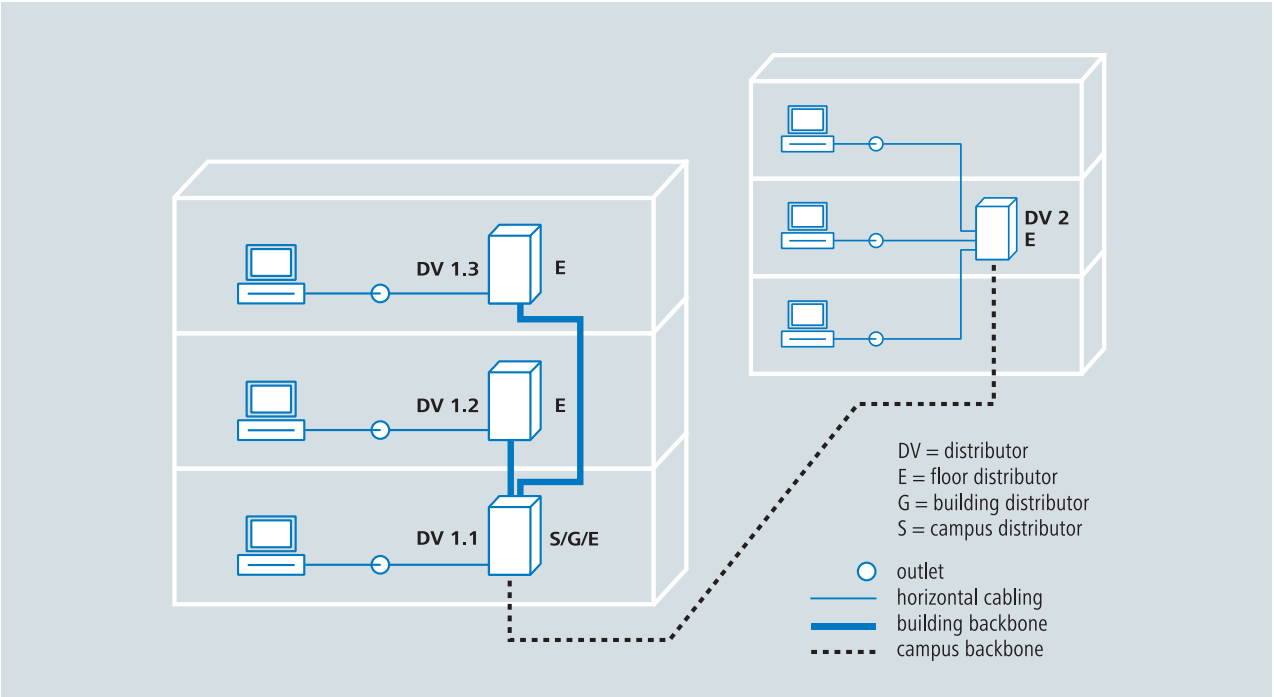
The demand for vendor independent and neutral cabling led to the international standard ISO/IEC 11801 on which the European standard EN 50173 is based. These standards define a structured cabling which shall be designed independent of the use or dedication of rooms or any network technology. The standards also contain performance specifications for components and links, as well as appropriate testing methods.

Structured cabling consists of the horizontal cabling, the building backbone, and the campus backbone. The campus backbone runs between buildings on the same campus. Apart from telephone cables, only fiber optic cables are used to connect the buildings to a central campus distributor.

The cabling to connect the floor distributors to the building distributor following a star topology is called building backbone. According to the standards, each floor should have at least one floor distributor. However, it is also possible to use one floor distributor for several floors should they be sparsely populated.

The horizontal cabling runs from the floor distributor to the outlets. Mainly twisted-pair cabling is used here, but fiber optic cabling might offer some advantages depending on the size of the network and the details of the individual cabling project. In a lot of projects the data cabling is also used for telephony.

Telephones need another pin assignment than Ethernet, but when all pins of a jack are connected to the cable, the outlet can be used for either telephone or data. Telephone and data over the same cabling is called a converged network.



An example for sturctured cabling

EN 50173

The first editions of ISO/IEC 11801 and EN 50173 were published in 1995. Since then, they have been updated on a regular basis to keep up with the demands of the ever growing data rates.

Currently, components for 10 Gigabit Ethernet with a bandwidth of 500 MHz (Class E_A / Category 6_A) are used in commercial buildings and for 40 Gigabit Ethernet up to 2000 MHz (Class I / Category 8.1) in data centres.

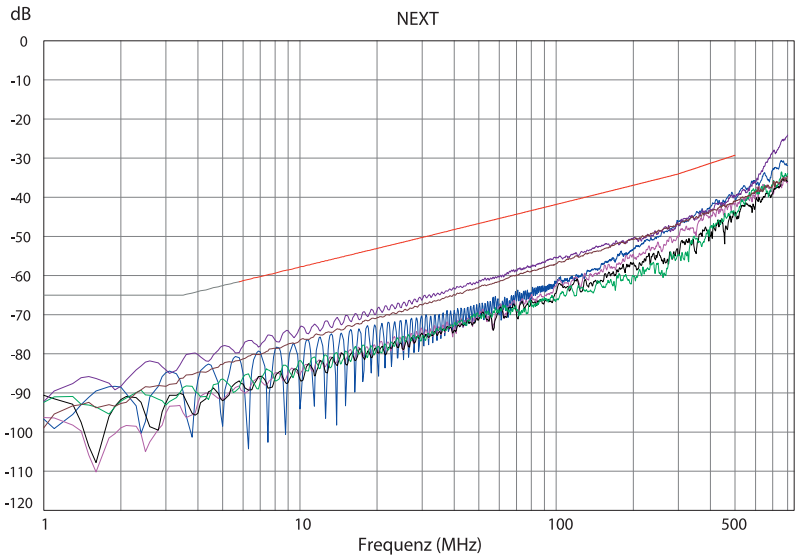
EN 50173 has become a series of six standards, focusing on different environments and scenarios:

DIN EN 50173-1:2018 General requirements
DIN EN 50173-2:2018 Office spaces
DIN EN 50173-3:2018 Industrial spaces
DIN EN 50173-4:2018 Homes
DIN EN 50173-5:2018 Data centre spaces
DIN EN 50173-6:2018 Distributed building services

ISO/IEC 11801

is the international set of standards for structured cabling. It is very similar to EN 50173, and since November 2017 it even has the same structure of six parts:

ISO/IEC 11801-1:2017: General requirements
ISO/IEC 11801-2:2017: Office premises
ISO/IEC 11801-3:2017: Industrial premises
ISO/IEC 11801-4:2017: Single-tenant homes
ISO/IEC 11801-5:2017: Data centres
ISO/IEC 11801-6:2017: Distributed building services



Large headroom of Telegärtner Cat.6_A cabling components measured in a 90 m Class E_A Permanent Link in accordance with ISO/IEC 11801

TIA-568

Apart from ISO / IEC 11801, the American standard TIA-568 is very common in the United States. Currently, the fifth issue of TIA-568 is published as TIA-568-D, which replaces all preceding ones.

Some specifications of TIA-568-D differ from the ones in ISO / IEC 11801 and thus EN 50173. TIA-568 applies only to the U.S.A. unless explicitly stated otherwise.

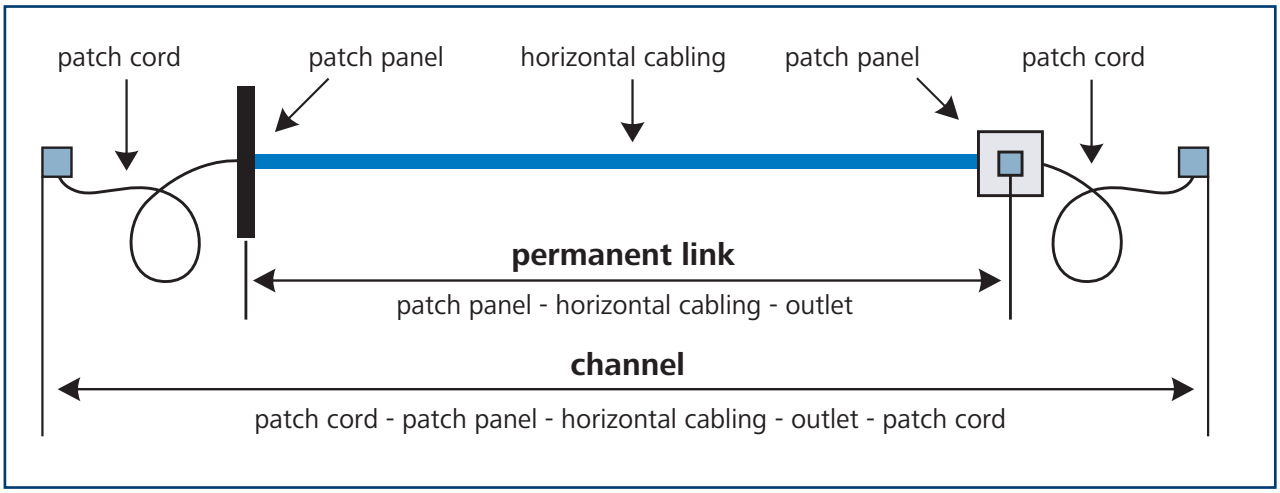
The set of TIA-568-D consists of five parts:

TIA-568.0-D: Generic Telecommunications Cabling for Customer Premises
TIA-568.1-D: Commercial Building Telecommunications Infrastructure Standard
TIA-568.2-D: Balanced Twisted-Pair Telecommunications Cabling and Components Standard
TIA-568.3-D: Optical Fiber Cabling and Components Standard
TIA-568.4-D: Broadband and Coaxial Cabling and Components Standard

Permanent Link and Channel

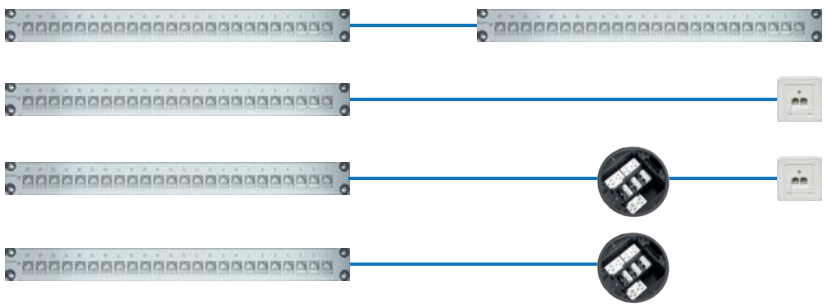
The permanent link comprises the components that will stay permanently in place, so in most installations this means patch panel, horizontal cable, and outlet.

„Channel“ means the whole connection between two electronic devices like a PC and a switch, including all necessary patch cords (very often, the channel consists of the permanent link and the patch cords). In most cases, the channel will only be tested when problems have occured to make sure that the whole cabling is fine. After the installation is done, nearly always the permanent link is tested. The reason for this is simple: Following the test procedures for the channel would mean that all of the patch cords had to remain plugged into the outlets and patch panels.



Permantent Link and channel

EN 50173-2:2018 specifies four different configurations of horizontal cabling.



Configuration A
Patch panel - patch panel

Configuration B
Patch panel - outlet

Konfiguration C
Patch panel - consolidation point - outlet

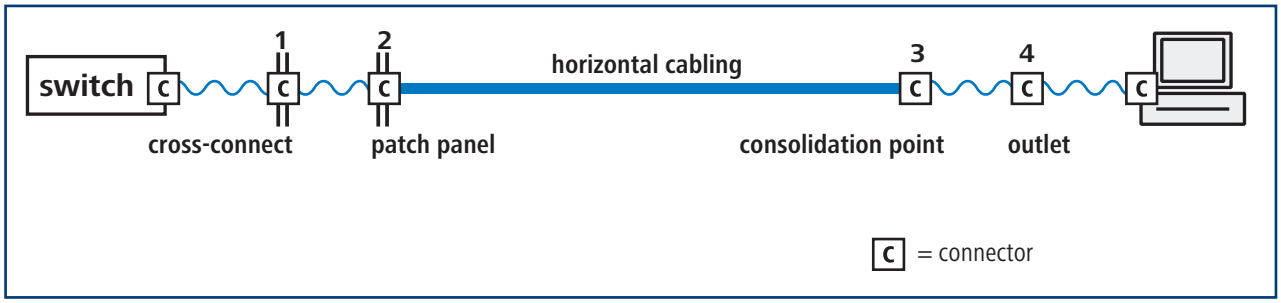
Configuration D
Patch panel - consolidation point

Links with 2, 3 and 4 Connectors

A link can contain two to four connections. The connections directly at the electronics like switches or at the equipment like PCs are not taken into consideration.

Permanent link and channel contain in the most simple configuration just one connection at the patch panel and one at the information outlet.

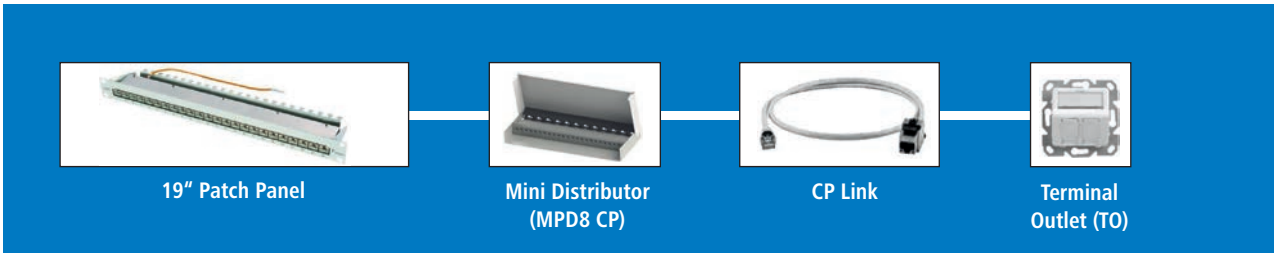
Link and channel can also have a consolidation point near the outlets, which is common in large office spaces. There can be one more connection in the distributor, e.g. when the active components like switches are connected to a patch panel of their own. Patch cords connect the patch panels of the switch and the horizontal cabling, which is called a „cross-connect". Cross-connects are popular in the United States but are rarely used in Europe.



Channel with 4 connectors

Cabling with Consolidation Point

Sometimes it is useful to lay a bundle of horizontal cables between the floor distributor and a consolidation point, which is made of a group of outlets or a small distributor. From the consolidation point, cables are run to fixed or mobile outlets, to which PCs or other end devices are connected. An example of a consolidation point is a small distributor, installed in suspended ceilings or cellular floors in open-plan offices or for industry solutions, where cover plates or utility columns provide flexibility. Floor outlets may also serve as consolidation points when patch cords plugged in, which are not connected to PCs but to other outlets in desks or furniture.



Cabling with Consolidation Point

Class and Category

„Class“ means something completely different than „category“. The class (or „category link“ according to TIA) always applies to the installed link, the category as such applies only to one single component, e.g. the cable or the outlet; the component is tested and verified by either the labs of the manufacturer or independent verification labs. The installed link is always tested according to classes (or category links).

Cabling classes acc. to EN 50173 and ISO/IEC 11801-1:

Class D: up to 100 MHz, for data rates up to 1 Gbps
Class E: up to 250 MHz, for data rates up to 1 Gbps
Class E_A: up to 500 MHz, for data rates up to 10 Gbps
Class F: up to 600 MHz, for muti media applications
Class F_A: up to 1.000 MHz, for multi media applications
Class I: up to 2.000 MHz, for data rates up to 40 Gbps
Class II: up to 2.000 MHz, for data rates up to 40 Gbps

Component categories acc. to EN 50173 and ISO/IEC 11801-1

Category 5: up to 100 MHz, for data rates up to 1 Gbps
Category 6: up to 250 MHz, for data rates up to 1 Gbps
Category 6_A: up to 500 MHz, for data rates up to 10 Gbps
Category 7: up to 600 MHz, for multi media applications
Category 7_A: up to 1.000 MHz, for multi media applications
Category 8.1: up to 2.000 MHz, for data rates up to 40 Gbps
Categorye 8.2: up to 2.000 MHz, for data rates up to 40 Gbps

Class I/II and category 8.1/8.2

Class I and class II channels are specified for a maximum length of 30 m. 24 m of them are for the horizontal cable (permanent link) and 3 m patch cords on each end.
Category 8.1 is based on category 6_A. It recognizes the RJ45 connector of IEC 60603-7-81 and is backwards compatible to categories 5, 6 and 6_A.
Category 8.2 is based on category 7_A. It is backwards compatible to all all other categories including 7 and 7_A, but specifies a plug that is not compatible to RJ45 jacks, e.g. the TERA connector of IEC 61076-3-104 or GG45 or ARJ45 of IEC 60603-7-82.
IEEE specified 40 Gigabit Ethernet 40GBASE-T with an RJ45 compatible plug, so category 8.2 components are very rarely used.

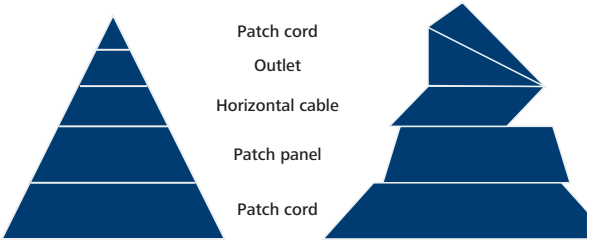
After 40GBASE-T was standardized, IEEE added 25GBASE-T. Its data rate is 25 Gbps, which is a little more than half of 40GBASE-T. 25GBASE-T runs over cabling components that meet the specs of Cat.8.1 only up to 1250 MHz. In other words: When users want to specify or use Cat.8.1 components, they have to make sure that these components meet the specs of EN 50173-1 within the full frequency range of up to 2000 MHz; if they meet the specs only up to 1250 MHz, they can transmit only a bit more than half the data rate.

The correct spelling of Class E_A and Category 6_A: Originally, an „a“ in lower case was used. Later on, TIA and ISO agreed to use an „A“ in upper case. ISO (and thus Cenelec) use the „A“ in subscript (A), TIA uses it in the same level as „6“:

Link and Channel according to ISO:	Class E_A
Link and Channel according to TIA:	Category 6A
Components according to ISO:	Category 6_A
Components according to TIA:	Category 6A

Cabling Systems versus Mix & Match

Even though the cabling standards were created to offer the possibility of using components from different vendors in the same link, standard compliant links („mix & match“) might lead to serious problems. The specifications allow large tolerances and different vendors may use different ways of eliminating capacitive and inductive interference. It may well happen that components of standard compliant systems cause reflections of the signal, which lead to high bit error rates. The system becomes slow and offers only poor performance.



Cabling systems vs. mix & match

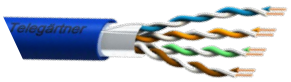
Twisted Pair Cables

ISO developed a standardized, systematic naming for the different types of construction of twisted pair cables. The first letter stands for the overall screen, the second one – separated by a slash – stands for the element screen.

„S“ means braid screen, „F“ means foil screen. „TP“ stand for twisted pair, the balanced element.

Different types of twisted pair cables

S/FTP
overall braid screen (S),
elements foil screened (FTP)

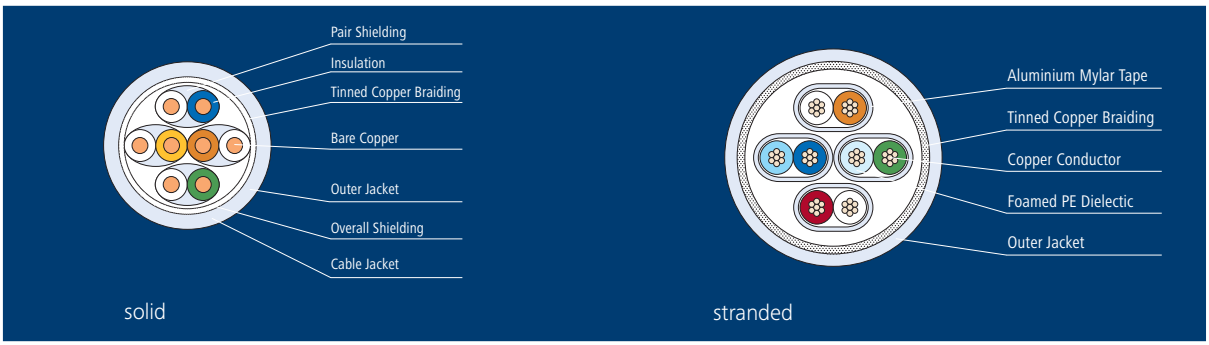


F/UTP
overall foil screen (F), elements unscreened (UTP)

SF/UTP
overall braid and foil screen (SF),
elements unscreened (UTP)

U/UTP
no overall screen (U),
elements unscreened (UTP)

Twisted pair cables are available with solid and stranded conductors.



Connecting Hardware

The RJ45 has become the dominant connector for copper cabling. The term “RJ45” is not standardized, but it’s widely used. The American term 8P8C is more precise. „P“ stands for „positions“ and „C“ for „contacts“. An 8P8C connector has 8 positions for the contacts and 8 of them are populated. The standard series EN 60603-7 (international: IEC 60603-7) specifies the RJ45 in both, shielded and unshielded versions, and from category 5 to category 8.1.

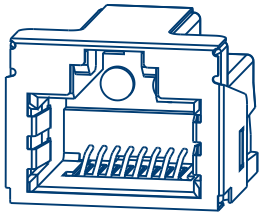
The American standard TIA-568 defines two different colour codings for RJ45 plugs and jacks. The colour coding T568A was originally developed for the military and is still mandatory for U.S. federal installations.

The colour codings of TIA-568 are not contradictory to EN 50173. EN 50173 points to EN 50174, which contains two wiring schemes („option A“ and „option B“). Either one may be used, but both ends of the cable have to be connected in the same manner.

RJ45 jacks should have an integrated protection against overbending the contacts. When the cord of a telephone or a fax machine with an RJ11 or RJ12 connector is plugged into an RJ45 jack, the outer contacts (1/2 and 7/8) can be damaged.

RJ11 and RJ12 connectors are similar to the RJ45, but they are a bit smaller. An integrated protection against overbending protects the contacts of the jack. Even after many “mispluggings”, the jack can transmit high data rates without any problems.
Another common term for RJ12 is 6P6C, which means the connector has 6 positions for contacts of which 6 are populated.

RJ45

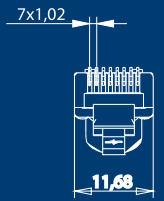


T568A	PIN RJ45	T568B
white / green	1	white / orange
green	2	orange
white / orange	3	white / green
blue	4	blue
white / blue	5	white / blue
orange	6	green
white / brown	7	white / brown
brown	8	brown

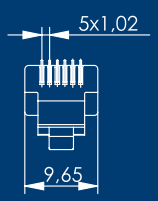
pair 3: 1, 2 — pair 2: 3, 6 — pair 1: 4, 5 — pair 4: 7, 8

RJ45 pin assignment and colour coding

RJ45 (8P8C)



RJ12 (6P6C)



In industrial and transport applications circular M12 and M8 connectors are used. Their metric threading ensures reliable connection even during vibrations.
The D-coded M12 accepts four wires, meets the category 5 specifications and thus can be used for data rates up to 100 Mbps.
The X-coded M12 has the same size as the D-coded version but accepts four wire pairs, which are completely separated from each other by a metal shielding cross. The M12-X meets the category 6_A specifications and can be used for data rates up to 10 Gbps.

The circular M12x1 X-coded connector can transmit data rates up to 10 Gbps.

The M8 accepts four wires like the M12-D, meets the category 5 specifications and thus can be used for data rates up to 100 Mbps. It is much smaller than the M12 and is an ideal solution for applications in restricted spaces.

Outlets with boards or individual modules

Constantly growing technical requirements and at the same time cost pressure demanding shorter installation time were successfully solved by the modular design of the connecting hardware. In the old days, outlets contained small printed circuit boards to which the jacks were soldered.
Now the jacks are mounted directly on the end of the cable and just snapped into the frame of the outlet or the patch panels. Each cable is terminated on both ends with an individual jack. This leads to a much better electrical performance of the link and to an enormous time saving when terminating the cables and installing the connecting hardware. An additional benefit: Individual links can be added later at much lower costs.
Either concept works, and Telegärtner offers both of them, of course. The AMJ K Cat.6_A was the first board based outlet with LSA+ contacts and Cat.6_A performance verified by the independent test lab GHMT worldwide.

Horizontal cables do not necessarily have to be terminated with a jack. When they are terminated with a plug, they can be inserted into an outdoor housing of an IP surveillance ca- mera, for example. There is no need anymore for an outlet near the camera. This benefit is also welcome by industrial applications, and even in residential cabling the outlet can be omitted – in many installations there is no space for an outlet anyway. Good plugs can be mounted on site and can be used for any application, from analogue telephony up to 40 Gigabit Ethernet.

MFP8 connector by Telegärtner: mounted on site in less than 60 seconds without the need of special tools and ready to work in networks up to 40 Gigabit Ethernet.

Power over Ethernet (PoE)

With PoE, the devices can be powered using the data cable. The standards body IEEE has specified PoE in the industry standard IEEE 802.3 and its amendments:

PoE and especially PoE+ and 4PPoE demand high quality connecting hardware as the small contacts have to transmit data and power at the same time.
The contact design plays a key role with Power over Ethernet. When an RJ45 plug is unplugged while the end device is still powered over the data cable, sparcs occur that will damage the small contacts of plug and jack. The sparcs cannot be avoided, so it is vitally important that the area where data is transmitted is far away from the area where the sparcs damage the contacts. With such a PoE optimized design, the connection can transmit the full data rate even after multiple disconnections under load.

Telegärtner's tip

Disconnecting an RJ45 connection under load is not specified as regular operation and should be avoided in any case. The contact design of Telegärtner plugs and jacks is optimized for PoE applications, and so the area where data is transmitted is far away from the area where the sparcs damage the contacts. This gives the user the peace of mind that the connection will work properly even after the connection has been accidentialy disconnected under load several times.

Versions of Power over Ethernet

	Standard	Year	Power at the device typ.	Electrical current per wire pair
PoE	IEEE 802.3af	2003	12.95 W	350 mA
PoE+	IEEE 802.3at	2009	25.5 W	600 mA
4PPoE	IEEE 802.3bt	2019	51.0 W	600 mA
			71.3 W	960 mA

De-embedded/Re-embedded

The cabling infrastructure of high speed data networks calls for high tech testing, especially when testing individual components. The de-embedded testing method was developed for Cat.6 components. It uses a reference jack which has to be tested with 12 different plugs to ensure it can cope with the complete spectrum of mix & match applications.

Of course, this leads to different margins with the different connectors, and all of them have to be standard compliant. De-embedded testing is precise enough for testing individual components of category 6 up to 250 MHz for data rates up to 1 Gbps. Despite of this effort, this testing method is not precise enough for testing Cat.6_A components up to 500 MHz for data rates up to 10 Gbps. With de-embedded testing, a jack under test was tested as a single, stand-alone item. Re-embedded testing test the jack re-embedded into the board, it tests "the whole thing". Re-embedded testing uses a reference plug with well-known margins. It also uses two test heads, which are connected to a network analyzer. One of this heads has a soldered receptacle for the reference plug; the jack to be tested is connected to the other test head using twisted pairs. Then the two test heads are connected and tested.

Re-embedded testing using multiple boards according to IEC 60512 is still not precise enough for Telegärtner: In the Telegärtner's test lab, the board with the reference jack is directly connected to the network analyzer using coaxial cables. This has the benefit of eliminating near-end cross-talk (NEXT) and effects caused by interference among the twi- sted pairs. The special testing procedure with coaxial cable enables higher precision than the procedure according to IEC 60512.

Telegärtner Real-Time Re-Embedded Cat.6_A

Using an 8-port network analyzer with implemented re-embedding calculation, the Real-Time Re-Embedded test procedure by Telegärtner makes real-time evaluation of connecting hardware possible. With this, effects of any changes of the device under test can be tracked in real-time. The time consuming testing of all pair combinations belongs to the past.

REAL-TIME
RE-EMBEDDED

Cat.6_A Patch Cords

In many installaitons, patch cords are ignored – with unpleasant consequences, as the cabling infrastructure will not reach it's full performance when low-cost patch cords degrade the quality of the channel. But how can one tell that a specific path cord is a high quality product?

Cat.6_A components have been tested using the re-embedded test procedure for quite a while by now, but patch cords haven't – the physics made it next to impossible.

Once again, Telegärtner lead the way: The Telegärtner test lab was the fist test lab worldwide that was able to test Cat.6_A patch cords. The test procedure is more advanced and more precise than specified by international standards.

Telegärtner uses Real-Time Re-Embedded testing, which tests all four pairs simultaneously with an 8-port network analyzer. This high-end test procedure without baluns leads to much more precise test results and sets the trend for testing high-quality patch cords. This ensures that the channel can transmit the full data rate.

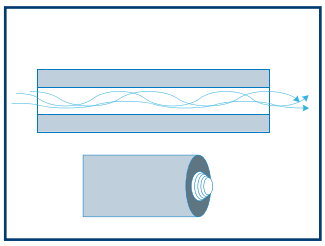
FIBER OPTIC NETWORKS

Design of Optical Fiber

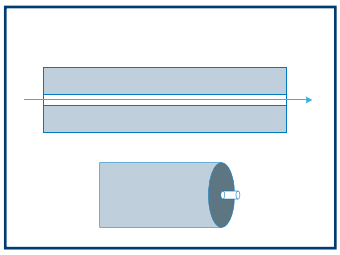
State of the art fiber optic cables contain multimode fibers with graded refraction index (marked with a „G“) or singlemode fiber (marked with an „E“). Loosely, one can assume that several rays of light (modes) travel along a multimode fiber in different ways, whereas in singlemode fibers only one of them does so (these „rays“ stand for the main distribution of electromagnetic energy that satisfies Maxwell’s equations and boundary conditions in guided wave propagation).

The light is guided in the inner part of the fiber. The outer part ensures that only light that doesn’t exceed a certain angle can enter the fiber, that it will be guided travelling along the fiber, and that light which left the inner part may not reenter causing signal irritation. The inner part of a fiber is called core (multimode fibers) or mode field (singlemode fibers), the outer part is called cladding. As core and cladding are made of glass with different refraction indices, light will be reflected at the border (total reflection).

Thus, a maximum of light will be guided through the fiber core. Nowadays, multimode fibers with a core diameter of 50 µm are common, in the old days it was 62.5 µm. The two multimode fiber types may not be mixed in the same link, for that would lead to a heavy loss of light, especially when light travels from the 62.5 into the 50 µm fiber. The core diameter of singlemode fibers is typically 9 to 10 µm, depending on the fiber manufacturer and on the wavelength of the light. The outer diameter of all of the fiber types mentioned above is 125 µm.



Multimodef fiber G50/125



Singlemode fiber E9/125

Optical fibers

ISO/IEC 11801 and EN 50173-1:2003 specify different performance categories for optical fibers. There are five of them for multimode fibers (OM1 to OM5) and two for singlemode (OS1a and OS2, with OS1 fibers being superseded by OS2 by now). Fiber category OS1 of EN 50173 was renamed to OS1a and has now the same designation as in ISO/IEC 11801-1:2017. The specifications of OS1 according to EN 50173 were not changed..

LEDs usually work fine at transmission rates up to 100 Mbps. Gigabit and 10 Gigabit Ethernet use lasers, as LEDs can’t be switched on and off fast enough.
Cost-effective VCSELs (vertical cavity surface emitting lasers) work at 850 nm. For other wavelengths such as 1310 nm or 1550 nm, standard lasers have to be used.

Maximum attenuation in dB / km							
	Multimode OM1 bis OM4		Multimode OM5		Singlemode OS2		
Wavelength	850 nm	1300 nm	850 nm	1300 nm	1310 nm	1383 nm	1550 nm
Attenuation	3.5 dB	1.5 dB	3.0 dB	1.5 dB	0.4 dB	0.4 dB	0.4 dB

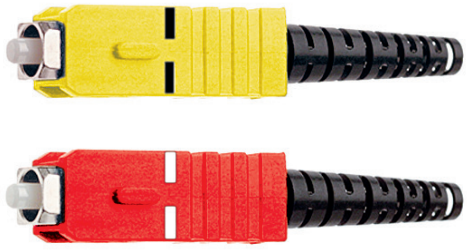
Permissible power loss (attenution) in optical fibers acc. to EN 50173-1:2018

Plastic optical fibers

Optical fibers do not necessarily have to be made of glass. They can partially or completely be made of plastic.

Polymeric optical fibers, also called plastic optical fibers or POF, are completely made of plastic. Unlike glass fibers, polymeric optical fibers cannot be fusion spliced together, as the plastic would just melt.

POFs are connected using connectors or clamps. With sharp knives, POFs can be cut precisely, and there is no need to polish the fiber ends.



Connectors for polymeric optical fibers

Telegärtner's tip

Optical fibers should always be tested with the type of light source they will be used with for data transmission. Most optical testers (optical time domain reflectometer, OTDR) typically use standard lasers. However, depending on the type of Ethernet, LEDs and VECSELs are used with multi-mode fibers instead of standard lasers. The wrong source of light might lead to wrong test results.

Bend-intensitive optical fibers

Bend-insensitive optical fibers have a lot of advantages in installations with very tight space. Such fibers can be layed in very narrow turns and still offer the full bandwidth. But not all of them are backwards compatible with common optical fibers.

Bend-intensitive singlemode fibers are specified in the ITU-T G.657 standard. Fibers of the G.657.A series are fully compatible with standard singlemode fibers as specified in ITU-T G.652. Fibers of the G.657.B series in most cases aren't, but they have a smaller minimum bending radius than the ones of the A series.

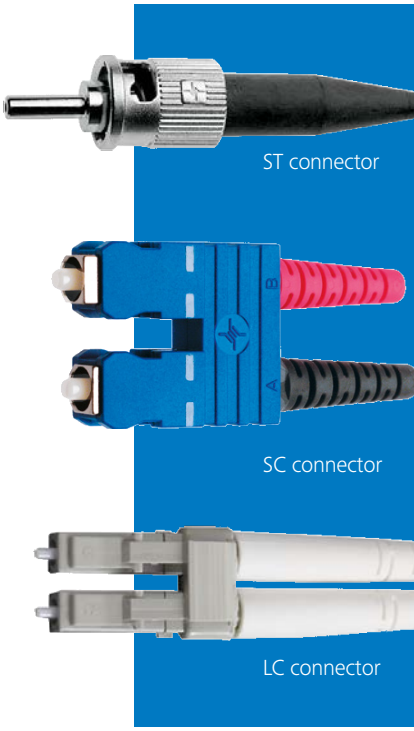
Depending on the manufacturer, bend-insensitive multimode fibers (BIMMF) might be backwards compatible with conventional OM3 and OM4 fibers. A look at the data sheet is highly recommended, an explicit statement of the manuf- acturer will help best.

WDM systems

Low waterpeak fibers are very important for WDM systems. WDM stands for wavelength division multiplexing. Where standard systems send light of only one wavelength along a singlemode fiber, WDM systems send multiple rays of light of different wavelengths simultaneously along one single fiber.

Each channel is assigned to an individual wavelength, and to ensure a constant transmission of all signals, the physical properties of the fiber must be the same for all of the channels, i.e. for all of the appropriate wavelengths. Today, WDM systems can only rarely be found in the LAN environment, but still low waterpeak fibers have to be minded when designing or installing new networks to ensure that the future migration towards WDM will be possible wihout replacing the cables.

Fiber Optic Connectors



EN 50173 specifies the LC duplex fiber optic connector for the work area (outlets). In legacy installations where the older SC duplex connector is used, links with SC duplex can still be added. For any other area all other connectors specified by IEC standards are allowed.

Many manufacturers of networking devices have begun to use small form factor (SFF) connectors like the LC duplex as they consume not more space than RJ45 jacks. It has to be minded, though, that a high density of connectors in patch panels or consolidation points might proof to be disadvantageous as far as handling, robustness, and clearness are concerned.

In legacy installations, ST connectors can be found alongside with the SC duplex and the LC duplex.

To achieve best possible optical performance, connectors for singlemode fibers are also available in an angled version. Because of the sloping surface of the tip of the connector, reflected light cannot return into the mode field of the fiber but is reflected away from the connector end.

Telegärtner's tip

Never look into fiber optic connectors or jacks. VCSELs and standard lasers emit invisible infrared light which can cause serious health hazards.

Never plug connectors with a rectangular end (physical contact connector, PC) and connectors with a sloping surface (angled physical contact connectors, APC) into the same coupling. When using APC connectors make sure that slope of both connectors in one coupling has the same angle.

Standardized colour code for fiber optic connectors

EN 50173-1:2018 only specifies colors for plugs and couplings for single-mode fibers:

- Singlemode PC, rectangular connector tip (PC = physical contact): blue
- Singlemode APC, angled connector tip (APC = angled physical contact): green

However, some colours have become common for the different types of multimode fibers as well.

	CONNECTOR/ ADAPTOR	PATCH CORD	PRE-ASSEMBLED INSTALATION CABLE
OM1	beige	orange	orange
OM2	beige	orange	orange
OM3	aqua	aqua	orange
OM4	violet	violet	orange
OM5	lime green	lime green	orange
OS2 PC	blue	yellow	yellow
OS2 APC	green	yellow	yellow

Colour scheme: connectors, patch cords, pre-assembled installation cables

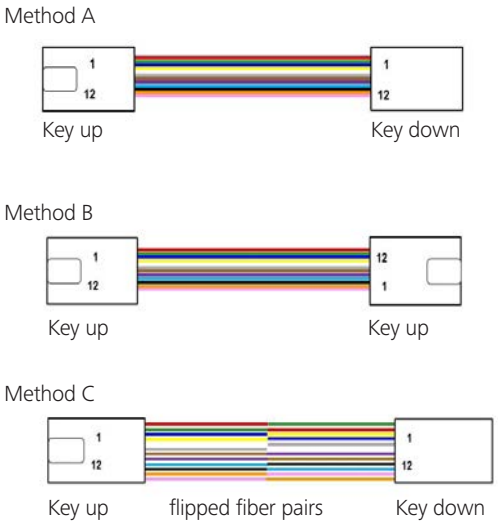
Fiber optic cabling with MPO connectors

Pre-terminated cabling components with MPO connectors are becoming more and more popular in fiber optic networks. They can be found in data centres, server rooms, equipment rooms of telecommunication service providers and, increasingly, in office buildings. Pre-terminated components are truly plug-and-play which saves a lot of time during installation. On top of that, MPO cabling offers an easy migration path to 40 and 100 Gigabit Ethernet with multimode fibers which use 8 or 20 fibers respectively.

MPO connectors have an alignment key on the top of the connector housing to ensure the connector can't be plugged in the wrong way. Two MPO connectors can be plugged together with their keys on opposite sides (key up to key down, known as method A) or on the same side (key up to key up, known as method B). Method C is similar to method A, but the fibers of method C trunks are pairwise flipped to ensure proper fiber polarity in networks where the links have just two fibers.

Fiber positions in a 12-fiber MPO connector

Please refer to Telegärtner's whitepaper on MPO for further information.



MPO trunks and patch cords of method A, B and C.

INCOMMING FIBER	OUTGOING FIBER		
	Method A	Method B	Method C
1	1	12	2
2	2	11	1
3	3	10	4
4	4	9	3
5	5	8	6
6	6	7	5
7	7	6	8
8	8	5	7
9	9	4	10
10	10	3	9
11	11	2	12
12	12	1	11

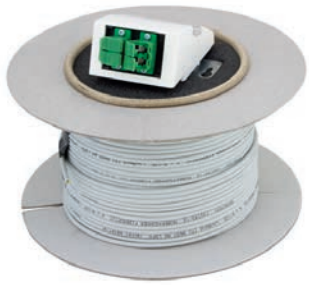
FTTH

Fiber-To-The-Home

High speed internet, Triple Play (TV, telephone and internet via the same connection), video on demand or DSL links connecting company headquarters with subsidiaries need powerful infrastructures. Legacy cabling has grown over decades and very often can't compete anymore. It's only logical to extend the powerful fiber optic cabling of the wide area network and bring it closer to the end-user: fiber to the home (FTTH).

FTTH calls for a large product portfolio of optical couplers, optical fibers, fiber optic connectors and even coaxial connectors and application-specific RJ45 connectors for office, home and industrial applications. A general term for the various applications of optical fibers is FTTx.

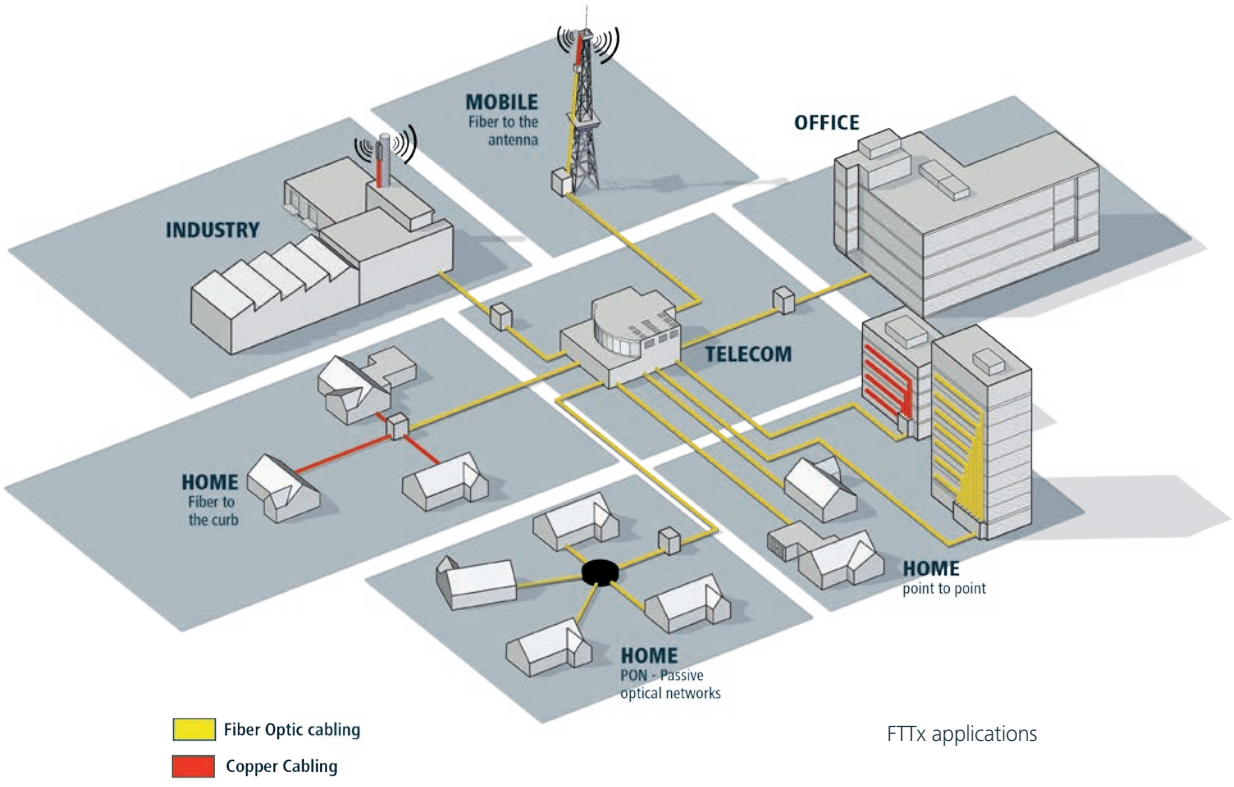
Contact us at fttx@telegaertner.de.



Pre-assembled fiber optic outlet and cable

Telegärtner's tip

The expression „fiber to the ..." is often used in different ways. It is recommended to add information on the network design (using fiber optic outlets, installation switches, etc.).



FTTx applications

FTTA

Fiber optic connections for high-performance mobile communication networks

The amount of data transmitted by the mobile communication networks is constantly growing. Social media, e-mails, phone calls, online shopping, mobile apps – the list of useful mobile helpers is getting longer every day. Many people are using two or three mobile devices at the same time.

In order to cope with the huge amount of data, mobile communication providers are installing more powerful antenna systems still. These antennas have become active system components with integrated electronics. In order to transmit a maximum amount of data over the long distance between base station and antenna pole, providers are using optical fibers: Fiber To The Antenna (FTTA). In FTTA systems, the electronics is either located in close proximity to the antenna or integrated in the antenna housing.

Fiber optic connections on antenna poles are exposed to a harsh environment: Heat and cold, dust, rain, snow, ice and ultra-violet radiation are putting stress on the cables and the connectors. As an innovative company, Telegärtner has enlarged its proven portfolio of coaxial cables and connectors with FTTA product solutions and has matched them precisely to the needs of its customers. The pre-terminated cables can be ordered with TOC TDC, TOC FXC, TOC RBC, TOC FEM and of course with the proven full-metal version of TOC to meet standardized or customer-specific needs. Customers have the peace of mind that any customer-specific or special product solution meets the high Telegärtner quality levels.

TOC TDC

TOC FXC

TOC RBC

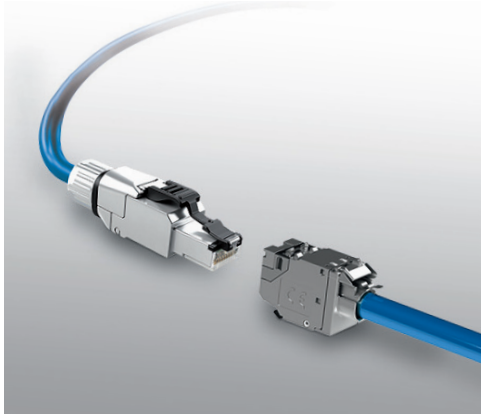
TOC FEM

DATA CENTER

Data Center infrastructure

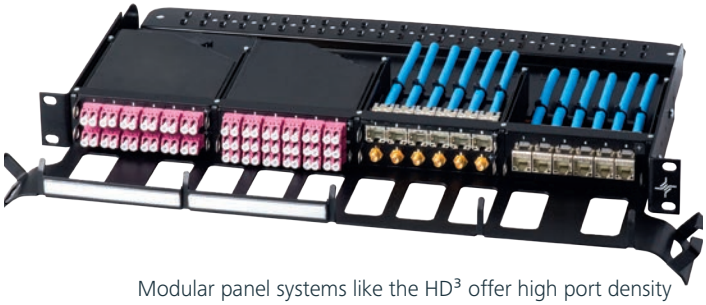
In data centers, fiber optic cables for high data rates have become standard. Most commonly used are OM3 and OM4 fibers which can transmit data rates of 10, 40 and 100 Gbps according to the standard IEEE 802.3. Highest quality, high port densities, flexibility and minimum disruptions at the same time are the demands for today's data center infrastructure.

To address this challenging environment, Telegärtner offers pre-terminated solutions. Cables with 12, 24, or 48 fibers are terminated with 12-fiber MPO connectors or with duplex LC or duplex SC connectors. A major benefit of pre-terminated cables is that they can be installed whenever data center processes allow, very often even during live operations. Whenever new servers, switches, or mainframes are installed or moved, the pre-terminated cables are already in place, ready for service. Time consuming cable cutting and stripping, connectorization, curing, and polishing belong to the past. Pulling grips protect the connectors during cable installation and guarantee factory-proven quality even under rough installation conditions.



Cabling systems with Category 8.1 components enable data rates of 40 gigabits per second

Pre-terminated cabling systems are not limited to optical fibers. More and more pre-terminated copper solutions are used. Such solutions are available with RJ45 jacks for patch panels as well as with stranded cabling and RJ45 plugs as multi plug cables, which can save a lot of time when uses for large switches.



Modular panel systems like the HD³ offer high port density and at the same time an enormous flexibility by a mix of divverent cabling media.

Pre-terminated cables
MPO – MPO (left) and MPO – LC-Duplex (right)

Telegärtner's tip

Pre-terminated cables can be installed whenever data center processes allow, very often even during live operations. Whenever new servers, switches, or mainframes are installed or moved, the pre-terminated cables are already in place, ready for service. Time consuming cable cutting and stripping, connectorization, curing, polishing or crimping belong to the past. And the online configurator is at your service at any time.

Parallel Optics and 40/100 Gigabit Ethernet

The bandwidth of multimode fibers is much smaller than the one of singlemode fibers. For shorter link lengths, multimode fibers are used as the electronics for multimode application is much cheaper than the electronics for singlemode fibers.

With 40 and 100 Gigabit Ethernet, the data streams are divided into channels of 10 Gbps which are transmitted simultaneously ("parallel"), which led to the term parallel optics. 40 Gigabit Ethernet uses 8 optical fibers (4 fibers for transmitting, 4 fibers for receiving), 100 Gigabit Ethernet uses 20 of them (10 fibers for transmitting, 10 fibers for receiving). The MTP®/MPO connector, which is already used for pre-terminated cables, will also be used for parallel optics.
Currently systems with 25 Gbps per fiber are evaluated. They could offer 100 Gbps using 8 fibers and 400 Gbps using 20 fibers. In both cases, the 12-fiber MPO connector could be used (in case of 400 Gbps two connectors would be needed on each side).

Contact us at datacenter@telegaertner.com.

INDUSTRIAL ETHERNET

Ethernet for industrial environment

The harsh environments of plants and workshops put much more stress on the components than the office environment does: Dust, moisture, chemicals, mechanical stress, extreme temperatures and much higher electromagnetic interference lead to specifications which were unknown and unrivalled in the past. At the same time, plants and workshops demand highest possible reliability and availability, as even short service interruptions lead to high losses.

One hour downtime of a PC in an office is annoying; one hour downtime of a production line is not acceptable as it inevitably means losing enormous amounts of money. Especially in the industrial environment quality and reliability of the components – above all outlets and connectors – are exceptionally important and in most cases mission-critical. So it's no wonder that for industrial applications different standards apply, e.g. ISO/IEC 24702 for the cabling and IEC 61076-3-106 for the connectors.

SELECTION OF STANDARDS FOR COMPONENT TESTING FOR INDUSTRIAL ETHERNET

Protection class

In addition to the quality of carefully coordinated components, protection against solid and liquid substances is also important in industrial applications. The international standard IEC 60529 defines the IP code (International Protection) as a simple designation system: the first digit indicates protection against the ingress of solid bodies such as dust, the second digit indicates protection against water / moisture.

PROTECTION AGAINST SOLID FOREIGN OBJECTS*

First digit	Description
0	no particular protection
1	Protection against solid foreign objects Ø 50 mm or more
2	Protection against solid foreign objects Ø 12,5 mm or more
3	Protection against solid foreign objects Ø 2,5 mm or more
4	Protections against solid foreign objects Ø 1,0 mm or more
5	Dust-protected
6	Dust-tight

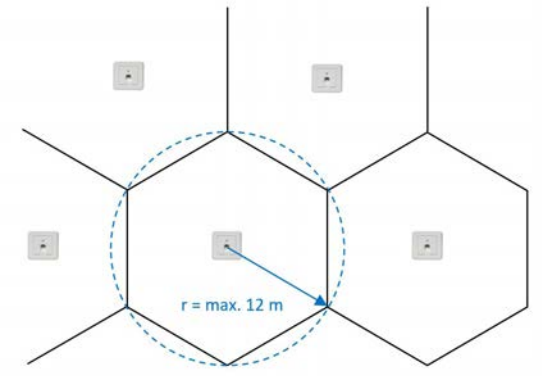
PROTECTION AGAINST WATER*

Second digit	Description
0	no particular protection
1	Protection against vertically dripping water
2	Protection against dripping water. There must be no harmful effect on mate rials tipped (in a container) up to 15° from its normal position
3	Protection against fine water spray
4	Protection against water splashing
5	Protection against water jet
6	Protection against stong water jet
7	Protection against water, when the material is temporarily immersed in water
8	The material is suitable for continous submersion in water; to be agreed between customer and vendor
9	Protection against water when high-pressure or steam cleaners are used; to be agreed between customer and vendor.

* Definitions see IEC 60529

IP-BASED BUILDING NETWORKS

More and more building technology applications come with an IP port: Video surveillance, access control, time recording, lighting, heating, ventilation, air conditioning, blinds, WiFi, cordless telephone and smart phones (DAS), sensor networks, ... the list grows nearly every day. EN 50173-6 specifies the appropriate cabling for this.



Design guide for the arrangement of outlets for WiFi access points according to EN 50173-6:2018-10. The honeycomb structure is not mandatory, other shapes like circles, squares, etc. can also be used.

Digital Ceiling

WiFi access points are not the only IP devices that can be installed in ceilings. LED lighting fixtures and their controllers, temperature and light sensors, presence detectors – all of them with Ethernet ports – can be placed there, which led to the term „digital ceiling“. As the devices as well as their cabling can be installed very easily in drop ceilings, digital ceilings play an important role in smart buildings. A universal cabling for any application allows easy and cost-effective changes of devices.

End-to-end Link

Using patch cord and outlets to connect devices to the network is not always the best solution. Patch cord and outlets for cameras in high-security areas or WiFi access points in a lobby do not please the eye at best and can become a security risk at worst. Field-installable RJ45 plugs that are mounted directly on the horizontal cable eliminate the need for outlets and patch cords. What has to be minded, however, is that such end-to-end links or „modular plug terminated links (MPTLs)“ have to be tested using the appropriate test adapters. Channel test adapters won‘t do the job as they disregard the first and the last connector in a link.

Field-installable plugs can be mounted directly on the horizontal cable, eliminating the need for outlets and patch cords.

Single Pair Ethernet (SPE)

Not all devices need four pairs to be connected to the network. Single Pair Ethernet (SPE), which uses just one twisted pair of wires, can be a very interesting alternative, saving space and money. The objectives of SPE are to deliver data rates of 10 Mbps, 100 Mbps and 1 Gbps. Standardization is not finalized yet. Variants are or will be standardized in

IEEE 802.3cg (10 Mbps)
IEEE 802.3bw (100 Mbps)
IEEE 802.3bp (1 Gbps)
IEEE 802.3ch (2.5, 5 und 10 Gbps), scheduled for mid/end of 2020

The link lengths depending on the data rate are 15 m, 40 m and 1000 m; some variants should be able to offer up to ten connections in a link.

Power over Data Lines (PoDL)

SPE allows the remote powering of devices via the horizontal cable, eliminating the need of an additional electrical socket. This can come in very handy especially for very small devices like sensors and actuators. The technology for this is quite similar to the familiar Power over Ethernet (PoE), but they are not compatible as PoE needs a minimum of two wire pairs. In order to avoid any confusion, a new name has been created for the new remote powering over just one wire pair: Power over Data Lines (PoDL).
PoDL is standardized in IEEE 802.3bu. During normal operation, devices can use up to 50 W drawing 1360 mA.

FURTHER READING

WHITEPAPER MPO

Pre-terminated cabling components with MPO connectors are becoming more and more popular in fiber optic networks. They can be found in data centres, server rooms, equipment rooms of telecommunication service providers and, increasingly, in customer premises. The individual components are pre-terminated and only need to be plugged together, which significantly reduces installation time. In addition, cabling with MPO connectors allows simple migration to 40 and 100 Gigabit Ethernet over multimode fibers.
This whitepaper describes the different components used and looks in detail at the different connectivity methods for maintaining the polarity in cabling with MPO connectors.

The whitepaper can be downloaded from the Telegärtner website at https://www.telegaertner.com/en/service/downloads/publications/

DICTIONARY OF IT INFRASTRUCTURES ENGLISH – GERMAN / GERMAN – ENGLISH

What's the proper designation of „ground" in German? What does „Schneidklemme" mean? And what is a „Geräteverbindungsschnur" as specified in DIN cabling standards?
This is the German edition, but the dictionary works in both ways: English – German („Deutsch") and German („Deutsch") – English.

Traeger, Dirk: Fachwörterbuch IT-Infrastrukturen Englisch – Deutsch / Deutsch – Englisch;
Joachim Treiber MEISTERBUCHVERLAG
ISBN 978-3-946045-03-8