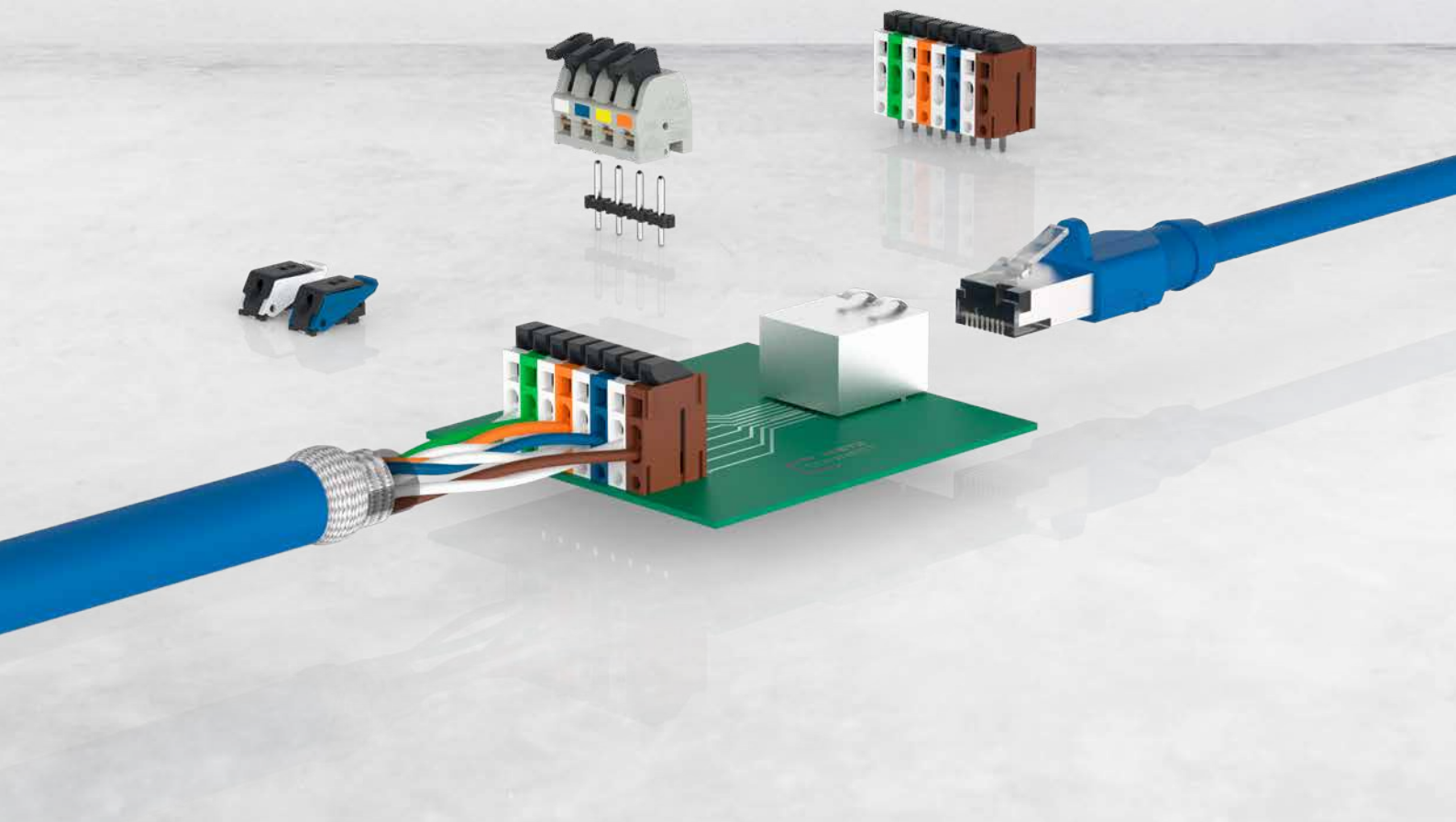
METZ CONNECT

We realize ideas

APPLICATION NOTE

Ethernet terminal blocks

Circuit board terminal blocks as an Ethernet interface – alternative connection options for IoT and IIoT devices



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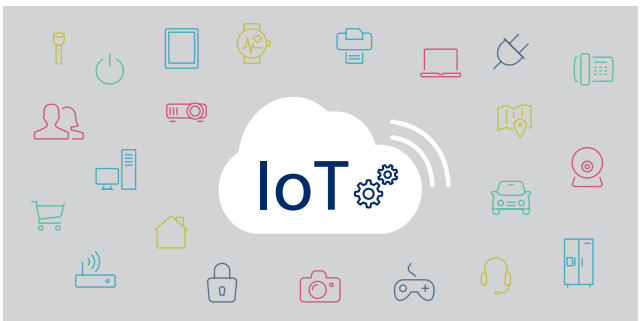
1

Ethernet terminal blocks

What would happen if ...

… you did not need a connector at all for Ethernet/IP-enabled devices of the IoT and IIoT?

Internet of Things, abbreviated IoT, is the main term for constant change. The term encompasses the omnipresent digitalization and networking of every conceivable "thing"" device, sensor, machine, vehicle, service, person, and more. With a view to industry, we also refer to the IIoT - the Industrial Internet of Things. Behind this is the digitalization of products, production methods and processes, on the basis of which Industry 4.0 is developing. In this world, all objects in industry are networked. People, machines and even products communicate with each other.



RJ45, M12 and M8 connectors are common connection options in a network cabling infrastructure and as interfaces for Ethernet/IP-enabled devices. This makes it possible to cover a wide variety of applications and requirements in terms of data transfer rates and simultaneous power supply in a standardized transmission medium and protocol.

With the growth of fiber glass, 5G and WLAN transmission media, the question arises about the future of twisted-pair network cabling. One benefit is that the further development of Ethernet transmission technology and PoE power supply with currently up to 90 W also creates new applications with an Ethernet interface. In addition, an increase need for standardized, lean transmission technology is developing, both in respect of the transmission protocol, as in respect of hardware, connectors and cabling. Ideally, the standardized transmission technology extends directly to the sensors and actuators at the field level. This should be made possible in the future with Single Pair Ethernet (SPE).

While the trend in the past was towards the highest possible transfer rates with up to eight buffers, the focus in the future will be on the aim of being able to completely open up the Ethernet world.

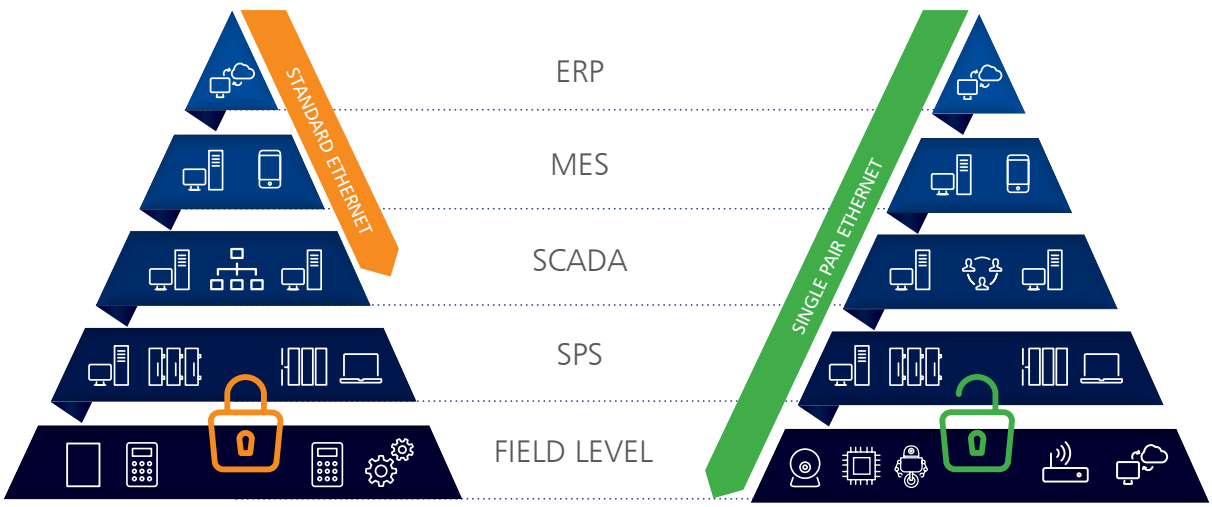


Image 1: Extension of the Ethernet network up to field level

What would happen if ...

... you did not need connectors at all for Ethernet/IP-enabled devices, and what impact would that have on the IoT and IIoT world of today and tomorrow?

The answer to that is circuit board terminal blocks. They provide an alternative connection option as the Ethernet interface of devices and offer a variety of benefits compared to RJ45 or M12 connectors:

- Cost benefits due to a possible component reduction
- Functional benefits
- Assembly-friendly
- Size
- Connection without special tools
- Color coding (for various Ethernet applications)

The application note covers, among other things, possible data transfer rates, the impact on the circuit board design/ layout, and possible handling of cable infeeds, strain relief, cable shielding and terminal block types. However, it also shows the limitations of circuit board terminal blocks and presents the application areas in which connectors have their merits.

Ethernet terminal block solutions

In principle, corresponding mechanical requirements, data transfer rates and power supply are needed for different applications. In the case of connectors, the choice depends on the application and requirements, for example between RJ45, M12, M8 or SPE, with IP20 or IP67 protection, and one, two or four pairs. Similar to connectors, it makes sense to select the terminal block according to the requirements. Since the terminal blocks are installed on or in the device, the focus is less on IP protection and more on the data transfer rate, connection method, connection type, grid dimension or size.

	PRODUCT NAME	PROPERTIES	CABLE STRUCTURE
	Gigabit Ethernet	4 pairs, 8 buffers 1/10 GBit/s PoE, PoE+, 4PPoE (up to 90 W)* Up to 100 m	
	Fast Ethernet & Industrial Ethernet	2 pairs, 4 buffers 10/100 MBit/s PoE (15.4 W), PoE+ (30 W)* Up to 100 m	
	SPE Single Pair Ethernet	1 pair, 2 buffers 10/100/1000 MBit/s Power over Data Line (60 W) Up to 1,000 m	

*Switching states are to be changed for load-free systems

Connection using IDC contacts is common for fast, industrial and Gigabit Ethernet. Stripping the individual buffers is rather untypical and not easy with cable cross-sections between AWG 22 and 26. Therefore, terminal blocks with IDC cutting contacts are particularly suitable for this purpose. Depending on the device, however, the cable or wire infeed or the size also plays an important role. Alternatively, there are various spring clamp terminal blocks, which can be soldered or plugged. Compact spring clamp terminal blocks mainly make sense in Single Pair Ethernet devices. One benefit of the spring clamp terminal blocks is that the larger wire cross-sections targeted for SPE in process automation are already covered with AWG 16 to 18 for a cable length of up to 1.000 m. Pluggable terminal blocks make sense especially where devices have to be replaced frequently for maintenance purposes or where, for example, the installation has to be prepared and simplified. Whether an additional pole should be used for the connection of the cable shield depends on the type of terminal on the one hand, but also on the device on the other hand. Finally, there is already a wide range of qualified Ethernet terminal blocks. However, the decision on which is the ideal terminal block for the desired application cannot be determined in a generalized manner and must be evaluated during design-in.

SPE in comparison to two-pair or four-pair Ethernet

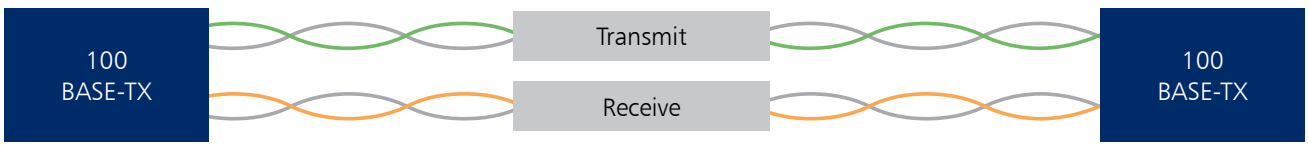
GBit Ethernet

250 MBit/s or 2.5 GBit/s per twisted pair, bi-directional

Gigabit Ethernet uses four pairs for the bi-directional parallel transmission and receipt of data.

Fast Ethernet

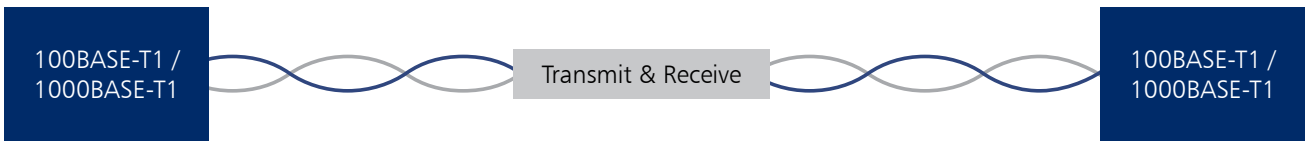
100 MBit/s per twisted pair, uni-directional



Fast Ethernet uses two pairs: one pair for the transmission and one pair for the receipt of data.

Single Pair Ethernet

100 MBit/s or 1 GBit/s via a twisted pair, bi-directional



Single Pair Ethernet uses one pair for the bi-directional parallel transmission and receipt of data.

Connection made easy – various identification/coding options

Identification using:

Dyed single poles

Printed color fields

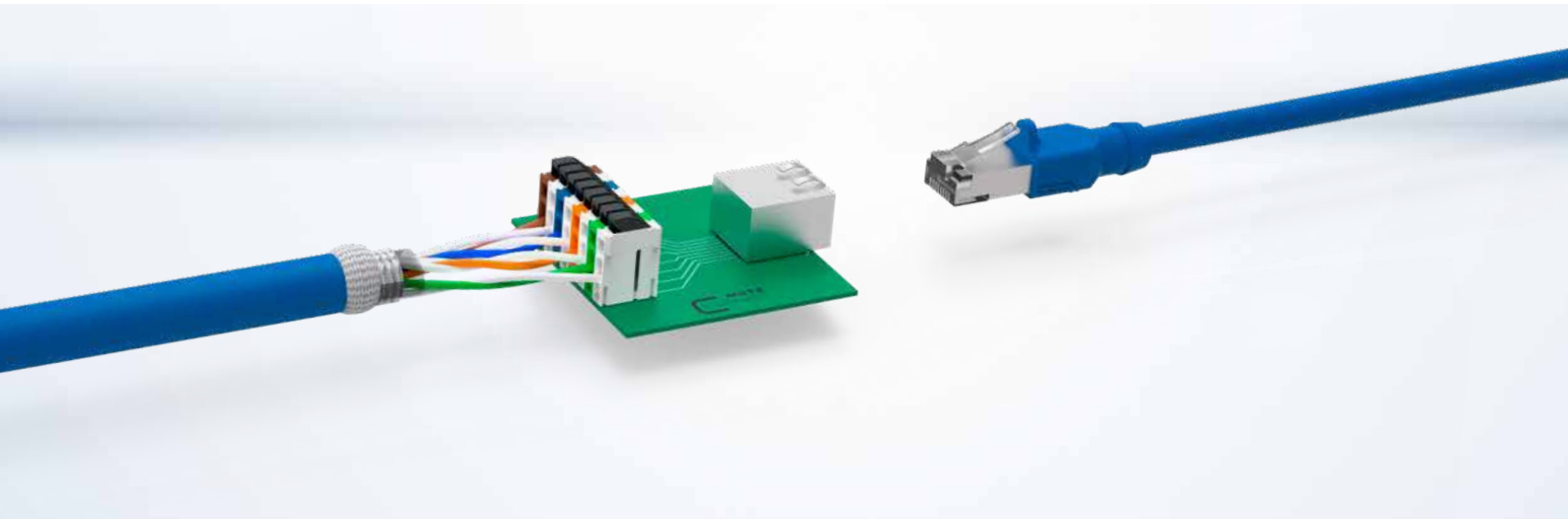
Printed labeling

Benefits

There is already an increasing demand for terminal blocks as an interface for any Ethernet application, be it for Gigabit-enabled devices, Industrial Ethernet, Single Pair Ethernet, or Advanced Physical Layer (APL).

- Easy handling, color coding
- Assembly-friendly, without special tools
- Pluggable or permanently soldered
- Broad cover of cable cross-sections
- Different designs
- Ideal for compact devices with tight space conditions
- Cost-effective solutions
- Fewer components
- Data transfer properties for up to 10 GBit/s Ethernet
- Single, double or four-pair Ethernet
- PoE, PoE+, 4PPoE, PoDL and more*
- Hybrid system for Ethernet and power supply possible
- SPE ready for up to 1.000 m

*Switching states are to be changed for load-free systems



Application options

Need for Ethernet terminal blocks

Terminal blocks instead of connectors are of interest for devices that are permanently installed and do not need a plug/removable connection, do not need a maintenance interface and which typically are installed permanently in one location. For example sensors, lights, etc.

Circuit board terminal blocks are and increasingly will be a beneficial alternative to the standard Ethernet connectors and connection technologies.

Driving topics

- General growth in IoT/IIoT devices with Ethernet interface
- Permanently installed devices that usually do not have to be plugged in, e.g. static devices, sensors, etc.
- Transfer-related benefits
  - 1 MBit/s up to 10 GBit/s
  - Power over Ethernet/Power over Dataline
- Technical benefits
  - Wide range of buffer cross-sections
  - Various designs for different applications
- Single Pair Ethernet
  - Networking of the field level in industry, process and building automation
  - Many compact terminal devices
  - Long distances up to 1,000 m with cable cross-sections up to AWG 16
- 4-pair Ethernet infrastructure
  - Miniaturization
  - Building automation

SUMMARY

The application options are very versatile and extensive,
i.e. everywhere where Ethernet interfaces are required: Building, industry, process automation, outdoor, transport technology, and much more.

2

1-pair cabling – Single Pair Ethernet

Use Cases

Description

Single Pair Ethernet describes the transmission of Ethernet via only one pair of copper wires and, in addition to data transmission via Ethernet, also enables simultaneous power supply to terminal devices via PoDL - Power over Data Line. Previously, two twisted pairs were required for Fast Ethernet (100 MB) or four pairs for Gigabit Ethernet. When we talk about IoT and IIoT, with the associated myriad of new devices coming into the Internet and therefore the network infrastructure, SPE provides the ideal foundation. This is because not all devices and applications require data transfer rates of 10 GBit/s or more, but rather compact connection options and new dimensions of the transmission path. SPE opens up completely new possibilities and fields of application, both in building and industrial automation.

Fields of application

- Industrial automation
- Process automation
- Building automation
- Public transport
- Smart Grid
- Traffic control and monitoring
- Energy and environmental technology
- Medical technology
- Smart Home
- and much more

Main fields of application – focus on industry and buildings

PROCESS INDUSTRY

- Field instrumentation
  - Flow sensors
  - Level sensors
  - Pressure sensors
  - Temperature sensors
  - Loggers
  - Field switches

Field buses → T1L Ethernet

INDUSTRIAL AUTOMATION

- Ethernet-based field level
  - Sensor/actuator networks
  - Valves
- Motor starters
- Rotary encoders
- Robotics

SPE delivers TCP/UP functionality to application areas that were previously covered by BUS or analogue technologies.

Various field buses → T1L Ethernet

BUILDING AUTOMATION

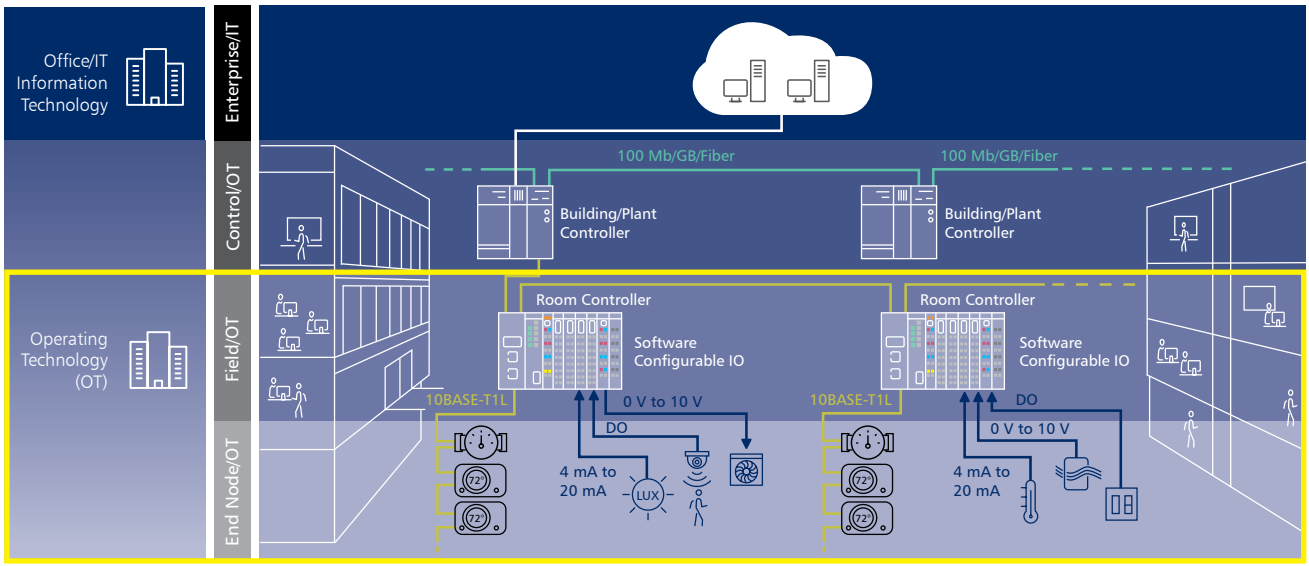
- Ethernet-based building services
- HVAC control
- Elevators and escalators
- Security controls

RS485 → T1L Ethernet

Applications

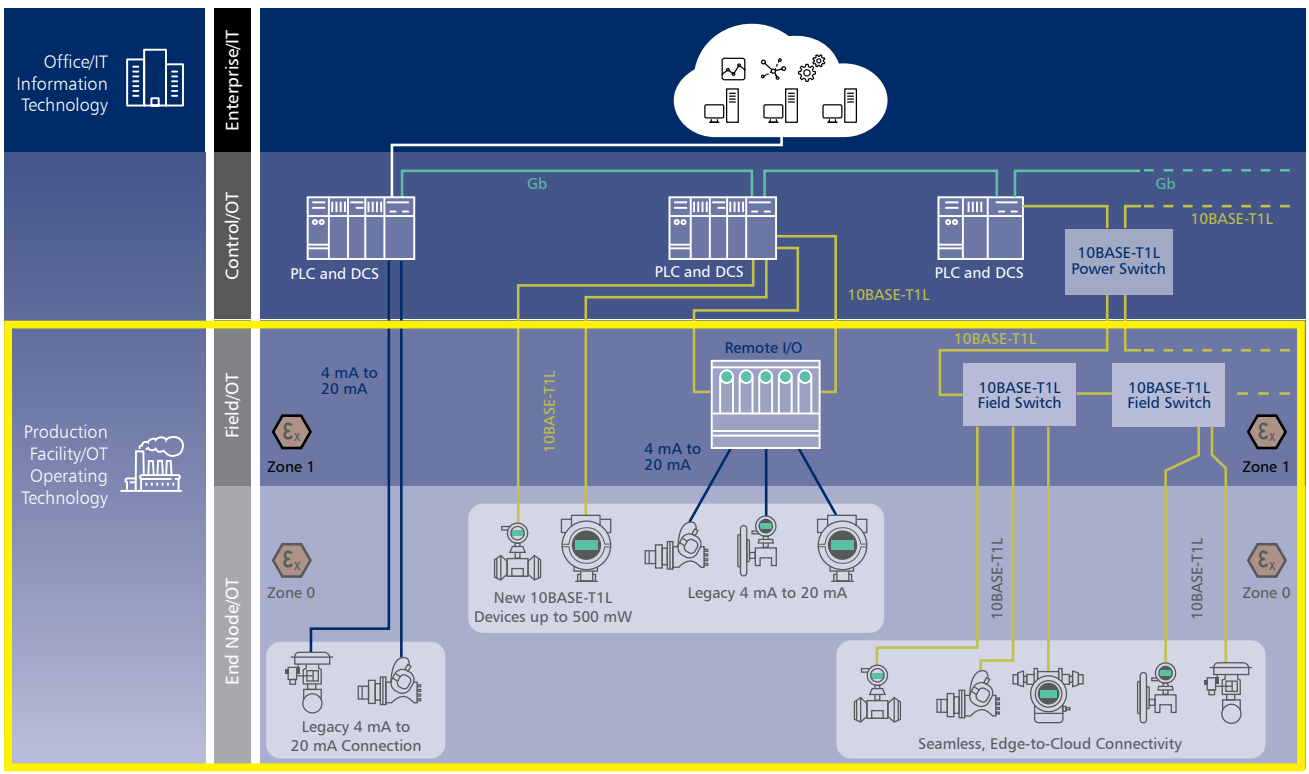
All devices with a communication interface. Intelligent sensors and actuators that combine both data (SPE) and energy (PoDL) via just one interface when required and depending on performance, and do not require gateways or further interfaces. Gateways, Ethernet switches, IPC, industrial communication, image processing, HMI, control for rotary and swivel drives, sensors, control elements, machine safety, level measurement, actuators, robotics, door intercom systems, fire protection technology, heating, air conditioning, ventilation, wall thermostats, IP cameras, access control, elevator systems, and much more. Sensors, especially with the possibility of covering intelligent “multifunctional sensors”.

Building automation example



○ Standard Ethernet ● Legacy 4 mA to 20 mA/DO/ 0 V to 10 V ● 100 MB/GB Industrial Ethernet ● 10BASE-T1L Industrial Ethernet

Industrial automation example



○ Standard Ethernet ● 4mA to 20mA with HART ● Gb Industrial Ethernet ● 10BASE-T1L Industrial Ethernet ● Main application for 1-pair terminals

Technology & typical requirements

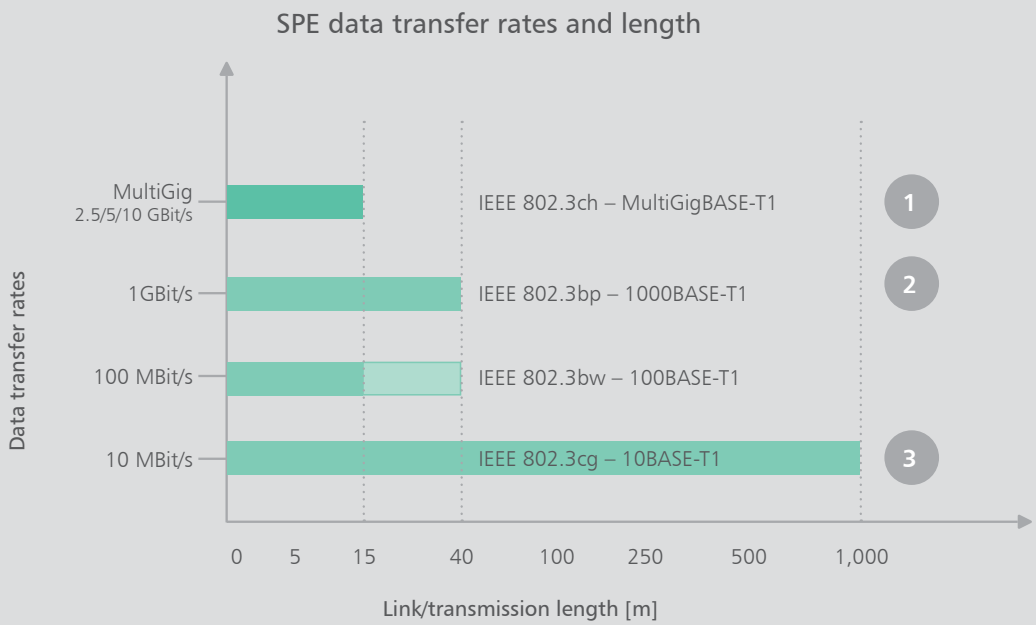
Requirements for Single Pair Ethernet for single pair cabling with two contacts:

1. Energy transmission/voltage supply using **Power over Data Line (PoDL)** according to IEEE 802.3bu (voltage, current carrying capacity, clearance and creepage distance, etc.)
2. **Data transfer** via SPE protocol according to **IEEE 802.3cg/bw/bp/ch for Single-pair Ethernet**

IEEE 802.3*

	DATA TRANSFER						VOLTAGE SUPPLY
	*cg	*cg	*da	*bw	*bp	*ch	*bu
	10BASE-T1L	10BASE-T1S	10BASE-T1 Multidrop	100BASE-T1	1000BASE-T1	MultiGigBASE-T1 (2.5/5/10 GBit/s)	PoDL (Power over Data Line)
Transmission properties	10 MBit/s 20 MHz	10 MBit/s 20 MHz		100 MBit/s 66 MHz	1,000 MBit/s 600 MHz	Up to 10,000 MBit/s 15 m	60 W max. PSE
Distance and shielding	1,000 m STP	15 m UTP		15 m UTP	15 m UTP 40 m STP	15 m STP	

Data transfer rates and applications



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- Vision sensors, image-processing technology in industry
- 3D laser scanner
- Measurements and analyses
- Human machine interface (HMI)
- Industrial PC (IPC) and monitoring
- Medical technology
- Measuring and control technology
- Networks on public transport (bus, train, etc.)

2

- Human Machine Interface (HMI)
- Industrial PC (IPC) and monitoring
- Motion & drivers / robotics
- Production control and monitoring
- Predictive maintenance
- Medical technology
- Measuring and control technology
- Networks on public transport (bus, train, etc.)
- Mobile working machines

3

- Sensor & actuator network
- Machine control
- Advanced Physical Layer (APL)
  - SPE 10BASE-T1L in combination with intrinsically safe remote powering
- Networks on public transport (bus, train, etc.)
- Building automation

3

2-pair cabling –

Description

For networking within Industry 4.0., Ethernet-based data transfer is the basic requirement for the Internet of Things. The most widespread Industrial Ethernet systems include, among others, PROFINET, EtherNet/IP, EtherCAT, Modbus-TCP or POWERLINK. The METZ CONNECT terminal blocks suitable for Industrial Ethernet offer an interesting alternative to RJ45 or M12 connectors. The reasons for this are both the cost benefits of a fixed connection due to a reduction in components and the assembly-friendly connection without special tools. In addition, the terminal blocks can be color coded for various Industrial Ethernet applications. The standard Industrial Ethernet data transfer rates of 10/100 MBit/s can be covered with the METZ CONNECT terminal blocks capable of up to 10 GBit/s.

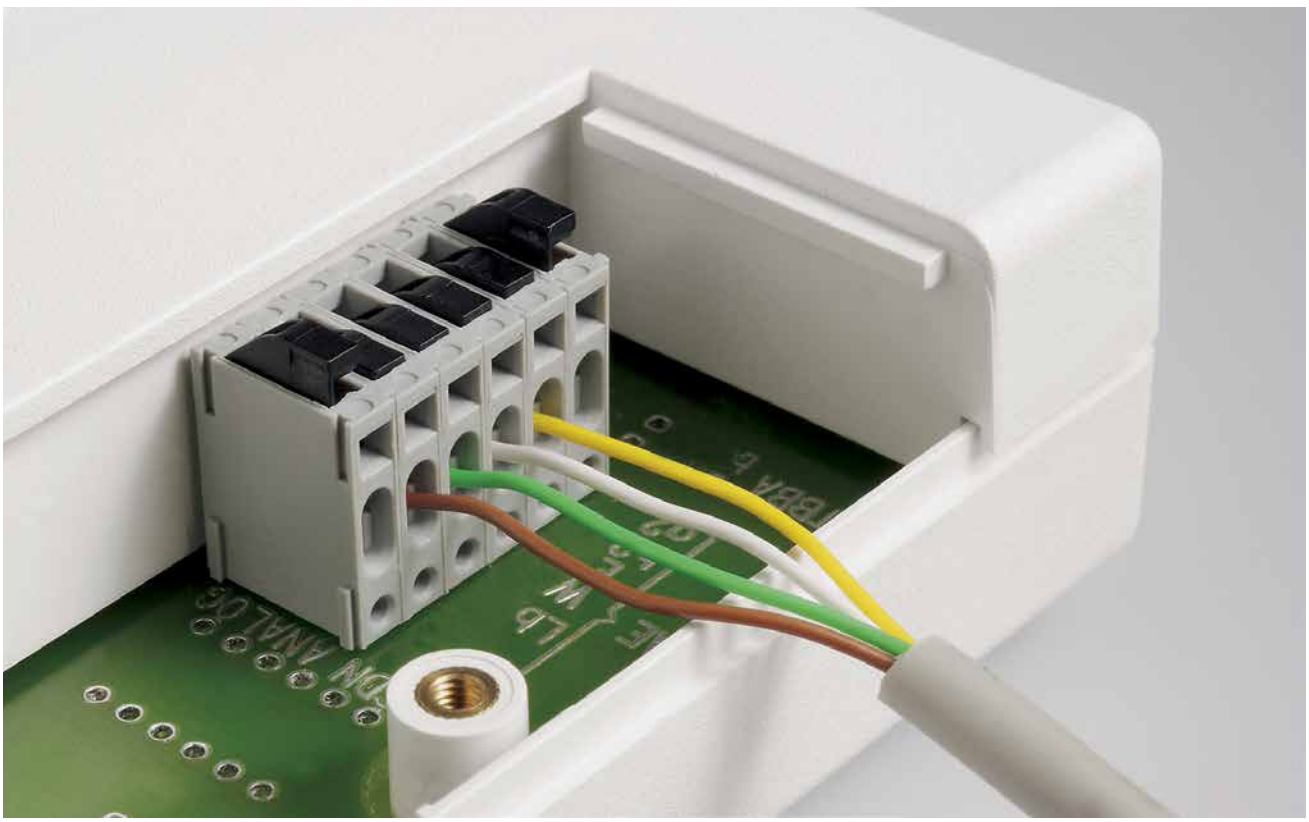
Application examples

- Industrial automation
- Process automation
- Building automation
- Energy and environmental technology
- and much more

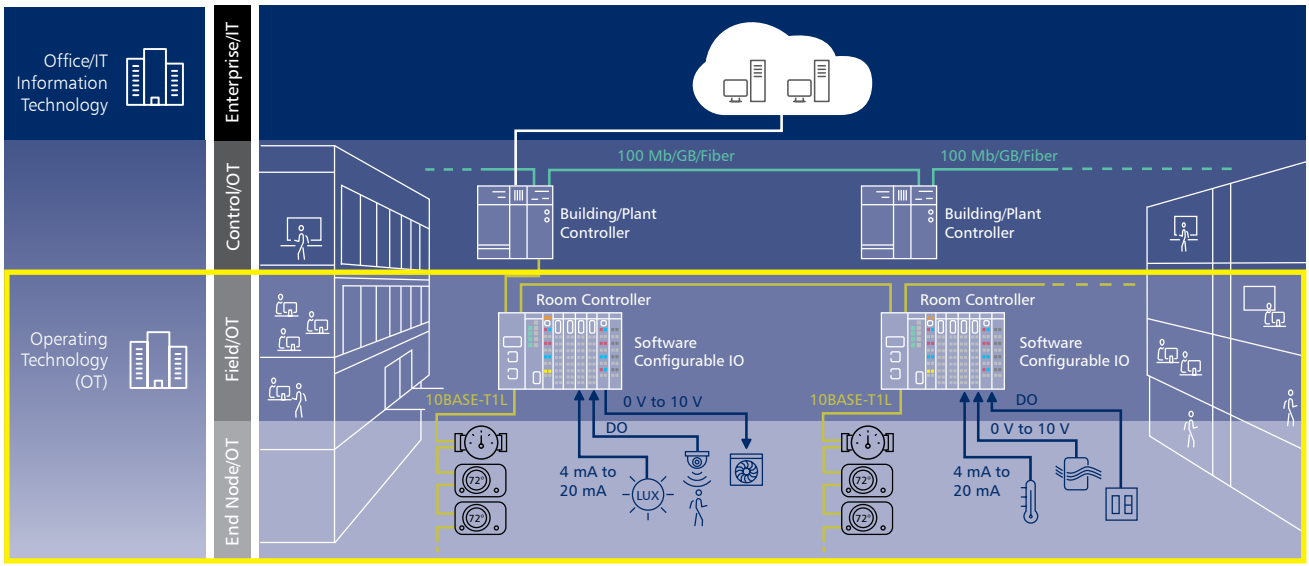
Applications

Terminal blocks for 2-pair cables for Industrial Ethernet are basically used wherever RJ45 connectors or M12 D-coded connectors are already used as an Ethernet interface today.
These include switch cabinet applications, industrial communication devices such as Industrial Ethernet switches, controllers, gateways, IPC, industrial image processing, HMI, sensors, controls, machine safety, level measurement, actuators, robotics, safety engineering, and many more.

The 4- to 5-pole terminal blocks are not only interesting in the field of Industrial Ethernets; also for classic Fast Ethernet/ Megabit Ethernet applications with 2-pair cables for 10 to 100 Mbps. Due to PCB connection technology and the associated benefits depending on the application and device, cabling for 2-pair cables could also regain significance in network infrastructure and building automation. Possible applications include heating, air conditioning, ventilation, energy management or smart metering.

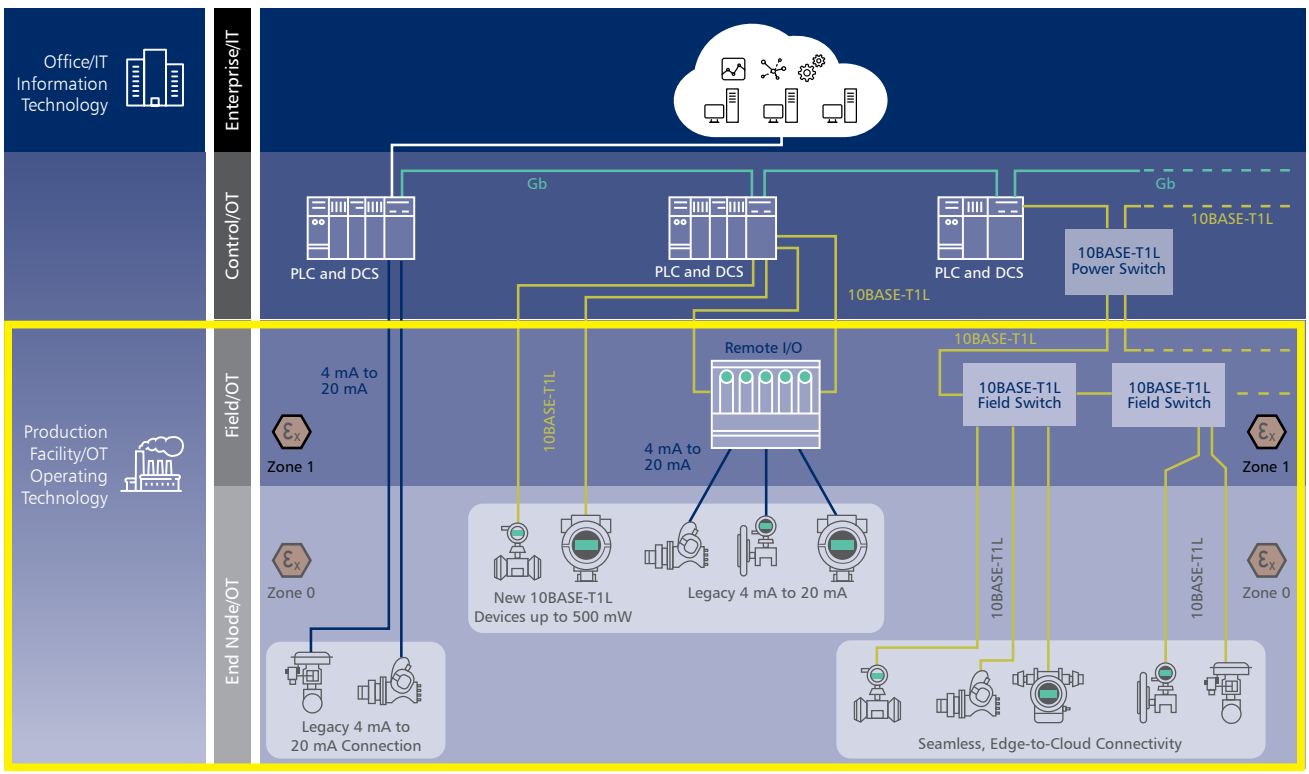


Building automation example



○ Standard Ethernet ● Legacy 4 mA to 20 mA/DO/ 0 V to 10 V ● 100 MB/GB Industrial Ethernet ● 10BASE-T1L Industrial Ethernet

Industrial automation example

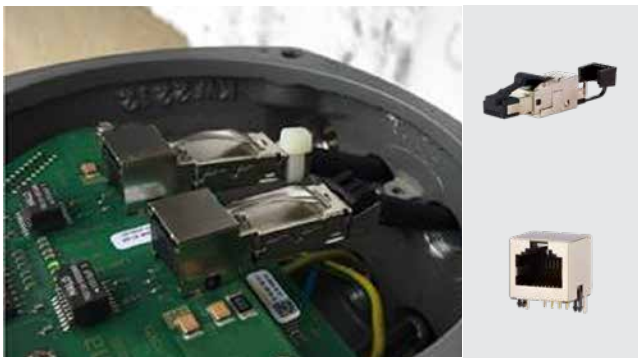


○ Standard Ethernet ● 4mA to 20mA with HART ● Gb Industrial Ethernet ● 10BASE-T1L Industrial Ethernet ● Main application for 1-pair terminals

Use Cases

Example of protected connections in housings in industrial environments

For devices that need to be changed frequently or require an interface for maintenance purposes outside the housing, RJ45 connectors in IP protected housings, or M12 circular connectors are often used. Many other devices, sensors, actuators or DIN rail devices in switch cabinets have the connection placed in the housing. Cable glands, among others, are used for the cable infeed. IP20 connectors are used inside this housing, which results in a range of different challenges. Often twisted pair installation cables are used for which there are no commercially available RJ45 "crimp plugs" or none at hand. Furthermore, special tools are required for these plugs. So-called field assembly connectors, both RJ45 and M12 circular connectors, provide the answer. They offer a solution for quickly and easily connecting plugs to cables with a wide range of diameters and buffer cross-sections without special tools. However, tight space conditions in the housings, contact problems in case of vibrations or contact losses, as well as increased damping if bending radii are disregarded remain the risks for plug connections using a jack and plug. Ethernet terminal blocks can be a solution here, as the following example clearly shows:

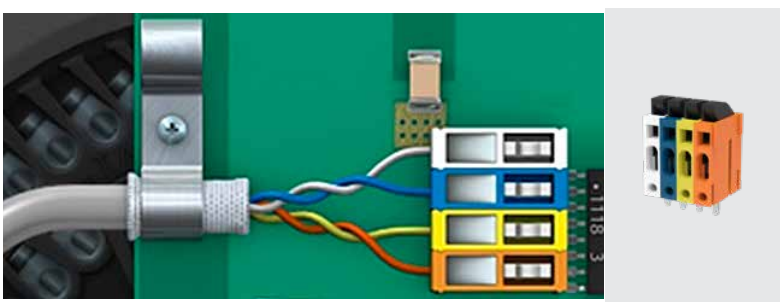


Problem "Profinet connection in a control unit for actuators":

- Cable feed using a cable gland
- Connection using RJ45 connectors suitable for field assembly
- Offset between the cable infeed and circuit board
- Limited space for the connection
- Load on the plug connection against the contacting
- Vibration in industrial environments
- Contact problems

Solution

Replacement of the RJ45 jacks and RJ45 connectors with an Ethernet terminal block (Industrial Ethernet, Profinet). The cable can be routed further to the circuit board and remains more flexible. Strain relief and the seal is provided using the cable gland on the housing. The cable shield is supported by a clamp on the circuit board. The buffers can easily be inserted into the terminal block. Contacting is made by IDC cutting contacts when the clamping chamber is pressed down (same principle as for common field assembly RJ45 connectors). There is no more strain on the contacts and the circuit board. The connection can be easily released and the device replaced in an emergency. The terminal block can also be reused if the connection is incorrect. The terminal block does not take up more space than the RJ45 jack on the circuit board and, in addition, the installation space of the device could be reduced. This principle can be derived to many applications.



Technology & typical requirements

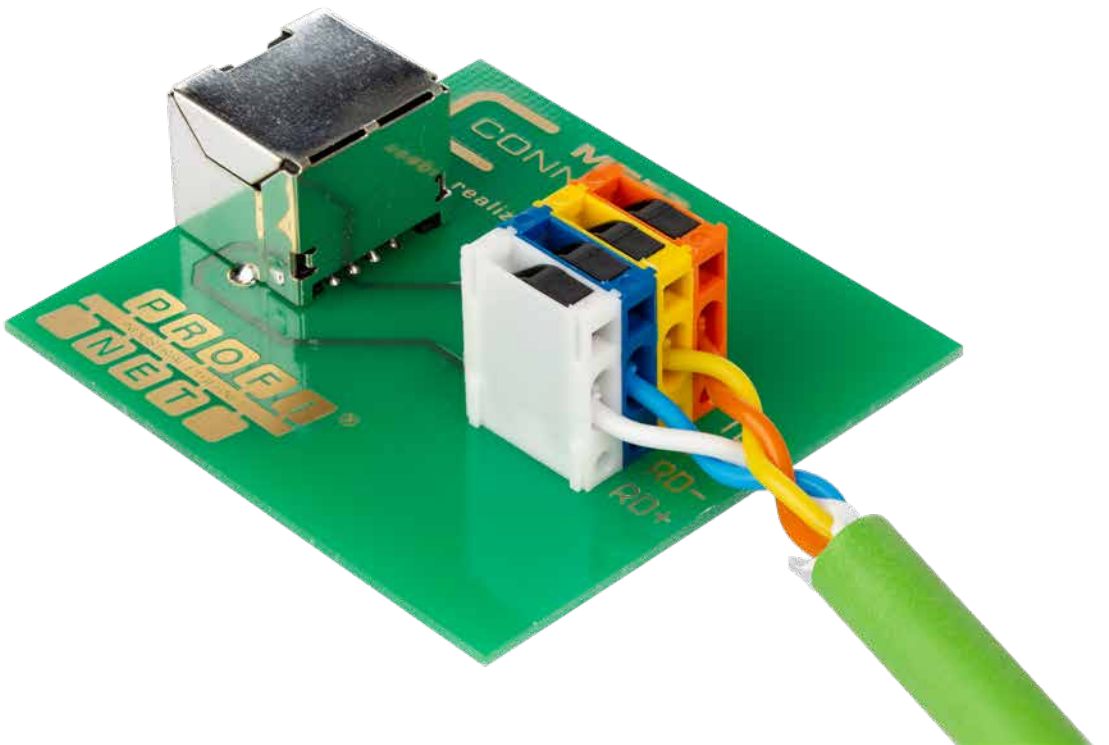
Requirements for Ethernet and Industrial Ethernet for two-pair cabling with four contacts:

1. Power transmission/voltage supply via PoE (Power over Ethernet)
   15.4 W according to IEEE 802.3af and PoE+ 30 W according to IEEE 802.3at*
   (voltage, current carrying capacity, clearance and creepage distance, etc.)
2. Ethernet Data transfer currently up to 100 MBit/s
3. Industrial Ethernet or Guidelines for Profinet

IEEE 802.3*

	DATA TRANSFER			VOLTAGE SUPPLY	
	*i	*u	*y	*af	*at
	10/100BASE-T(2)	10/100BASE-T(2)	10/100BASE-T(2)	PoE (Power over Ethernet)**	PoE+**
Transmission properties	Cat. 5 10/100 MBit/s 10 MHz	Cat. 5 10/100 MBit/s 12.5 MHz	Cat. 5 10/100 MBit/s 31.25 MHz	15.4 W max. PSE Class 3	30 W max. PSE Class 4
Distance and shielding	100 m	100 m	100 m	100 m	100 m

**Switching states are to be changed for load-free systems



4

4-pair cabling –

Description

RJ45 or M12 X-coded connectors are common connection options for Ethernet/IP-enabled devices with high data transfer rates, high power requirements and the associated 4-pair cables. Fiberglass, 5G and WLAN are also important transmission media in the Ethernet ecosystem. However, it is becoming increasingly difficult for manufacturers and users to develop compact/miniaturized devices on the one hand and to connect the devices accurately or integrate them into the network infrastructure on the other. I.e. for compact devices that manufacturers prefer to wire due to the need for PoE and a high data transfer rate, a circuit board terminal block offers the ideal conditions.

Furthermore, terminal blocks instead of connectors are of interest for devices that are permanently installed and do not need a plug/removable connection or not need a maintenance interface and which typically are installed permanently in one location. For example sensors, lights, etc.

Circuit board terminal blocks are and increasingly will be a beneficial alternative to the standard Ethernet connectors and connection technologies. The reasons for this are both the cost benefits of a fixed connection due to a reduction in components and the assembly-friendly connection without tools. The 8-pole cutting terminal block from METZ CONNECT is suitable for a data transfer rate of up to 10 GBit/s.

Fields of application

- Building automation
  - Network infrastructure
  - Share building services
  - IoT in outdoor fields
- Industrial automation
- Process automation
- Public transport
- Shipping
- Smart Grid
- Traffic control and monitoring
- Energy and environmental technology
- Medical technology
- Professional audio and video technology
- Data centers
- Own home/home applications/Smart Home
- Transport and logistics
- and much more

Application examples

- Building automation
  - Fire protection technology, heating, air conditioning, ventilation, wall thermostats, access control, elevator systems, smart metering, shades
- Lighting (PoE lighting, Smart Lighting)
- CCTV/IP cameras
  - Ethernet connection directly to cameras
  - Ethernet connection to PoE injectors as a transitional interface for power and data
- WLAN access points
  - Indoor WAPs (classic), pluggable or permanently soldered terminal block, cable catch optional
  - Outdoor WAPs, ideal for small space requirements of the connector, cable feeding and cable catch by means of cable gland, if necessary pluggable for maintenance purposes
- Multimedia
  - Digital signage
  - HDBaseT
  - SAT-IP
- Industrial automation
  - These include switch cabinet applications, industrial communication devices such as Industrial Ethernet- controllers, gateways, IPC, industrial image processing, HMI, sensors, controls, machine safety, level measurement, actuators, robotics, safety engineering, and many more.
- Passive connection technology
  - Adapters
  - Interfaces

Technology & typical requirements

Requirements for Gigabit Ethernet and Industrial Ethernet with four-pair cabling and eight contacts:

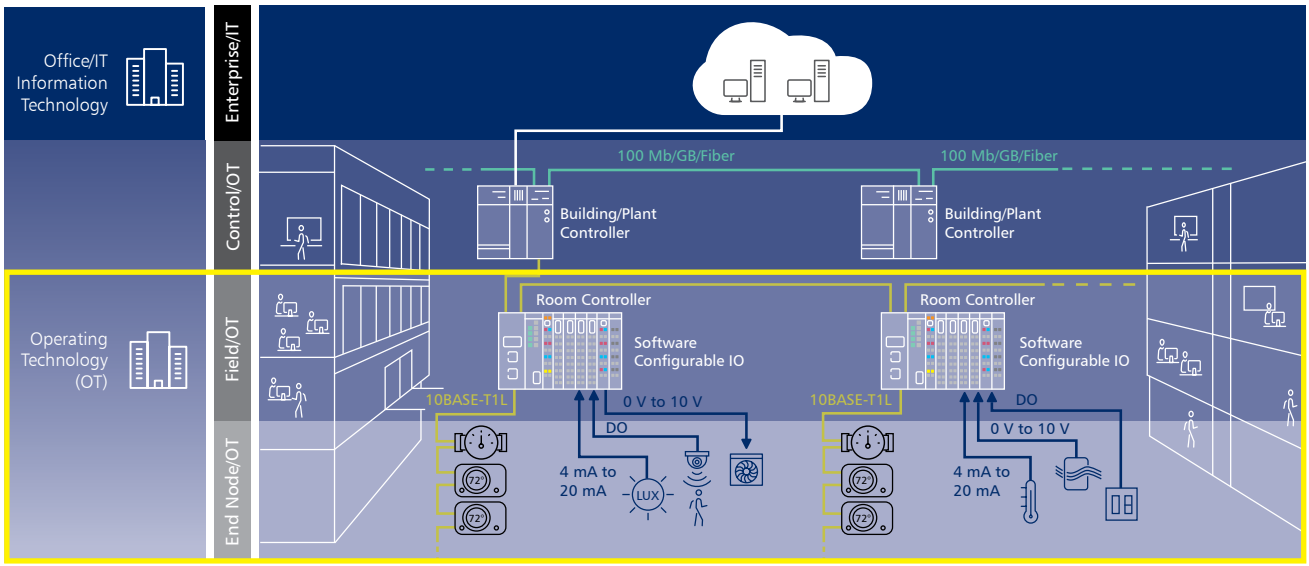
1. Power transmission/voltage supply via **PoE* (Power over Ethernet) with up to 90 W according to IEEE 802.3bt** (voltage, current carrying capacity, clearance and creepage distance, etc.)
2. **Gigabit Ethernet data transfer up to 10 GBit/s**

IEEE 802.3*

	DATA TRANSFER		VOLTAGE SUPPLY	
	*ab	*an	*bt	*bt
	1000BASE-T(4)	10GBASE-T(4)	4PPoE** 4-Pair-Power-over-Ethernet	4PPoE** 4-Pair-Power-over-Ethernet
Transmission properties	Cat. 5e/6 1 GBit/s 250 MHz	Cat. 6_A 10 GBit/s 500 MHz	60 W PSE Class 6	90 W PSE Class 8
Distance and shielding	100 m	100 m	100 m	100 m

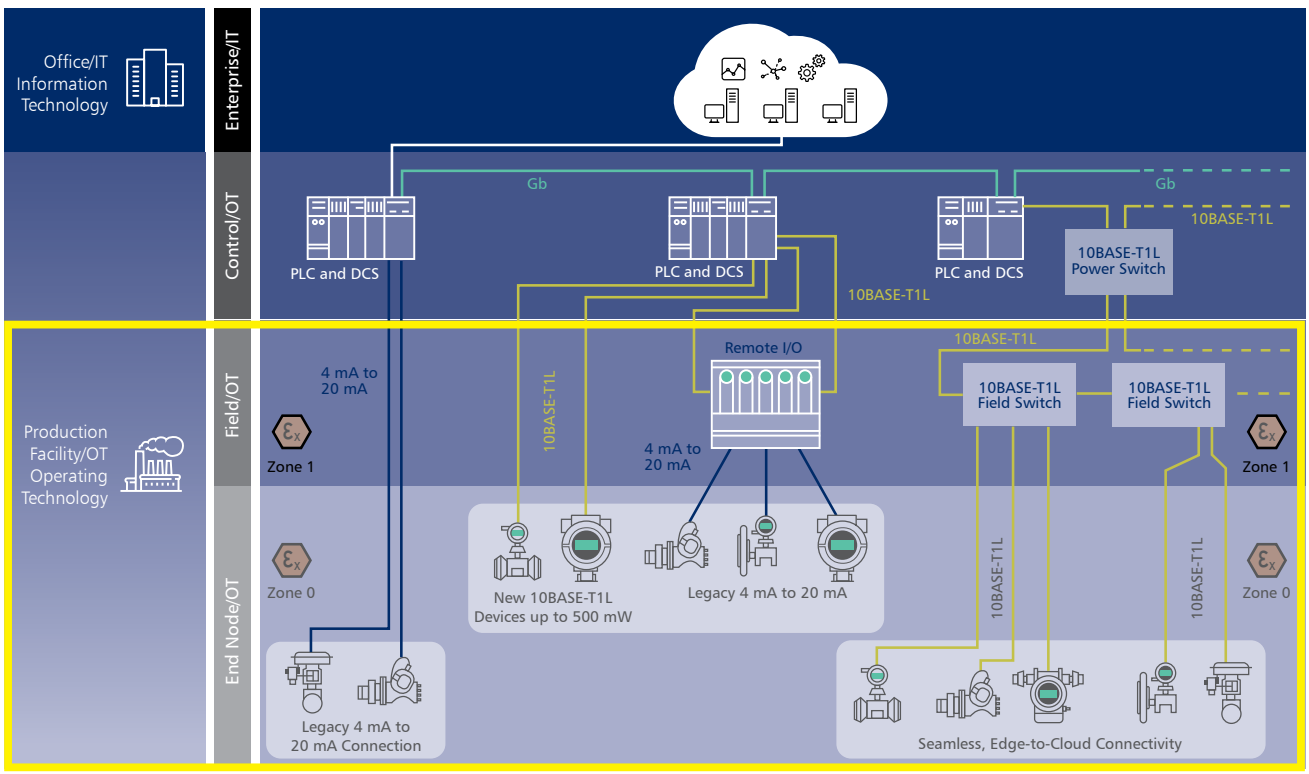
**Switching states are to be changed for load-free systems

Building automation example



○ Standard Ethernet ● Legacy 4 mA to 20 mA/DO/ 0 V to 10 V ● 100 MB/GB Industrial Ethernet ● 10BASE-T1L Industrial Ethernet

Industrial automation example



○ Standard Ethernet ● 4mA to 20mA with HART ● Gb Industrial Ethernet ● 10BASE-T1L Industrial Ethernet ● Main application for 1-pair terminals

Use Cases

Two terminal devices that are similar in terms of application area and requirements are WLAN Access Points and IP cameras.

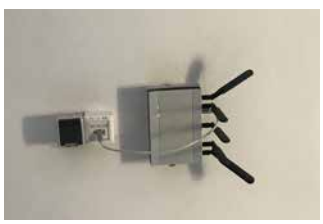
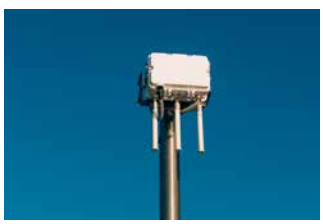
Things in common

WLAN Access Points and IP cameras are being increasingly found both inside and outside of buildings. Indoors more likely with the interface on the housing, outdoors with the interface in the housing and a cable infeed by means of cable gland. Both ideally work with a single interface for data transfer and power supply, i.e. with PoE.

Requirements

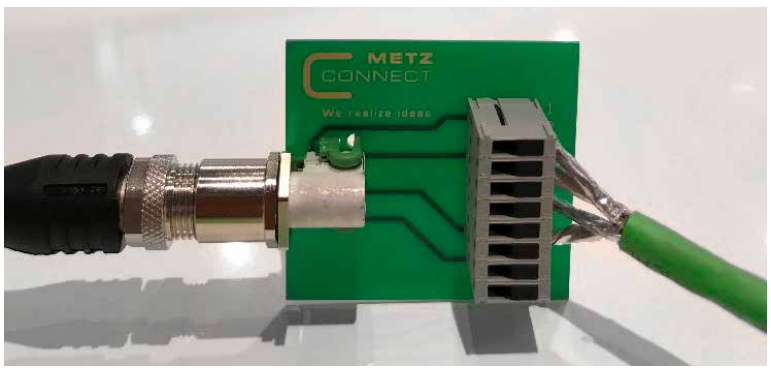
Depending on the device and performance requirements in the application, both devices require high data transfer rates as well as power. The housings should be as compact and visually appealing as possible, i.e. a connector is often only possible with compact patch cords or even special patch cords from the manufacturer. This means that a wall outlet near the terminal device is also required. In addition, the cable must be able to be fed through a non-separable cable gland with or without a connector. The problem of cable glands and the need for an additional wall outlet can be solved by means of field assembly RJ45 connectors, but the housings of the terminal devices are then often too tightly calculated or the bending radii of the cables cannot be maintained. Since the devices are installed in a fixed location for a long time, there is also no need for a pluggable connection. For this case Ethernet terminal blocks are an ideal alternative. However, if service or maintenance is due, Ethernet terminal blocks can also be reconnected. For terminal devices with high power requirements, such as cameras with an additional heating element, the Ethernet terminal blocks can also be planned with additional poles for a separate voltage supply as a hybrid solution. For classic twisted pair installation cables with cross-sections in the range of AWG 22 to AWG 23, Ethernet terminal blocks with IDC cutting contacts are suitable. This means that the fine buffers do not need to be stripped.



Application examples with similar requirements and options are, for example

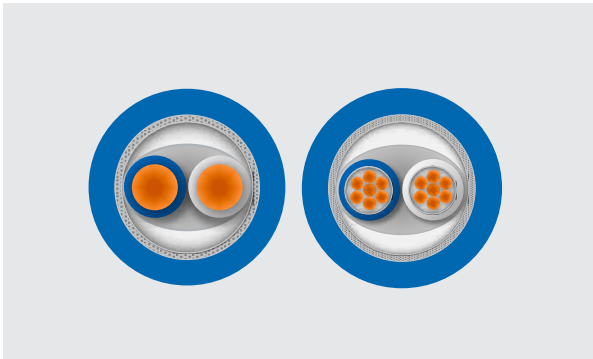
- Intelligent lighting, PoE Lighting
- Antenna systems
- Twisted Pair cable connectors for outdoor or industrial applications
- PoE Injector/Midspan devices for outdoor applications
- Wall-boxes for E-mobility
- and much more



Relevant cable/buffer cross-sections

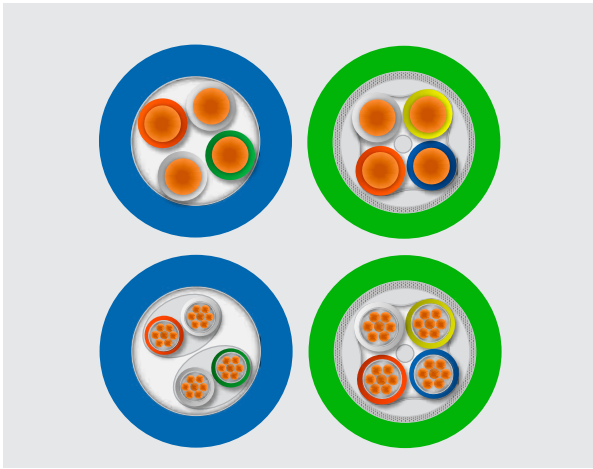
1-pair

With Single Pair Ethernet, new buffer cross-sections are entering the Ethernet world. Whereas Gigabit applications with up to 600 MHz bandwidth over short distances of currently up to 40 m generally use standard buffer cross-sections of AWG 22 to 26 for solid and stranded conductors, Megabit applications with 20 MHz over distances of up to 1,000 m require buffer cross-sections of AWG 16 or 18.



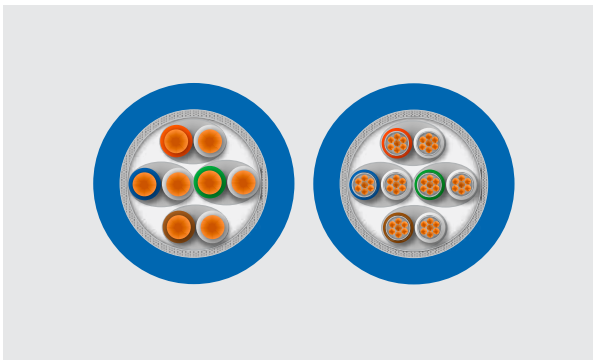
2-pair

Typical cables for Ethernet and Industrial Ethernet with two-pair cabling are designed for a cabling infrastructure according to ISO/IEC 11801-x and DIN EN 50173-x with up to 100 m. Frequencies of 10 to 31.25 MHz play a role here. Especially in the field of Industrial Ethernet, the cable properties with regard to the cable sheath are much more important. In these areas, resistant cables for use in harsh environments and thus oil resistance or protection against other chemicals or drag chain suitability and torsional capacity with high bending cycles play an important role.



4-pair

Typical cables for Ethernet and Industrial Ethernet with four-pair cabling are designed for a cabling infrastructure according to ISO/IEC 11801-x and DIN EN 50173-x with up to 100 m. Frequencies of 250 to 500 MHz play a role here. However, installation cables in category 7 and 7_A with 1,000 MHz are already commonplace, depending on the country. Especially in outdoor or industrial areas, the cable properties with regard to the cable sheath are much more important. In these areas, resistant cables for use in harsh environments and thus oil resistance or protection against other chemicals or drag chain suitability and torsional capacity with high bending cycles play an important role.



Other cable features

- Shielding
  - Shielded, S/FTP, F/FTP, SF/UTP, F/UTP
  - Unshielded, U/UTP
- Stranding element, separating element
- Drag chain suitability, torsional capacity and robotics applications
- Oil resistance
- Sheath materials: PUR, FRNC, PVC, FEP
- UL and CSA
- Cable color (Profinet, for example, green RAL6018)

Typical buffer dimensions for single-pair Ethernet cabling

BUFFER CROSSSECTION	SOLID CONDUCTOR CROSSSECTION	SOLID CONDUCTOR DIAMETER	STRANDED CONDUCTOR CROSS-SECTION (SIZE 7 STRAND)	(OUTER) STRANDED CONDUCTOR DIAMETER (SIZE 7 STRAND)	STRANDED CONDUCTOR WIDTH ACROSS FLATS (SIZE 7 STRAND)	STANDARD CABLE DIAMETER
AWG 26	0.129 mm^2	0.405 mm	0.141 mm^2	0.480 mm	0.438 mm	5 - 8 mm
AWG 24	0.205 mm^2	0.511 mm	0.244 mm^2	0.606 mm	0.552 mm	5.5 - 9 mm
AWG 23	0.258 mm^2	0.573 mm	0.283 mm^2	0.680 mm	0.620 mm	5.5 - 9 mm
AWG 22	0.326 mm^2	0.644 mm	0.356 mm^2	0.764 mm	0.696 mm	5.5 - 9 mm
AWG 18 (for SPE)	0.823 mm^2	1.024 mm	0.901 mm^2	1.215 mm	1.106 mm	6.5 - 8 mm
AWG 16 (for SPE)	1.309 mm^2	1.291 mm	1.433 mm^2	1.532 mm	1.395 mm	8 - 10 mm

* Depending on the shielding and application (e.g. drag chain suitability, outdoor, etc.), industrial or outdoor cables may also have diameters between 5.5 - 11.5 mm.

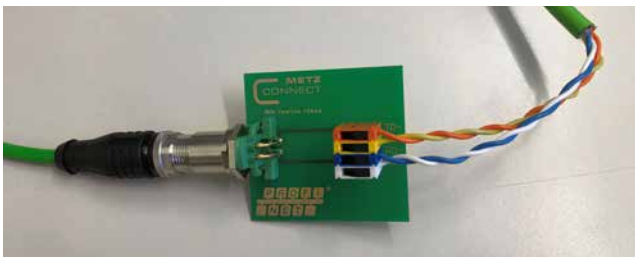
5

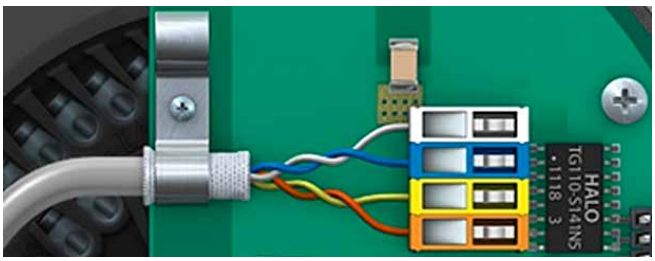
Handling the cable infeed, strain relief and shielding

Cable infeed and preparation

In addition to the buffer cross-sections, the shielding and the cable sheath are also important. Although the cable sheath is less important for the terminal block itself, the overall cable cross-section, especially for application-specific cables, must be considered when designing the cable gland, feeding and fixing or strain relief. The cable should be cleanly routed to the terminal block and fixed. Enough space should also be considered for handling and installation.

If a shielded cable with foil shielding around the respective pairs and wire braiding around all pairs is used, the foil shielding should be routed as close as possible to the terminal. Initial findings have shown that in field tests of Ethernet and Industrial Ethernet connections at 10 to 100 Mbit/s, the results were not critical even without an optimally routed foil shielding. To achieve optimal performance it is still recommended.





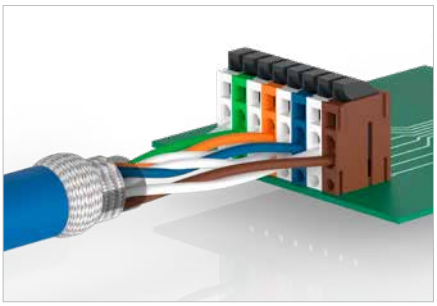
The wire braid should be collected and forwarded. The possibilities of this solution are described below.

Shield connection concepts

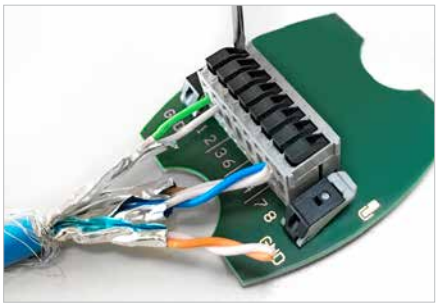
Examples

1) Shield contacting via the Ethernet terminal block

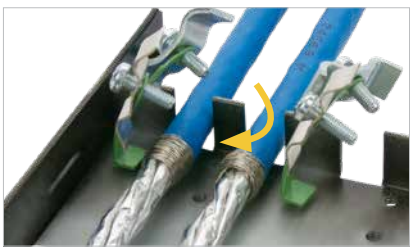
a) Additional pole/contact directly on the Ethernet terminal block

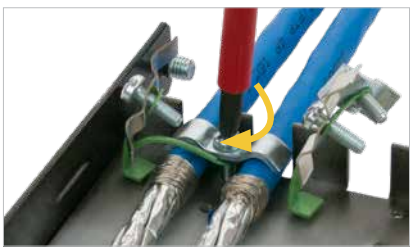


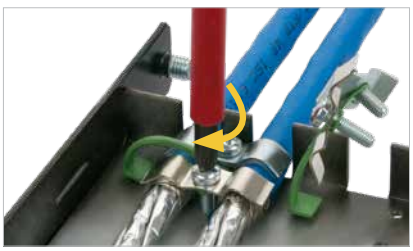
b) Separate terminal block for the shield connection



2) Shield connection and optimal strain relief via additional shield clamp and contact field on the circuit board.



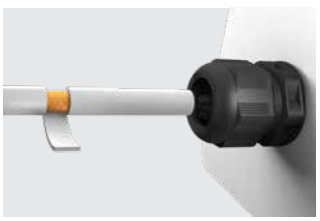




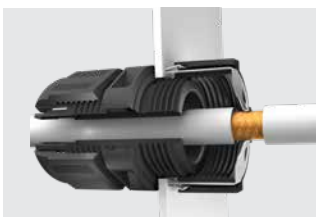
3) Shield catch directly on the housing

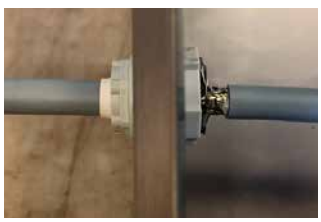
Step 1

Step 2

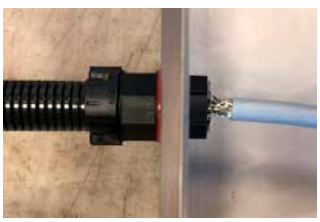


Step 3





Step 4

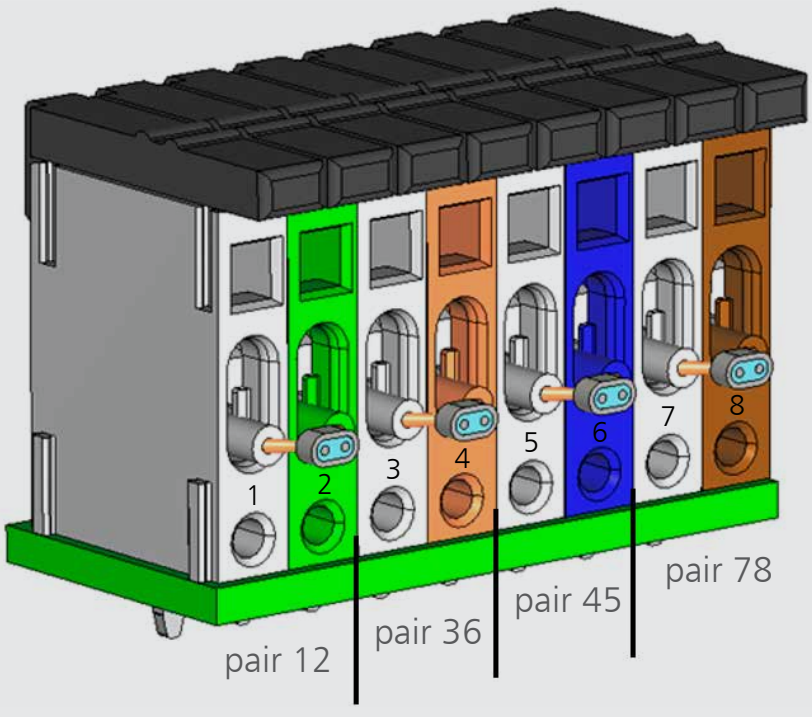


Measurements and tests

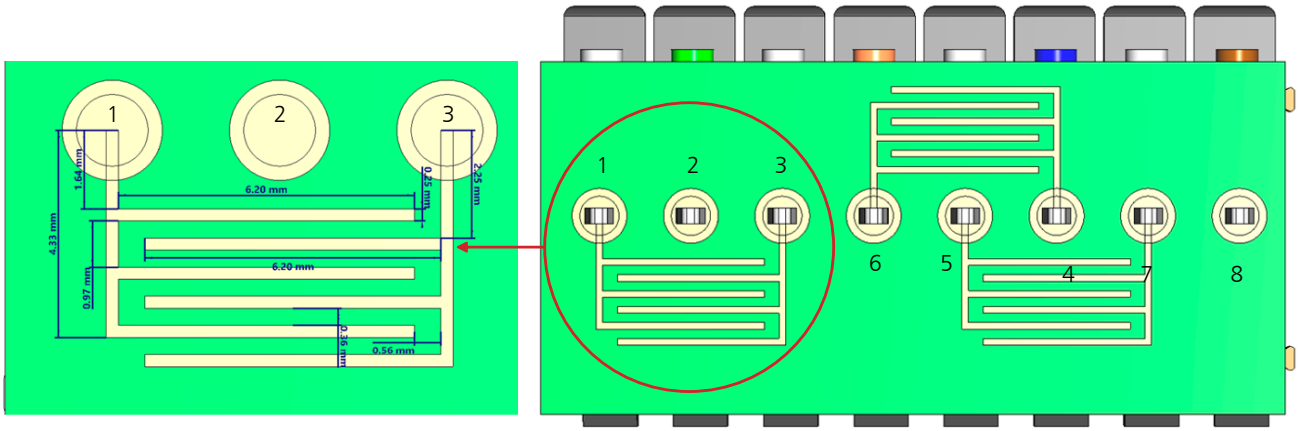
When using single-, two-, or four-pair cabling, depending on the desired data transfer rate and voltage supply, there are high HF requirements with regard to attenuation and crosstalk. In order to be able to guarantee a high bandwidth continuously and without interruptions or interference, depending on the transmission standard, the appropriate terminal block must be selected and, if necessary, the circuit board layout must be optimized.

A large selection of terminal blocks has already been tested for Ethernet capability, validated and, where possible, optimized for the circuit board layout. Therefore, when planning an Ethernet terminal block in a device, a large knowledge base can already be drawn upon.
When setting up the test or measurement procedure, the Ethernet terminal blocks were tested both with and without shield connection, in order to gain an insight into how the Ethernet terminal blocks react in devices with several connections lined up next to each other. In addition, the above scenarios were evaluated with and without circuit board layout optimization.

For the single-pair HF simulations, buffers with AWG 16 and AWG 24 were used and the limits T1-A and T1-B according to ISO/IEC 11801-1 as well as the limits SP1 to SP4 according to TIA 568.5 were applied. The test for the two-pair connections for, among others, Industrial Ethernet was tested according to Profinet guidelines. The testing of the four-pair connections was based on a component test for Cat.5e, Cat.6 and Cat.6_A with AWG 22/1 and 26/1 buffers. These limits were, among other things, the target for a possible optimization of the layout.



Example image



The current carrying capacity of the current Ethernet terminals is higher than that required for PoDL and PoE.

SUMMARY

- Choice of Ethernet terminal block depending on the requirements regarding the data transfer rate
- Optimization of the circuit board layout improves the performance
- Carrying the shielding improves the HF values
- Route the foil shielding as close as possible to the terminal block
- Voltage supply (PoDL, PoE*) uncritical
- Buffer cross-sections have an influence on the HF values, larger buffer cross-sections provide more reserve
- two-pole terminals with distance between the wire pairs reduce crosstalk
- Distance between several Ethernet terminals is critical, extend distance or shielding

*Switching states are to be changed for load-free systems

Further information, suggestions, recommendations, data sheets and details of the circuit board layout can be requested as required at: **www.metz-connect.com/contact**

Ethernet terminal blocks vs. RJ45 vs. M12

Requirements and solutions per sector

FUNCTIONS PROPERTIES	ETHERNET TERMINAL BLOCKS	SPE CONNECTOR	RJ45 CONNECTOR	M12 CONNECTOR
Data transfer rate	++ up to 10 GBit	+ currently 10-100 MBit	+++ up to 10 GBit (25 & 40 GBit)	++ up to 10 GBit
Transmission distance	+++ › 100 m › Up to 1,000 m SPE	+++ › 100 m › Up to 1,000 m SPE	++ 100 m	++ 100 m
Power transfer	+++ › Up to 90 W PoE* › Higher with hybrid use With additional poles for the power supply	+ Up to 60 W PoDL, Power over Data Line, (+++ Hybrid)	++ › Up to 90 W PoE* › Susceptible in the long-term when pulling and plugging under load	++ › Up to 90 W PoE* › Critical when pulling and plugging under load
Size Consideration of the circuit board connection influence on the circuit board and the device	+ Depending on terminal block type	+++ Slight benefit in relation to data transmission-related properties (++)	++	++
Size of overall connector Consideration of the entire connector (plug and jack). Influences the entire application	+++ Can be used well in very confined spaces inside and outside devices. Plug and jack in one connection.	++	+ Required depending on the design and choice of plug and jack. Angled connectors possible.	- Similar to RJ45, needs quite a lot of space. Angled connectors possible.
Price	+++	+	++	+
IP protection type	IP20 Ideal for installation in a housing with cable gland	IP20, IP67 (in M12 & M8 housing variant)	IP20, IP67 in enclosed housing (relatively large)	IP67
Benefits	› Cost-effective solution for static devices that do not need to be plugged in several times (e.g. for maintenance purposes) › Compact connection technology, especially in small housings › Very space-saving in combination with cable glands on device housings	› Compact connector for pluggable applications, especially in the field level	› Known connector face › Easy handling › Affordable	› Secure connection by screw connection › IP protected › Known connector principle, M12 circular connectors

*Switching states are to be changed for load-free systems

A summary of Ethernet terminal block benefits

Circuit board terminal blocks instead of connectors are of interest for devices that are permanently installed and do not need a frequently plug/removable connection and which typically are installed permanently in one location. Just like sensors, lights but also IP cameras etc. today, circuit board terminal blocks are and will increasingly become a beneficial alternative to the usual Ethernet connectors and connection technologies. There is already an increasing demand for terminal blocks as an interface for any Ethernet application, be it for Gigabit-enabled devices, Industrial Ethernet, Single Pair Ethernet, or Advanced Physical Layer (APL).

- Connection technology for the IoT devices of the future
  - Easy handling and color coding
  - Assembly-friendly connection without special tools
  - Pluggable or permanently soldered
- Technical benefits
  - Wide range of buffer cross-sections
  - Various designs for different applications
  - Ideal for devices with little space for connections in the housing
- Cost-effective solutions
  - Cost benefits over connectors
  - Component reduction for fixed connection
- Single Pair Ethernet
  - Networking of the field level in industry, process and building automation
  - Many compact terminal devices
  - Long distances up to 1,000 m with cable cross-sections up to AWG 16
- 4-pair Ethernet infrastructure
  - Miniaturization
  - Building automation
- Transfer-related benefits
  - 1 MBit/s up to 10 GBit/s Ethernet
  - Industrial Ethernet systems (such as PROFINET, EtherNet/IP, EtherCAT, etc.)
  - Single Pair Ethernet
  - Power over Ethernet, Power over Dataline, as well as higher voltage supply with additional poles as a hybrid connection

SUMMARY

The application options are very versatile and extensive,
i.e. everywhere where Ethernet interfaces are required: Building, industry, process automation, outdoor, transport technology, and much more.

Product overview

All of the following listed terminal blocks have SEV and UL approval

IMAGE	PRODUCT NAME	P/N	CONNECTION TYPE	NUMBER OF POLES	GRID DIMENSION	CONNECTION TYPE	BUFFER CROSS-SECTION AWG
SPRING CLAMP TERMINAL BLOCK							
	SP02502HDNC001 SPE	ASP0250204-001	Cage clamp spring	2	5	Pluggable (pin header THR reflow can be soldered)	16-28 conductor 18-28
	SP02503HDNC001 SPE S	ASP0250304-001	Cage clamp spring	3	5	Pluggable (pin header THR reflow can be soldered)	16-28 conductor 18-28
	SP02504HDNC004 PROFINET	ASP0250404-004	Cage clamp spring	4	5	Pluggable (pin header THR reflow can be soldered)	16-28 conductor 18-28
	SP02505HDNC002 PROFINET S	ASP0250504-002	Cage clamp spring	5	5	Pluggable (pin header THR reflow can be soldered)	16-28 conductor 18-28
	SP02508HDNC004 ETHERNET	ASP0250804-004	Cage clamp spring	8	5	Pluggable (pin header THR reflow can be soldered)	16-28 conductor 18-28

DATA TRANSFER	PoE* and PoDL capability (Power W at PSE)	RATED VOLTAGE ACCORDING TO SEV [A]	RATED CURRENT ACCORDING TO SEV [A]
IEEE 802.3cg; 10BASE-T1L; 10 MBit/s, 20 MHz; up to 1,000 m STP; IEEE 802.3bp; 1000BASE-T1; 1 GBit/s, 600 MHz; 15 m UTP/ 40 m STP	PoDL, IEEE 802.3bu, 60 W	250	10
IEEE 802.3cg; 10BASE-T1L; 10MBit/s, 20MHz; up to 1,000 m STP; IEEE 802.3bp; 1000BASE-T1; 1GBit/s, 600MHz; 15 m UTP/40m STP	PoDL, IEEE 802.3bu, 60 W	250	10
IEEE 802.3i/u/y; 10/100BASE-T(2); 10/100MBit/s; 10/12,5/31,25MHz; Cat.5, 100 m	PoE, IEEE 802.3af, 15,4 W PoE+, IEEE 802.3at, 30 W	250	10
IEEE 802.3i/u/y; 10/100BASE-T(2); 10/100 MBit/s; 10/ 12.5/ 31.25 MHz; Cat.5, 100 m	PoE, IEEE 802.3af, 15,4 W PoE+, IEEE 802.3at, 30 W	250	10
IEEE 802.3ab; 1000BASE-T(4); 1 GBit/s, 250 MHz; Cat.5e/6, 100 m	PoE, IEEE 802.3af, 15,4 W PoE+, IEEE 802.3at, 30 W 4PPoE, IEEE 802.3bt, 90 W	250	10

Product overview

All of the following listed terminal blocks have SEV and UL approval

IMAGE	PRODUCT NAME	P/N	CONNEC-TION TYPE	NUMBER OF POLES	GRID DIMENSION	CONNEC-TION TYPE	BUFFER CROSS-SECTION AWG
SPRING CLAMP TERMINAL BLOCK							
	SM99S01VBNN01G7 (cream)	SM99S01VBNN01G7	Push-in Single pole	1	-	SMT	16-24
	SM99S01VBNN05G7 (blue)	SM99S01VBNN05G7	Push-in Single pole	1	-	SMT	16-24
	SM99S01VBNN07G7 (gray)	SM99S01VBNN07G7	Push-in Single pole	1	-	SMT	16-24
	SM99S01VBNN02G7 (yellow)	SM99S01VBNN02G7	Push-in Single pole	1	-	SMT	16-24
	SM99S01VBNN06G7 (orange)	SM99S01VBNN06G7	Push-in Single pole	1	-	SMT	16-24
	SM99S01VBNN08G7 (brown)	SM99S01VBNN08G7	Push-in Single pole	1	-	SMT	16-24
	SM99S01VBNN03G7 (green)	SM99S01VBNN03G7	Push-in Single pole	1	-	SMT	16-24
	SR99S01VBNN01G7 (cream)	SR99S01VBNN01G7	Push-in Single pole	1	-	THT, THR	16-24
	SR99S01VBNN05G7 (blue)	SR99S01VBNN05G7	Push-in Single pole	1	-	THT, THR	16-24
	SR99S01VBNN07G7 (gray)	SR99S01VBNN07G7	Push-in Single pole	1	-	THT, THR	16-24
	SR99S01VBNN02G7 (yellow)	SR99S01VBNN02G7	Push-in Single pole	1	-	THT, THR	16-24
	SR99S01VBNN06G7 (orange)	SR99S01VBNN06G7	Push-in Single pole	1	-	THT, THR	16-24
	SR99S01VBNN08G7 (brown)	SR99S01VBNN08G7	Push-in Single pole	1	-	THT, THR	16-24
	SR99S01VBNN03G7 (green)	SR99S01VBNN03G7	Push-in Single pole	1	-	THT, THR	16-24

*Switching states are to be changed for load-free systems

DATA TRANSFER	PoE* and PoDL capability (Power W at PSE)	RATED VOLTAGE ACCORDING TO SEV [A]	RATED CURRENT ACCORDING TO SEV [A]
		300	9
		300	9
		300	9
		300	9
1 pair, 2 buffers, 2-pole IEEE 802.3cg 10BASE-T1L 10 MBit/s, 20 MHz up to 1,000m STP		300	9
IEEE 802.3bp 1000BASE-T1 1 GBit/s, 600 MHz 15 m UTP/ 40 m STP	1 pair, 2 buffers, 2-pole PoDL, IEEE 802.3bu, 60 W	300	9
2 pairs, 4 buffers, 4-pole IEEE 802.3i/u/y 10/100BASE-T(2) 10/100 MBit/s, 10/ 12.5/ 31.25 MHz Cat.5, 100 m	2 pairs, 4 buffers, 4-pole PoE*, IEEE 802.3af, 15,4 W PoE+*, IEEE 802.3at, 30 W	300	9
		300	9
4 pairs, 8 buffers IEEE 802.3ab 1000BASE-T(4); 1 GBit/s, 250 MHz; Cat.5e/6, 100 m	4 pairs, 8 buffers PoE, IEEE 802.3af, 15,4 W PoE+, IEEE 802.3at, 30 W 4PPoE, IEEE 802.3bt, 90 W	300	9
		300	9
IEEE 802.3an; 10GBASE-T(4); 10 GBit/s, 500 MHz; Cat.6_A, 100 m		300	9
		300	9
		300	9
		300	9
		300	9

Product overview

All of the following listed terminal blocks have SEV and UL approval

IMAGE	PRODUCT NAME	P/N	CONNECTION TYPE	NUMBER OF POLES	GRID DIMENSION	CONNECTION TYPE	BUFFER CROSS-SECTION AWG
IDC CUTTING TERMINAL BLOCK							
	IT02302HMNU000 SPE	AIT0230299-000	Cutting contact	2	3.5	THT	22-24
	IT02304HMNU000 PROFINET	AIT0230499-000	Cutting contact	4	3.5	THT	22-24
	IT02308HMNU001 ETHERNET 1	AIT0230899-001	Cutting contact	8	3.5	THT	22-24
	IT02308HMNU002 ETHERNET 2	AIT0230899-002	Cutting contact	8	3.5	THT	22-24

*Switching states are to be changed for load-free systems

DATA TRANSFER	PoE* and PoDL capability (Power W at PSE)	RATED VOLTAGE ACCORDING TO SEV [A]	RATED CURRENT ACCORDING TO SEV [A]
IEEE 802.3cg; 10BASE-T1L; 10 MBit/s, 20 MHz; up to 1,000 m STP; IEEE 802.3bp; 1000BASE-T1; 1 GBit/s, 600 MHz; 15 m UTP/ 40 m STP	PoDL, IEEE 802.3bu, 60 W	130	5
IEEE 802.3i/u/y; 10/100BASE-T(2); 10/100 MBit/s, 10/ 12.5/ 31.25 MHz; Cat.5, 100 m	PoE*, IEEE 802.3af, 15,4 W PoE+*, IEEE 802.3at, 30 W	130	5
IEEE 802.3ab; 1000BASE-T(4); 1 GBit/s, 250 MHz; Cat.5e/6, 100m; IEEE 802.3an; 10GBASE-T(4); 10 GBit/s, 500 MHz; Cat.6_A, 100 m	PoE*, IEEE 802.3af, 15,4 W PoE+*, IEEE 802.3at, 30 W 4PPoE, IEEE 802.3bt, 90 W	130	5
IEEE 802.3ab; 1000BASE-T(4); 1 GBit/s, 250 MHz; Cat.5e/6, 100 m; IEEE 802.3an; 10GBASE-T(4); 10 GBit/s, 500 MHz; Cat.6_A, 100 m	PoE*, IEEE 802.3af, 15,4 W PoE+*, IEEE 802.3at, 30 W 4PPoE, IEEE 802.3bt, 90 W	130	5

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899759-01 | 09/2023