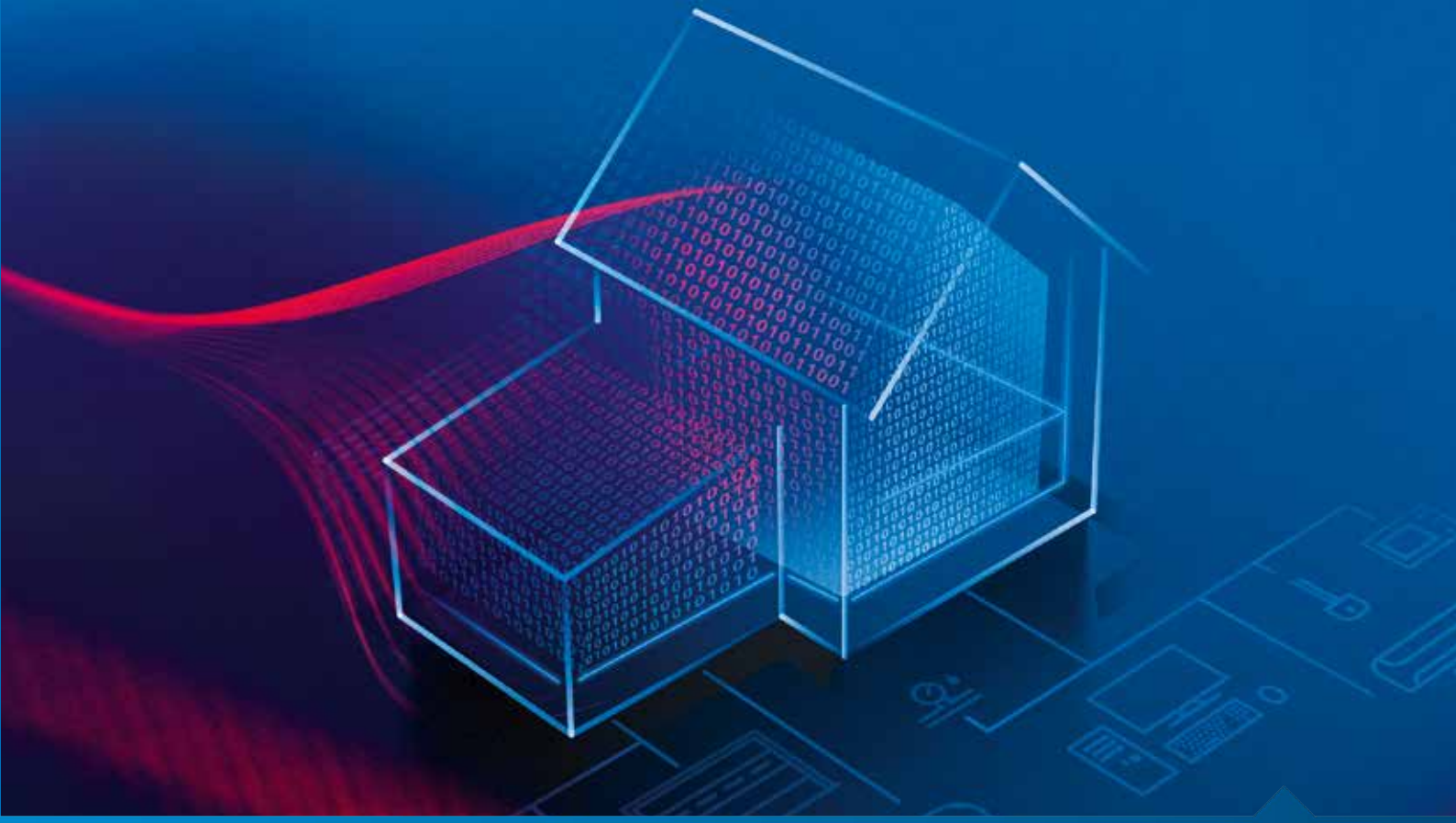
Telegärtner

White Paper

FIBER OPTIC CONNECTION: FTTH, FITB AND BEYOND

Reliable high-performance cabling for homes and commercial premises with fiber optic access



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BESTElectro BESTSmart BESTAir BESTCable BESTTools

RELIABLE HIGH-PERFORMANCE INFRASTRUCTURE

Ever-increasing data rates push telephone cables in the access network to their limit. Highly sophisticated coding makes higher data rates possible, but more and more often, future-proof, high-performance connections are made of glass. From the network provider's point of view, the network ends at the demarcation point, but the optical fiber has to be brought from there to the fiber outlet. Copper cables are installed from there to the rooms. Depending on the type of building and on the application, networks demand different designs. This white paper introduces the different typical scenarios in the different types of homes and commercial premises and shows proven solutions accordingly.

Introduction

Optical fibers offer much higher data rates and cable lengths than traditional copper cables, and so more and more buildings are connected to the public network via fibers. This applies to homes (Fiber-To-The-Home, FTTH) as well as to commercial premises (Fiber-To-The-Building, FTTB). The optical fiber installed by the network provider ends at the demarcation point. The entire network is divided into several areas or "layers". Layer 3 contains the optical fiber cable that runs from the street cabinet into the building. As this cable is the last piece of cable from the provider's perspective, this network layer is also called "last mile", regardless of whether the cable is in reality shorter or longer than a mile.

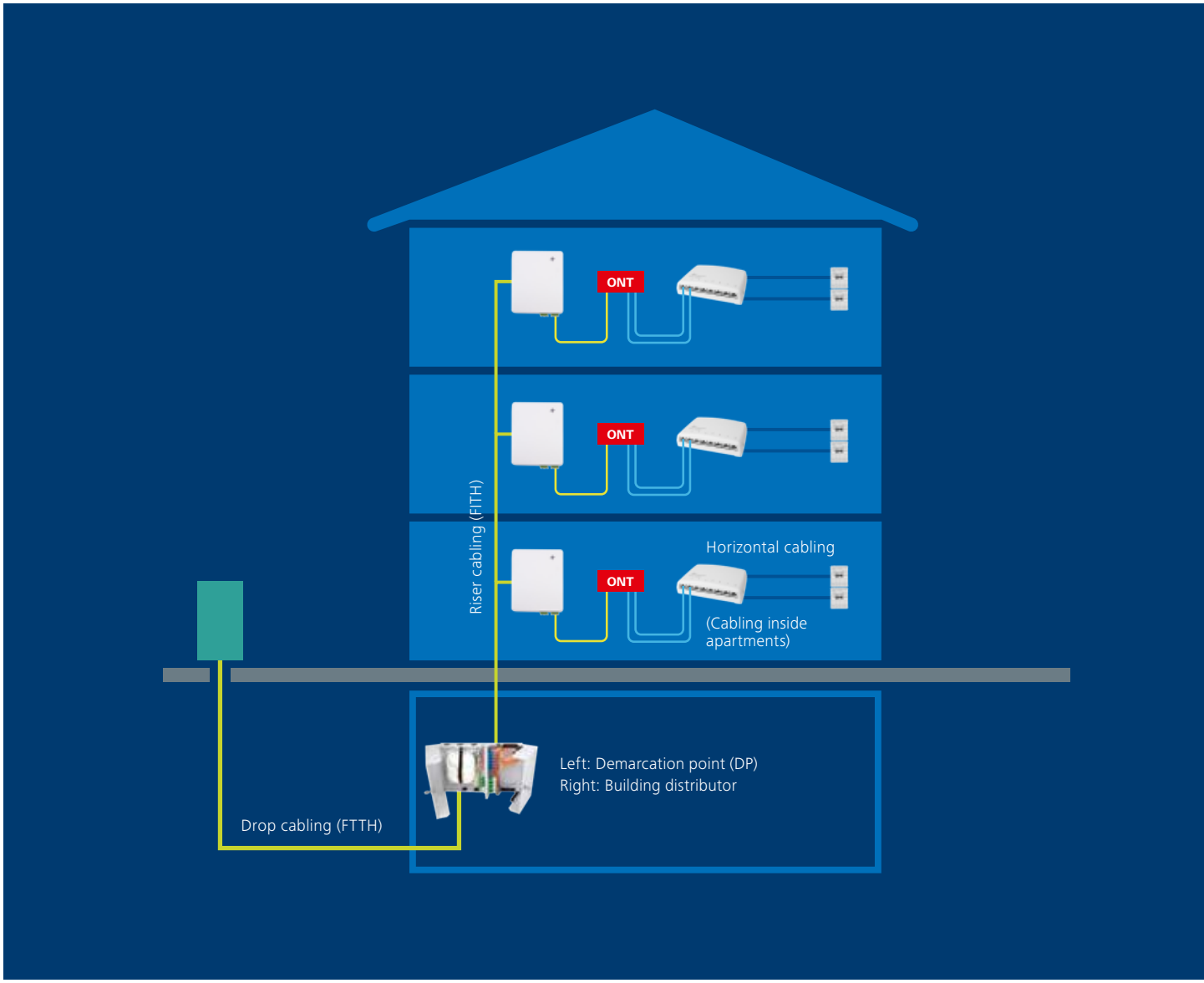
In rare cases, the demarcation point is an optical terminal outlet. Typically, the outlet is located somewhere else in the building. The fiber optic cabling inside of the building that runs from the demarcation point to the optical outlet is called Fiber-In-The-Home (FITH) or Fiber-In-The-Building (FITB) to differentiate it from the cable that enters the building which is called Fiber-To-The-Home or Fiber-To-The-Building. The FITH/FITB cabling is contained in network layer 4.

Devices like personal computers or WiFi access points typically do not have a fiber optic connection but have an RJ45 jack for copper networks. The transition from fiber to copper is done by an electronic device called "optical network terminal" or "ONT".. The ONT also translates the network protocol of the wide area network into Ethernet of the end-user's devices and vice versa.

ONTs can have one or more RJ45 ports, depending on the model. Should you want to connect several devices to an ONT with only one RJ45 port, a network switch has to be installed. The switch is connected to the ONT and the devices are connected to the switch. Some ONTs also have a coax port for TV and radio. In most cases the ONT is provided by the provider.

In very small networks the user's devices are connected to the ONT with RJ45 patch cords. In most cases, however, copper cables run from the area where the ONT is installed or from the server room to the outlets in the rooms or offices, which is also referred to as horizontal cabling. This copper cabling is network layer 5.

Multi-Tenant Homes



Example of a typical FTTH/FITH network in a multi-tenant home. Variations possible depending on the specifications and requirements of the provider.

	Street cabinet
	Small splice box, serves as demarcation point
	Building distributor
	Fiber optic outlet
ONT	Optical Network Terminal
	Small wall-mount distributor for copper cables
	Terminal outlet in the rooms
	Fiber optic patch cord
	Copper patch cord
	Fiber optic cable
	Copper cable

Example of a very flat and unobtrusive fiber optic outlet with a pre-terminated cable for FTTH/FITH and FTTB/FITB applications (OAD/F by Telegärtner). The cable can be ordered in standard lengths of 25, 50, 75 and 100 metres or in individual lengths from 5 to 150 metres with 1 metre increments. The reel is made of cardboard and can be disposed-of easily.

Typically a thin, flexible yet robust cable with four fibers is installed. For FTTH and FTTB only one fiber is needed, the other ones are spare.

In any fiber optic network – FTTH/FITH and FTTB/FITB – the optical fiber ends in an outlet. Such outlet ideally are unobtrusive and small. Such outlets that come with a pre-terminated cable that contains bend-insensitive fibers come in very handy. In such cases, the plugs of the cable are already plugged into the adaptors inside the outlet, so the other end of the cable just needs to be pulled in. Bend-insensitive fibers cope with narrow bends and still allow for the maximum data rate. Just for comparison: A standard singlemode fiber type ITU-T G.652.D has a minimum bend radius of 30 millimetres, a bend-insensitive singlemode fiber type ITU-T G.657.A1 has a minimum bend radius of only 10 millimetres and can be installed in nearly any conduit.

As the cable comes pre-terminated on the side of the outlet, it can be installed by nearly anyone. Specialists are only needed to connect the fibers of the cable to the fibers of the provider's cable. The fibers of the two cables can either be spliced or be connectorized or a combination of both: The connector is not installed directly on the fiber but comes factory-terminated and pre-polished with a short piece of fiber. This might seem cumbersome, but it offers a real benefit: Factory-terminated, pre-polished connectors have excellent optical parameters which are in most cases much better than connectors installed on-site.

The outlet does not necessarily have to be wall-mounted. It can also be installed inside the electrical distributor or fuse box with a fiber optic rail mount adaptor which resembles a fuse.

Please note: Any work inside a fuse box should be carried out by trained personnel only!

Example of a rail mount outlet for the installation inside an electrical distributor (STX mounting rail outlet by Telegärtner).

OPTICAL FIBERS: FUTURE-PROOF AND RELIABLE.

Example of a combo box; the left compartment holds splice cassettes and pigtails of the provider's cable, the right one terminated cables that run to the flats; the divider serves as patch panel (modular wall distributor by Telegärtner).

The fibers of the cables that run to the homes can be connectorized in different ways, depending on the provider's specifications:

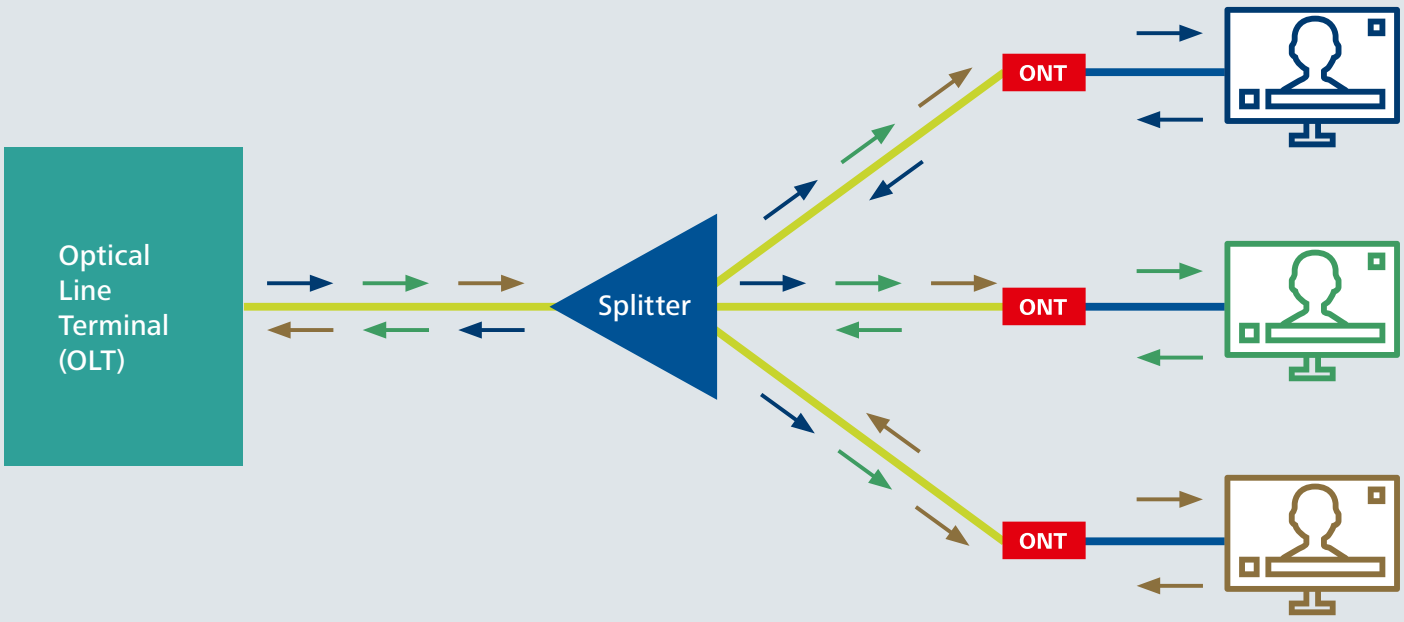
- The fibers of both cables are spliced, i.e. permanently joined, in the DP. However, this method is rarely used.
- Fiber optic connectors are installed on the fibers of the cables that run to the apartments as well as on the fibers of the provider's cable, so both can be connected with a patch cord. There are different ways to install a connector on a fiber:
  - The fiber is spliced to a pigtail; a pigtail is a short piece of cable or buffered fiber that has a factory-terminated and factory-polished connector on one end.
  - The connector is installed on the fiber with epoxy and polished on-site; this method is rarely used anymore.
  - A field-installable connector is used; such a connector contains a short piece of fiber and comes factory-terminated and factory-polished like the plug of a pigtail, only the fiber ends in the connector housing. The fiber of the cable just has to be stripped, cleaved and inserted into the connector. An integrated locking mechanism holds it reliably in place. Only a few specific tools and short training are needed to terminate fibers with field-installable connectors. As this leads to a much smaller effort compared to pigtails, this installation method is becoming more and more popular.
- The provider's cable as well as the cables that run to the apartments both end in a combo box. This box has two separate compartments, one serves as the provider's DP, the other one as a building distributor for the cables that run to the apartments. The divider between the two compartments is used as a patch panel, the cables to the apartment typically have connectors on the end so they can be plugged into the ports of the patch panel.

Example of a field-installable fiber optic connector (FFP by Telegärtner).

How the fiber optic network works

The Optical Line Terminal (OLT) in the central office of a provider or in a street cabinet manages the data transmission to and from the ONTs. The ONT translates the PON protocol of the fiber optic wide-area network into the Ethernet protocol the user's devices work with and vice versa. PON is the acronym of „passive optical network", which means only cabling components that neither need power nor actively manage the data transmission are installed between OLT and ONT.

Only one singlemode fiber is used to transmit data to several users. The signal is distributed to different buildings and different users by a splitter. A splitter connects one incoming fiber to several outgoing fibers. This works in both ways: The splitter collects the date of several ONTs and combines them on the one fiber to the OLT. To make this work, the OLT manages the ONTs and allocates time intervals for each ONT to make sure that only one ONT transmits data at a time.



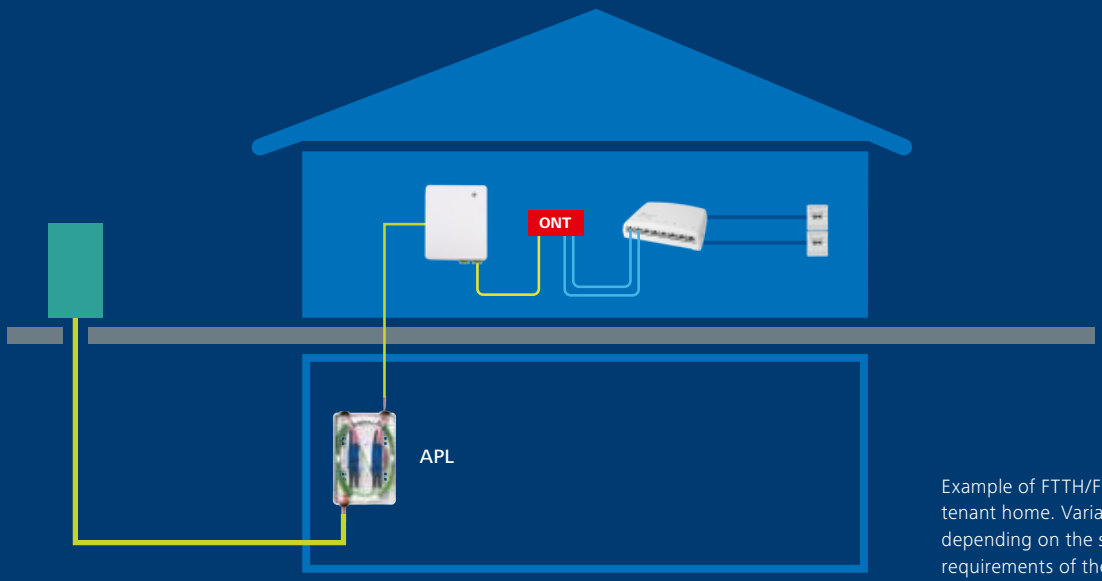
Interaction of OLT and ONTs. The splitter passes the data signals from the OLT on to the multitude of fibers that run to the ONTs and combines the ONTs' signals on the one fiber to the OLT.

CABLING FOR HOMES

FTTH and FITH in single-tenant homes

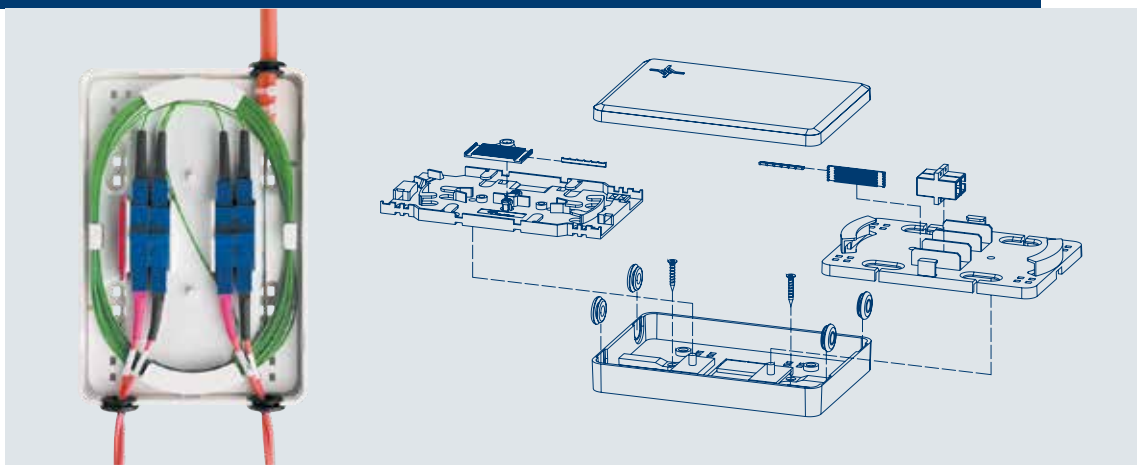
The easiest case of FTTH and FITH is a single-tenant home. A small splice box with connectors in the basement can serve as demarcation point. From there a small fiber optic cable runs to a fiber optic outlet.

Single-Tenant Home

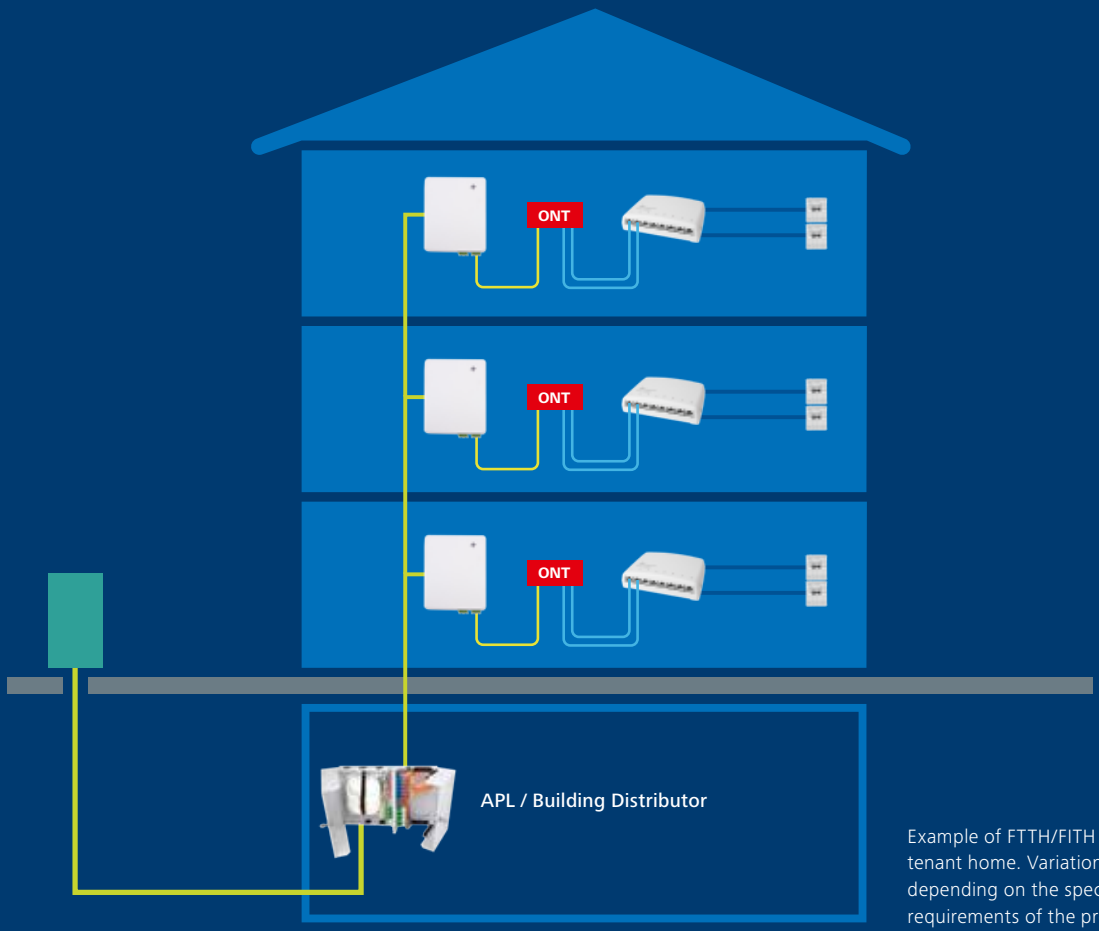


Example of FTTH/FITH in a single-tenant home. Variations possible depending on the specifications and requirements of the provider.

Example of a universal, small splice box for splices and/or connectors (Micro splice box by Telegärtner).



Multi-Tenant Homes



Example of FTTH/FITH in a multi-tenant home. Variations possible depending on the specifications and requirements of the provider.

Example of a combo box serving as a demarcation point and building distributor. In the left compartment the fibers are spliced to pigtails, in the right compartment field-installable plugs are installed on the fibers and plugged into the ports of the divider which serves as a patch panel. The two doors may have different locks, so only the network provider has access to the left part that holds the splice cassettes and the caretaker or the service provider has access to the right part (modular wall distributor by Telegärtner).

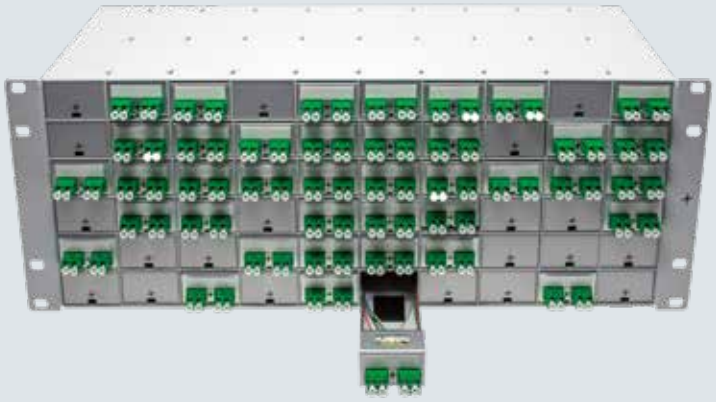
FTTH and FITH in multi-tenant homes

FTTH/FITH networks in multi-tenant homes can be regarded as a group of networks for single-tenant homes. Each flat has a fiber optic cable that runs down to the demarcation point, a fiber optic outlet and an ONT of its own. The cables from the flats end in a building distributor which can be installed next to the demarcation point. The building distributor and demarcation point can share a common housing. Special splice cassettes that can be folded away allow retro-fitting of cables and connections in the live network without disturbing the other connections and cables.

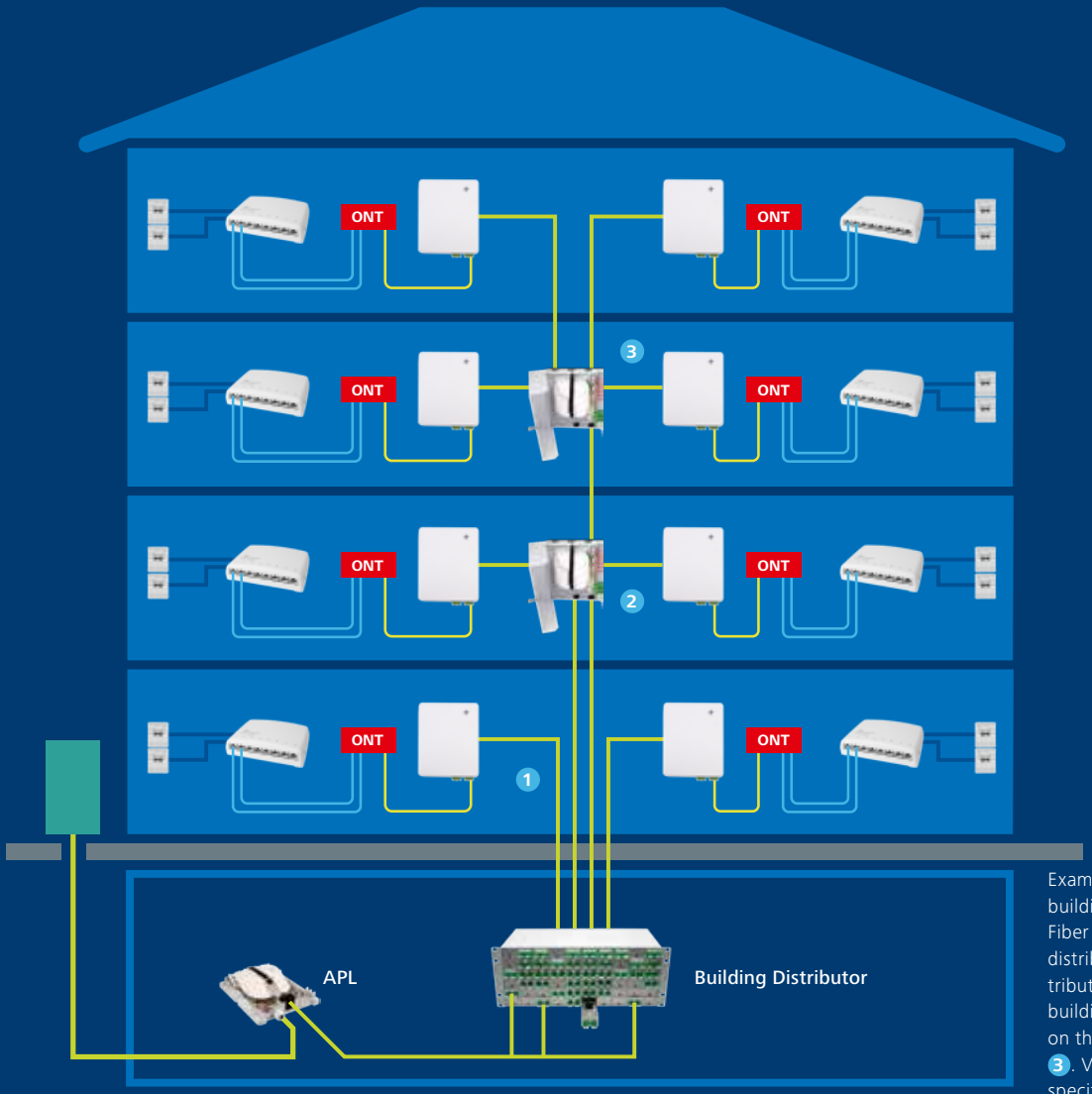
High-rise buildings and housing estates with many users can be regarded as a cluster of several multi-tenant homes. Very often, a wall distributor serves as demarcation point. As the building distributor might serve quite a lot of flats, it can be installed in a small cabinet. From there fiber optic cables either run to the individual flats or to floor distributors or both.

Example of a small wall-mount distributor with splice cassettes that can be folded away used as demarcation point (ODB54 with SAM cassettes by Telegärtner). The cover of the distributor was removed for illustration purposes.

Example of a rack-mount, fully modular building distributor for high-rise buildings and housing estates (FTB by Telegärtner). Each fiber optic cable that runs to a flat is connected to an individual splice module that is separated from all the other ones. This ensures that links can be retro-fitted changed without compromising the other links, which leads to a particularly efficient and cost-effective on-demand build-up of the network.



High-Rise Buildings / Housing Estates



Example of FTTH/FITH in a high-rise building. Different versions are possible: Fiber optic cables run from the building distributor to the flats 1 or to floor distributors. Depending on the size of the building, floor distributors only serve flats on the same floor. 2 or on several floors 3. Variations possible depending on the specifications and requirements of the provider.

Telegärtner's patch management system OWL automatically detects patched connections, keeping the network documentation constantly updated. Depending on the type, existing patch cords can be upgraded very easily.

FTTB and FITB in single-company commercial premises

FTTB/FITB networks in single-company commercial premises are similar to FTTH/FITH networks in single-tenant homes. The main difference is the distributor of the copper cables: In commercial premises there are many more outlets than in homes, so instead of a small wall-mount distributor there is one or more patch panels in a rack or cabinet.

FTTB and FITB in multi-company commercial premises

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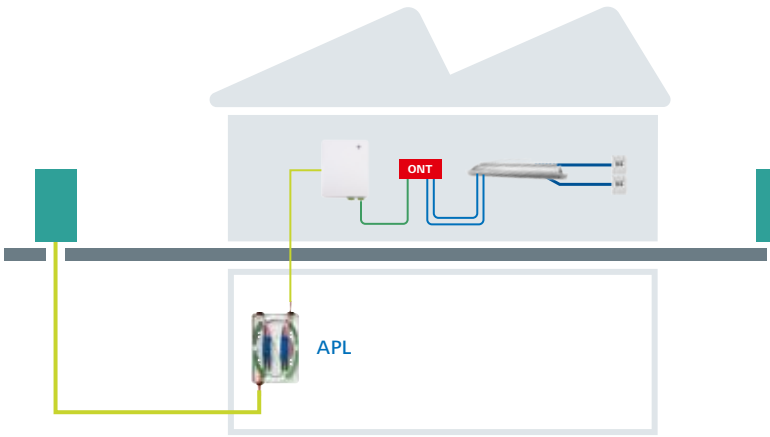
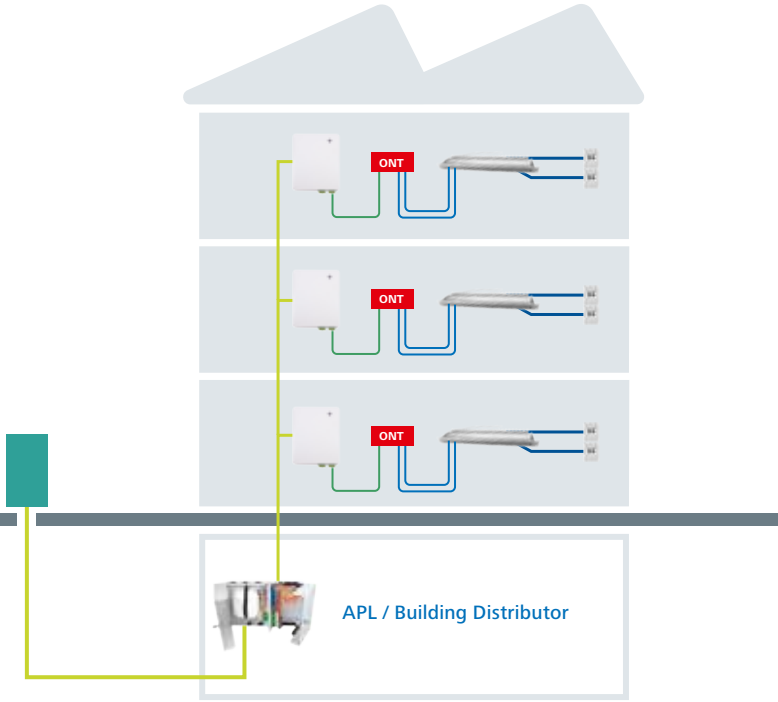


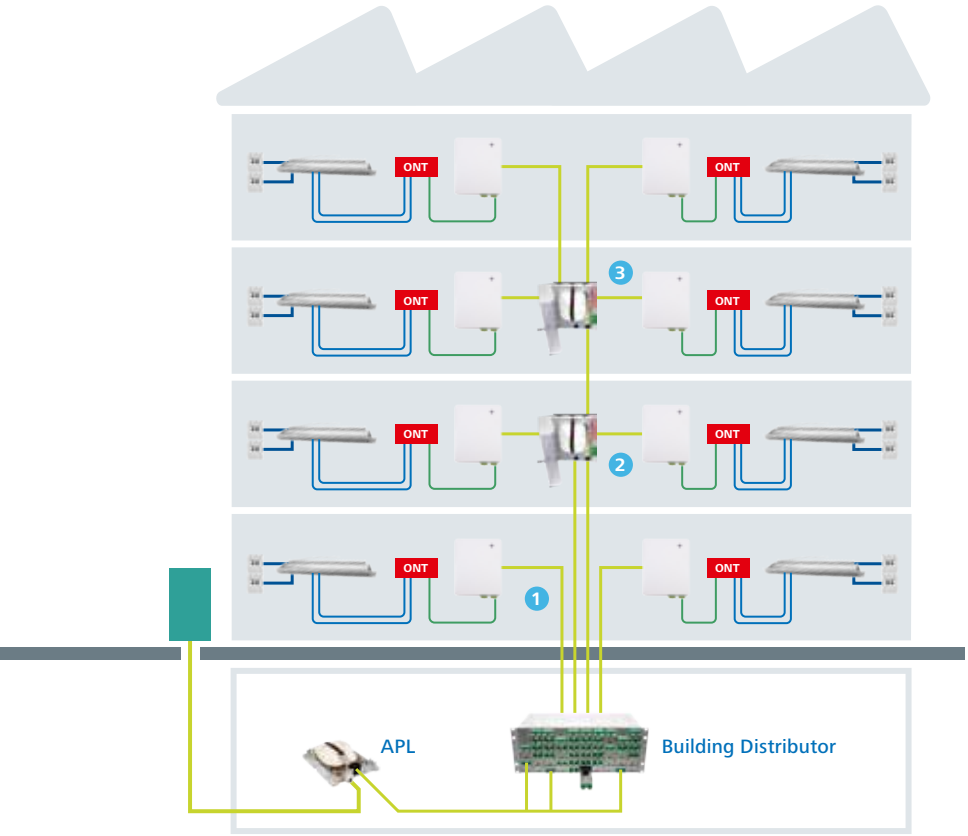
Example of FTTB/FITB in single-company commercial premises. It is very similar to FTTH/FITH in single-tenant homes, except for the distributor of the copper cables which is more complex (see page 13 of this white paper). Variations possible depending on the specifications and requirements of the provider.



Example of FTTB/FITB in multi-company commercial premises. It is very similar to FTTH/FITH in multi-tenant homes, except for the distributor of the copper cables which is more complex (see page 13 of this white paper). Variations possible depending on the specifications and requirements of the provider.

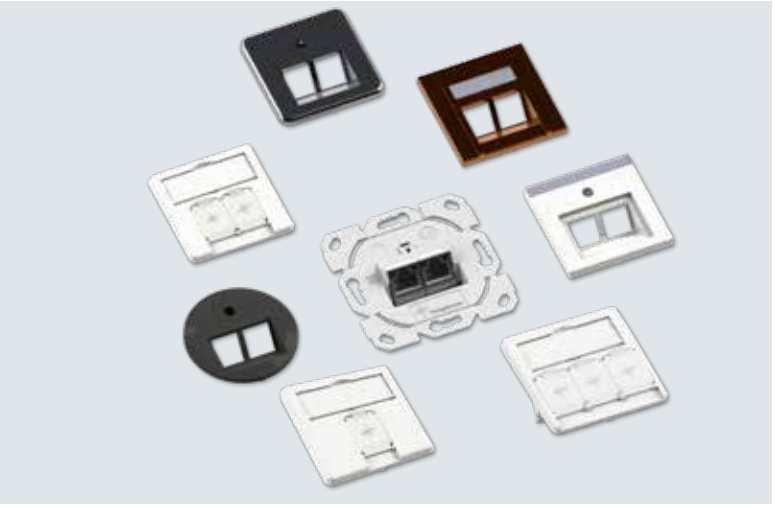
FTTB AND FITB FOR COMMERCIAL BUILDINGS

FTTB/FITB in commercial premises with many small companies like shopping malls is similar to FTTH/FITH in high-rise buildings and housing estates.

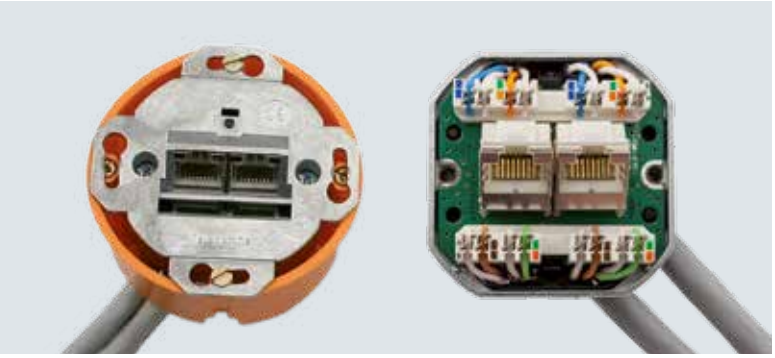


Example of FTTH/FITH in commercial premises with many small companies. Different versions are possible: Fiber optic cables run from the building distributor to the individual unit 1 or to floor distributors. Depending on the size of the building, floor distributors serve only units on the same floor 2 or on several floors 3. Variations possible depending on the specifications and requirements of the provider..

COPPER CABLING DISCREET AND UNOBTRUSIVE



Examples of a copper outlet that can be perfectly integrated into different installation programs of different vendors (AMJ45 8/8 K Up/0 by Telegärtner).



Example of an RJ45 outlet with vertical cable exit that can be turned in steps of 45°. The wires are connected on the front of the outlet. Such an outlet is ideal for flush-mount installation as the cable does not get squeezed or kinked when the outlet is installed (AMJ45 8/8 K Up/50 by Telegärtner).

Copper cabling in homes

Cabling in homes has to be unobtrusive. Outlets that can be integrated into existing installation programs are important as are small, flat and unobtrusive wall-mount distributors at the other end of the copper cable. Such distributors can be installed behind a small wardrobe or between shelves behind books and other things. Instead of a wall-mount distributor, mounting rail outlets can be installed in an isolated part in the electrical distributor. Mounting rail outlets accept RJ45 modules and a group of them serves as a distributor. Of course, any work regarding electrical distributors should be undertaken by an electrician!

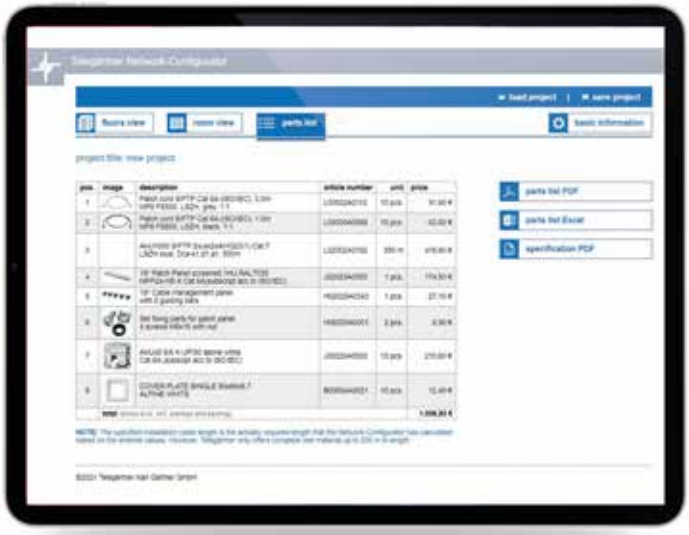
It is very important that flush-mount outlets leave enough space for the cable to maintain the cable's minimum bending radius. Outlets with a vertical cable exit that can be rotated in steps of 45 degrees and where the wires can be connected to the connecting blocks from the front instead of the rear come in very handy. This eliminates the need for cable slack which otherwise leads too often to bruises or kinked cables.

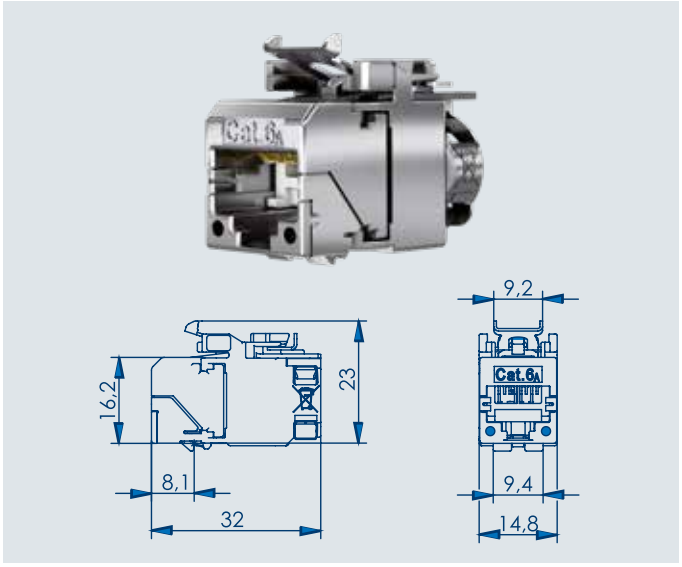
The number and location of terminal outlets in homes depend on the needs and demands of the tenants and are individually determined. A configurator for the cabling of homes helps network designers and installers to design the cabling quickly and easily and automatically creates the bill of materials. As the configurator is accessible via the internet, the design can be done on a laptop or a tablet PC on-site together with the tenant, which makes things even easier and saves a lot of time.

Example of a mounting rail outlet that holds an RJ45 module. Instead of a wall-mount distributor, a group of mounting rail outlets can be installed in the electrical distributor (TS45 by Telegärtner).

Examples of wall-mount distributors with very flat housing that can be installed behind a wardrobe or between shelves (MPD6-HS K Cat.6_A and MPD16 K Cat.6A by Telegärtner).

Example of a bill of materials with list prices created with the configurator in close dialogue with the tenant. It can be used for designing as well as for quoting and thus saves a lot of time.



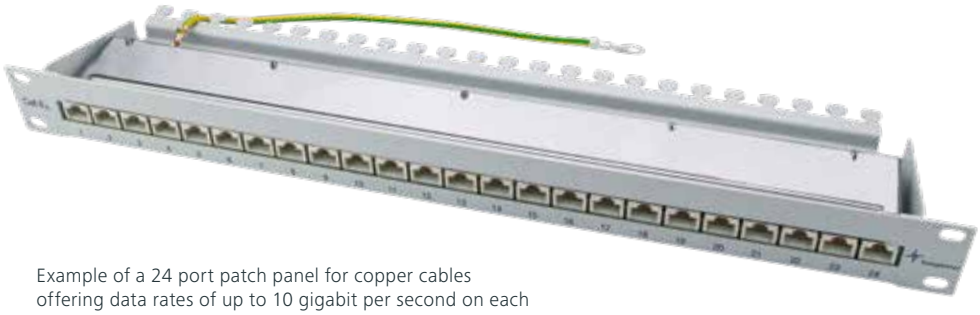


Very short RJ45 modules leave enough space for the cable ensuring reliable data transmission (AMJ-SL by Telegärtner).

Copper cabling in commercial premises

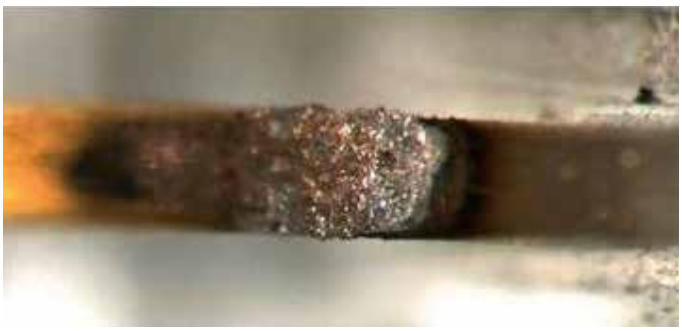
The horizontal copper cabling of small networks like in a doctor's office or a small shop in a shopping mall is nearly identical to the cabling of a home as described in the previous chapter. The cabling structure distributor – horizontal copper cable – terminal outlet is also used in large networks, but as there are many more outlets, there are many more copper cables as well. Large distributors are needed, and so patch panels are installed in large racks and cabinets, providing clear and easy administration of many connections.

Large commercial buildings very often have a raised floor where cables can be installed. Terminal outlets are typically installed in floor boxes with hinged covers and small cable exits for the patch cords that connect the devices to the network. RJ45 modules can be installed quickly and easily directly on the end of the cable and are just snapped into the frames or module carriers of the floor boxes. Modules with a short housing come in very handy as they leave enough space for the cable to maintain its minimum bending radius which is very important for reliable data transmission.

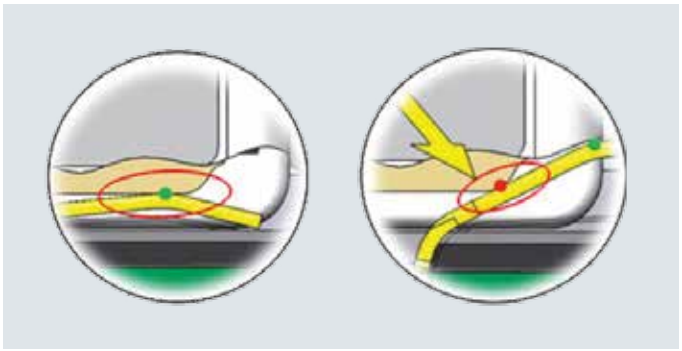


Example of a 24 port patch panel for copper cables offering data rates of up to 10 gigabit per second on each port (MPP24-JS-K Cat.6A by Telegärtner).

REMOTE POWERING
POWER OVER ETHERNET



Contacts of an RJ45 jack damaged by sparks. The damaged areas cannot transmit data anymore.



Protected by design: When Telegärtner plugs and jacks are unmated, the mating point travels along the contacts of plug and jack. The area where data is transmitted (marked green) is far awayfrom the area where damage by spark erosion (marked red) occurs.

Remote powering of devices via the horizontal cabling (Power over Ethernet) and protection against overbending of the contacts

More and more devices can be powered via the horizontal cable. Distributors and terminal outlets have to be designed to meet the additional demands remote powering puts on the connecting hardware. When plug and jack are unmated under load, sparks occur as the electrical current physically cannot be stopped instantly. The sparks damage the contacts of plug and jack, which is called „spark erosion". The area of the contact where such damage occurs cannot be used for data transmission anymore. Terminal outlets, consolidation points or patch panels with damaged contacts have to be replaced and the link has to be tested afterwards. This leads to downtime and high costs.

With plugs and jacks that are designed for remote powering the area where the damage caused by spark erosion occurs, is far away from the area where the data is transmitted. Even after un-mating under load several times, the connecting hardware still offers the full performance, i.e. cat. 6_A components still offer 10 Gbps.

Jacks that have an integrated protection against overbending of the contacts offer additional safety when RJ11 or RJ12 plugs of telephones or fax machines are plugged into RJ45 jacks. RJ11 and RJ12 plugs are smaller than RJ45 plugs but very often their sides are higher than their contacts. The sides then overbend contacts no. 1 and 8 of the RJ45 jack. Jacks without an integrated protection against overbending the contacts can be damaged severely and have to be replaced, too.

Conclusion

Connecting homes and commercial premises to the public network with optical fibers offers much higher data rates than copper cables do, the maximum data rate that a standard singlemode fiber could transmit is not reached by the electronics yet. From the provider's perspective, the fiber optic network ends at the demarcation point, but still a fiber has to run from there to the fiber optic outlet located somewhere inside the building.

Depending on the type of building and the number of users, there are quite different concepts and solutions for this. The same applies to the horizontal cabling using copper cables that has to be installed right after the optical network. A single-tenant home for example needs a completely different solution than a multi-unit commercial building with many different companies. To ensure the best possible and most economical network operation, the cabling has to meet the individual needs and demands of the users, consisting of high-quality components that are precisely matched.

STANDARDS AND FURTHER READING

International standards (English):
ISO/IEC 11801-1:2017 Information technology – Generic cabling for customer premises – Part 1: General requirements

ISO/IEC 11801-4:2017 Information technology – Generic cabling for customer premises – Part 4: Single-tenant homes

European standards (in national language):
EN 50173-1:2018-10: Information technology – Generic cabling systems – Part 1: General requirements

EN 50173-4:2018-10: Information technology – Generic cabling systems – Part 4: Homes

EN 50174-2:2018-10: Information technology – Cabling installation – Part 2: Installation planning and practices inside buildings;

American standards:
ANSI/TIA-568.0-D: Generic telecommunications cabling for customer premises

ANSI/TIA-568.1-D: Commercial building telecommunications infrastructure standard

ANSI/TIA-570-C: Residential telecommunications cabling standard

Further reading:
Basic knowledge data / network technology; Special topic brochure, Telegärtner Karl Gärtner GmbH, Steinenbronn,Germany

Whitepaper Remote Powering
Telegärtner Karl Gärtner GmbH, Steinenbronn

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Dirk Traeger studied communication engineering at Esslingen University of Applied Science. He worked as a network designer and project manager and specialist engineer in various cabling projects and for global manufacturers of cabling components. He has headed up the Telegärtner Technical Helpdesk and the global training programme for installers, consultants and end-users since 2015.

Dirk Traeger has written numerous textbooks, white papers and professional articles on important and current topics of data networking.

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