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TURCK

Field Guide:
Industrial Ethernet Connectivity

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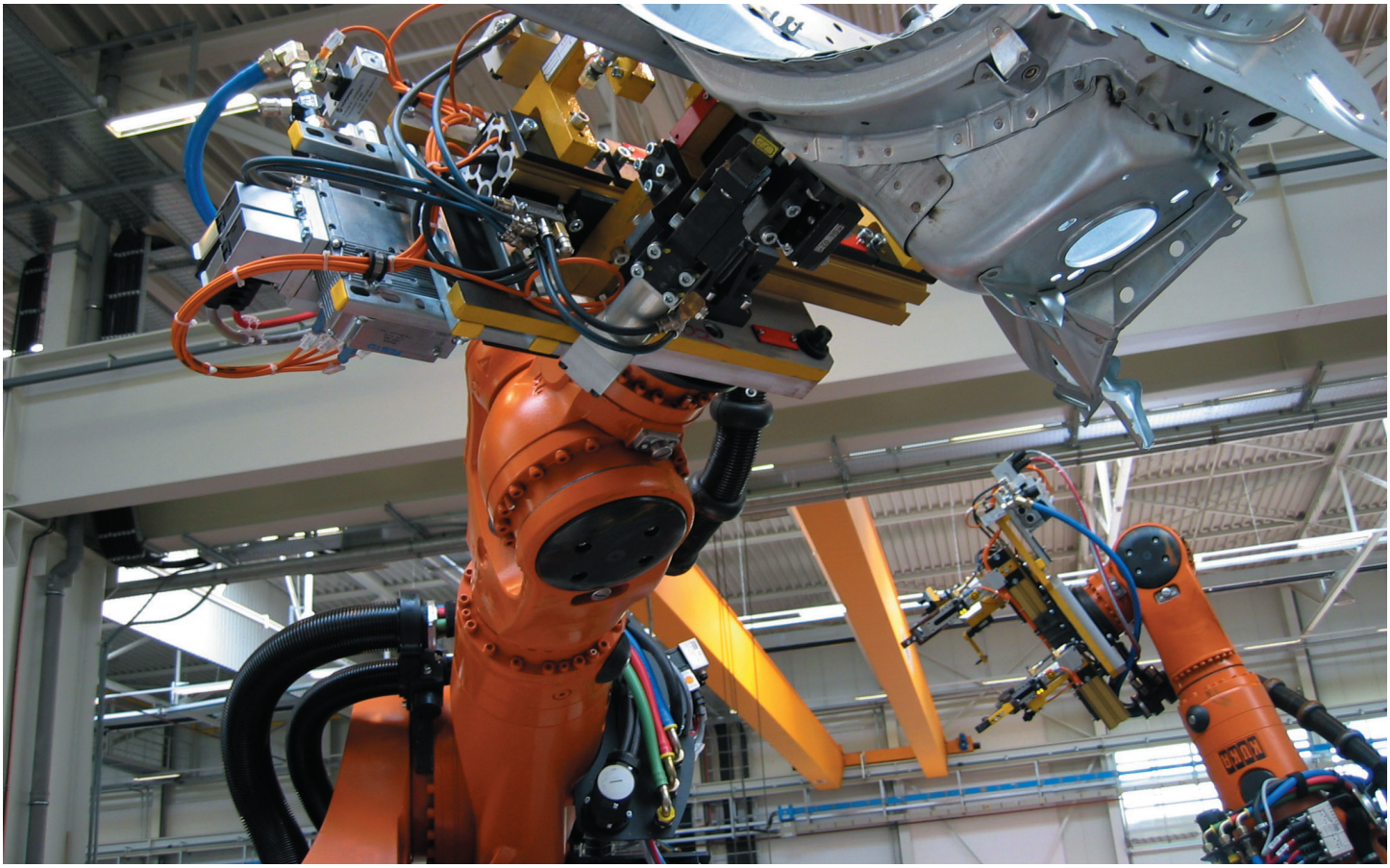


Ethernet is the most commonly used computer networking technology for local area networks (LANs) and is standardized in IEEE 802.3. As Ethernet continues to find its way into other applications, it is rapidly becoming the network of choice for higher-level industrial control applications. Industrial Ethernet is the result of applying traditional Ethernet standards for data communication to industrial applications.

In order for Ethernet to be used in the industrial environment, the cables and connectors must be adapted to withstand environmental conditions that are not present in commercial installations. These conditions include:

- Oils
- Chemicals
- Moisture
- Ozone
- UV
- Weld spatter
- Temperature fluctuations
- Flexing

In addition, environmental noise can have a negative affect on network performance. Electrical noise can come from nearby AC or DC circuits, motor drives, welders, and other electrical equipment. This results in increased RFI and EMI interference, which can decrease system performance. Industrial network connectivity needs to withstand all of these conditions and still reliably perform. More and more applications require real-time data, which increasingly makes Ethernet the optimal solution for today's industrial environments.

Keeping in mind the environmental conditions, one has to consider which cable, communication protocol, and connector(s) will work best for the installation. This guide will provide a brief overview of some of the most common options available today.

Cable

Equally important as the connector you choose for your industrial Ethernet application is the cable you choose. Off the shelf commercial Ethernet cable does not withstand the demands of an industrial environment. Rugged Industrial Ethernet cables, such as those using TPE cable jackets, are designed to hold up to the harsh environments common to industrial automation.

Industrial Ethernet cable commonly uses twisted pairs, which is wiring where two conductors that are part of the same circuit are twisted together. This process is intended to help cancel out EMI and interference from other sources. In addition, an extruded cable jacket on industrial Ethernet cables helps protect and hold the twisted pairs together.

INDUSTRIAL	COMMERCIAL
Extruded Jacket	Tubed Jacket
High Strand Count	Low Strand Count
Significant Jacket Wall	Thin Jacket Wall
High Flex Rated (up to 10 million cycles)	Static Install Only
Industrial Temperature Range (-40 °C to +80 °C)	Office Temperature Range (around 30 °C)
Sunlight, UV, Oil, Ozone, Moisture, and Weld Spatter Resistance	No Resistance
Industrial Approvals: UL, CSA for Communication, 600 V Rating, Tray Ratings, Shipboard or Rail Approvals	No Approvals
Tinned Copper	Bare Copper

A commercial Ethernet cable does not typically carry any ratings or approvals for industrial environments, and at most may include a rating for plenum or riser air spaces, which generally does not apply to industrial settings.

Industrial Ethernet cable does have a similar color code to commercial Ethernet (ANSI/TIA 568-C.2). The tables below illustrate the typical color codes used for industrial Ethernet applications.

Two Pair Color Code

PAIR ASSIGNMENT	SIGNAL NAME	TWO PAIR COLOR CODE
Pair 1	TX+	White/Orange
	TX-	Orange
Pair 2	RX+	White/Green
	RX-	Green

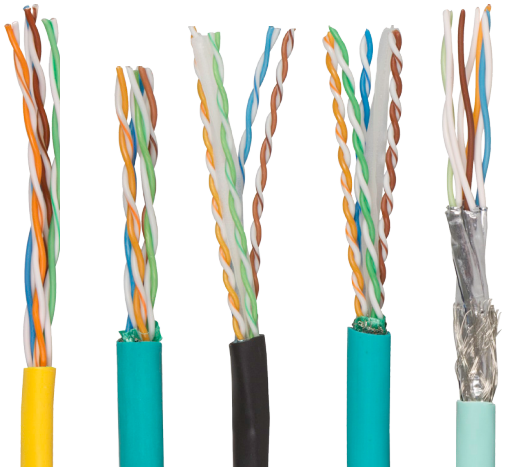
Four Pair Color Code

PAIR ASSIGNMENT	SIGNAL NAME	FOUR PAIR COLOR CODE
Pair 1	NA	White/Blue
	NA	Blue
Pair 2	TX+	White/Orange
	TX-	Orange
Pair 3	RX+	White/Green
	RX-	Green
Pair 4	NA	White/Brown
	NA	Brown

Ethernet Categories

Ethernet cables are referred to as category cables, because they are classified into specific categories of performance. The table below lists several common category cables and their associated frequency, speed, and number of pairs. Note, CAT 5e is available as either a 2-pair or 4-pair cable, but all 4-pairs are needed to achieve the 1000 Mbps speed; only 2-pairs are needed to achieve 100 Mbps.

CATEGORY	FREQUENCY	SPEED	PAIRS
Cat 5	100 MHz	100 Mbps	2-4
Cat 5e	100 MHz	1000 Mbps	2-4
Cat 6	250 MHz	1000 Mbps	4
Cat 6a	500 MHz	10 Gbps	4
Cat 7	600 MHz	10 Gbps	4



Cat 5 Cat 5e Cat 6 Cat 6a Cat 7

As the speed increases, so does the twisting of pairs and shielding

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An important consideration when choosing an Industrial Ethernet cable is the overall desired performance of the system. If the goal is to achieve 10 Gbps, then all devices and connecting hardware (switch, PLC, I/O blocks, camera, etc) need to be rated to the same speed. Your system will operate as fast as the slowest device. Utilizing CAT 6A cabling will not force a CAT 5e switch to operate differently.

Shielding

Shielded cordsets are an essential component of any connectivity solution to combat cross talk, which is the unwanted transfer of signals between communication channels and EMI/RFI. EMI/RFI stands for "Electro-Magnetic Interference" and "Radio Frequency Interference", which is high frequency / low energy noise emitted by factory devices such as motors, welders, power cables and processing equipment. The noise emitted disrupts packet transmission by overwhelming the normal signal information within the electrical circuit. A double shielding approach, with both foil and braided shield, is most effective in isolating the data communication from the external environment. This design takes advantage of the greater coverage of foil and the superior conductivity of the copper braid. Additionally, proper bonded grounding of all components is crucial to attaining effective shielding. When in doubt on whether or not to use shielded cable, err on the side of caution and choose shielded cables to prevent costly system downtime and errors.

Note: Turck has bulk cable available for use with all major protocols. For a listing of these, please visit the reference table included at the end of this guide.

Understanding Your Options for Industrial Ethernet Connectors and Cabling

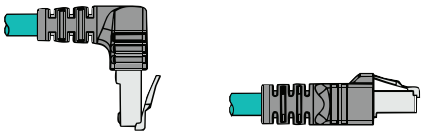
It is important to consider the conditions that the connector will be exposed to including how and where it will be mounted, what shielding is required and the conditions of the overall operating environment.

Connector Options

RJ45 Endview

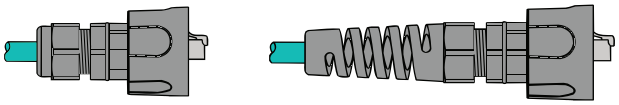
The RJ45 (8P8C) connector is the most widely established connector technology for Ethernet networks. These connectors are available for most Ethernet categories (i.e. CAT 5e, CAT 6, etc.), and their ease of use and quick connect/disconnect feature makes them a natural choice for office environments. RJ45 connectors are recommended only for limited use in industrial environments, and in protected/enclosed areas, as a patch cable converting commercial Ethernet to the factory floor. These connectors are capable of handling both 2 and 4-pair wiring and come in both IP20 and IP67 styles.

IP20 RJ45 Connector:



WRJ45E **RJ45**

IP67 RJ45 Connector:



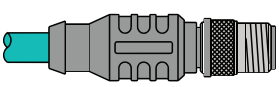
RJ45MIP67 **RJ45IP67**

When transitioning to the unprotected industrial environment, M12 Ethernet connectors are the superior choice for Industrial applications. Their rugged overmold design provides ingress protection against dirt and water as well as resistance to machine vibration and accidental impact. These factors make them a better choice for maintaining signal integrity and performance.

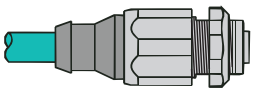
The M12 is available with three different pin configurations for Industrial Ethernet use. There is a 4-pin D-code, an 8-pin A-code, and an 8-pin X-code. The D-code M12 is intended for use with 2-pair (4-wire) Industrial Ethernet cables only. The 8-pin A-code can be used with either 2-pair or 4-pair (8-wire) Industrial Ethernet cable. The X-code is intended for use with only 4-pair shielded Industrial Ethernet cable. This connector is further detailed in a later section.

M12 connectors carry IP67 and IP69K ratings for industrial applications, and are available with stainless steel components suitable for environments requiring corrosion resistance. Similar to RJ45 connectors, M12 connectors can be used with most all of the existing Ethernet category cable types (i.e. CAT 5 up to CAT 7).

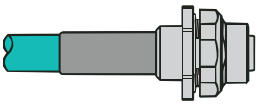
M12 Connectors:



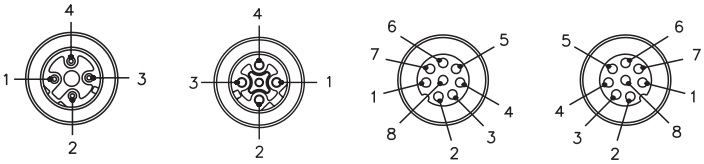
RSC/RSS; RSCD/RSSD



FKSDE; FKSDED



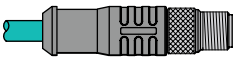
FKSD; FKFDD



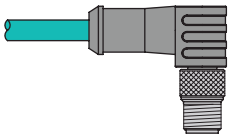
Male Female Male Female

The 4-pin M8, rated for IP67, is also available for use in Industrial Ethernet applications. The smaller size of the M8 allows users to bring Industrial Ethernet into applications with very limited space. It is available with the shield tied to the coupling nut, as required by the EtherCAT network protocol. The 4-pin configuration is suitable for 2-pair Industrial Ethernet cables.

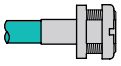
M8 Connectors:



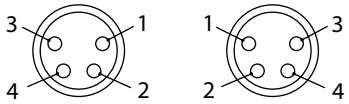
PSGS 4M



PSWS 4M

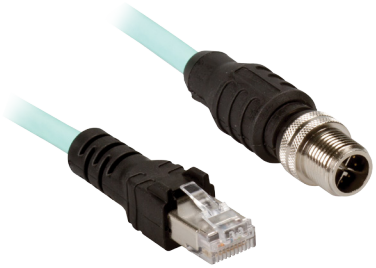


MFKS 4F



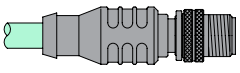
Male Female

Gigabit Ethernet (CAT6 and Higher)

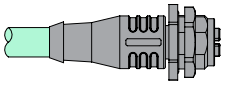


Newer applications for video, camera, and high-speed data acquisition demand a network cable that can handle more than 10/100 Mbps data transfer. Gigabit Ethernet, which may refer to 1 Gbps or 10 Gbps, can provide the speed and capacity needed. For 1 Gb applications, category 5e or higher cable is required. For 10 Gbp applications, category 6A cable or higher is required. Turck offers solutions for both. For applications that require 1 Gb communication (or if you have more than four connection points within the channel), it is recommended to use a CAT 5e, CAT 6, or CAT 6A cable along with the higher rated X-code M12 connector. For applications that operate at 10 Gb speed, it is recommended to use our CAT 7 cable along with the X-code M12 connector.

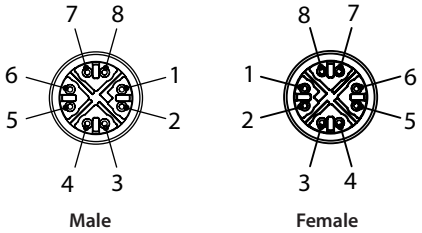
X-code M8 Connectors:



RSSX



FKSDX



Male Female

The X-code M12 features advanced shielding design. The metal contact holder isolates each of the pairs from the others. When paired with Turck's CAT 7 cable (type 862), it can communicate at 10 GBASE-T. Turck's CAT 7 cable is S/STP, where each pair has a foil shield, and an overall braided shield. This overall shield is carried through to the connector coupling nut, providing much needed protection from external noise. In addition, the X-code M12 is IP67 rated, and reliably operates in temperatures ranging from -20 degrees Celsius to 70 degrees Celsius.

A common application for Gigabit Ethernet is for cameras. Often

times, these cameras are located in protected areas and do not necessarily require a rugged M12. In this case, an RJ45 cordset with CAT 6 cable is an ideal solution. Turck's RJ45S RJ45S 861-*M works well for cameras or in other protected areas. It utilizes 4UTPX26 AWG cable, with overall foil and a black PVC jacket, and features Turck's robust overmold for the RJ45.

Power over Ethernet

Power over Ethernet (PoE) refers to the ability to transfer both data and power within an individual Ethernet cable. Standards have been established by the IEEE, specifically 802.3af and 802.3at, which detail the minimum category cable, how power should be delivered, and limits in terms of watts. Many applications have been established in the commercial world (VoIP, surveillance cameras, access control devices, etc.), and are making headway into the industrial environment as well. Turck stranded Industrial Ethernet cables (types 440, 441, 840, 841) are suitable for use in PoE and PoE+ applications.

A similar but very different concept is the desire for both power and Ethernet. The intent is the same, to utilize one cable for both data and power. However, instead of supplying low voltage/current over the data pairs, the cable includes additional larger gauge conductors specifically for power, and may supply power up to several amps. Power & Ethernet does not have any established standards or governing groups dictating how it should be designed or used. There exist many variations with different numbers of data pairs, different numbers of power conductors, and different styles of connectors. While Power & Ethernet does solve consolidation problems, it may not always be the most cost effective solution due to the custom cables and specialized connectors needed.

Installation Guidelines

The following section is intended to highlight some common "best practice" tips, for use in an Industrial Ethernet installation. Utilizing these tips at the beginning of an installation can minimize trouble-shooting after the installation. However, please keep in mind that every application is different. It is understandable that, in certain situations, these guidelines cannot be followed, but the systems can still function properly. The most important factors to consider with your application are the environment, the potential for noise and what electrical codes need to be followed (UL, NEC, NFPA, etc.).

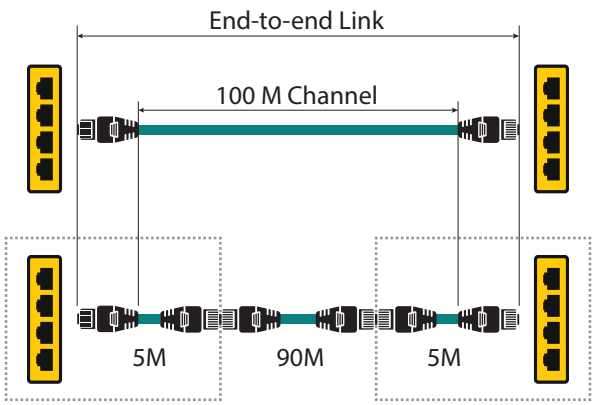
Grounding Shielded Cable

When using a shielded Industrial Ethernet cable, it is important to terminate the shield to ground. This is what prevents noise from having a negative effect on the cable's performance. The method of terminating shield to ground may be dependent on local electrical codes, network protocol (i.e. EtherNet/IP, Modbus, etc), or the system layout and personal experience. The ODVA recommends terminating only one end to ground; at the switch or panel, not at the active device. Conversely, PI recommends terminating both ends to ground; at the device and back at the panel. Regardless of the method chosen for the application, it is important to not leave the shield floating or unterminated at either end. When a shield is unterminated, it can act as an antenna and induce noise onto the cable, potentially causing significant communication problems for the system. While the task of determining which method of terminating shield to ground may seem daunting, the use of a shielded cable could lead to significant time and cost savings in the future. For instance, if equipment is moved around, a new machine is added, or additional cables are added to a tray where Ethernet exists, shielded cables are much less likely to experience communication problems due to unforeseen changes.

System Length:

When constructing your Ethernet topology, there are a few important terms and considerations to be aware of. The overall network infrastructure that interconnects various parts of the network - allowing information to exchange hands - known as the Ethernet backbone. Another common term is channel, which is the overall system length, including horizontal cabling and patch cables. Horizontal cabling refers to the longest run, typically solid conductor, max length 90 M (ex: from patch panel to outlet), or up to 100 M if you are direct connecting with no patch cables. Patch cables refer typically to short cables or stranded conductors, up to 30 M total (ex: from outlet to device).

Industry Standards limits channel length to 100 M (copper cable). Turck solid conductor Industrial Ethernet cables have full CAT 5e performance to 100 M. Turck stranded Industrial Ethernet cables have full CAT 5e performance up to 85 M.



This means that, in some installations, a Turck stranded industrial Ethernet cable could be substituted for a solid conductor cable, which may minimize inventory requirements for some customers and make it easier when specifying a bill of materials.

Connectors: It is recommended to minimize the number of connection points within an Ethernet network. Each mated connection point represents a short distance where Ethernet pairs are untwisted, and therefore are more susceptible to noise interference. Typical practice for Industrial Ethernet installations is to utilize cordsets with male connectors on both ends; this minimizes opportunities for someone to extend a cordset. All receptacles and bulkheads are recommended to be female. Regardless of connector type (RJ45, M12, M8), this is a common practice for Ethernet connectivity. ODVA spec recommends no more than six mated connections within a channel (Sec. 8-9.2.3.8). Anything more and it is suggested it could compromise communication.

Transition Out of the Cabinet

Turck offers a variety of connector options, to make transitioning out of the panel into the industrial environment easier. Typically, this means transitioning from an RJ45 to an M12, the preferred connector for use in an industrial environment. Using one of these receptacles or feed-thru style connectors can make the transition simple.

FKFDD or FKFD

FKSDED or FKSDE

FKSDX

FKD FKD 44/M12

FKSDD RJ45SF 44

RJ45 PANEL MOUNT IP20

FKX FKX 86/M12

Service Loops

Unlike general sensor cables, it is not typically recommended to utilize service loops for extra Ethernet cable. The individual pairs of an Ethernet cable are twisted and line up uniquely, so as to prevent crosstalk between pairs. Anything that distorts the twisting or alignment of the pairs has the potential to allow opportunity for crosstalk. This includes coiling loops of Ethernet cable, which may distort the pairs and their alignment. Whenever possible, try to specify Ethernet lengths close to the actual length needed.

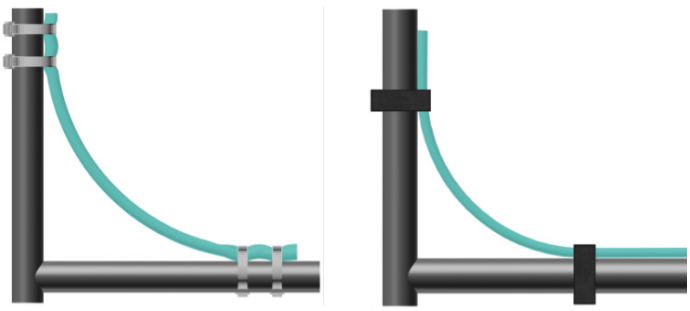
Proper Bend Radius

Static bend radius for Industrial Ethernet cables (stranded or solid, shielded or unshielded) is 4x the cable OD (Outside Diameter). Solid conductor cables are not recommended for flexing applications. Instead, use a stranded conductor cable. Turck's stranded Industrial Ethernet cables (both shielded and unshielded) are rated for 1 million flex cycles at 10x cable OD, and for 10 million flex cycles at 20x cable OD.

Providing sufficient bend radius will allow the cable to absorb the energy of bending over a greater portion of its length, increasing its effective working life. Small increases in the radius of the bend can produce substantial increases in cable life.

Tying Cables with Cable Ties

When tying cable with self locking cable ties, always leave the ties loose enough for the cables to move freely under the tie. Over tightening will create stress points that can cause the conductors to fail prematurely. Never tighten the cable tie to the point where the cable jacket becomes deformed or pinched (Figure 1).

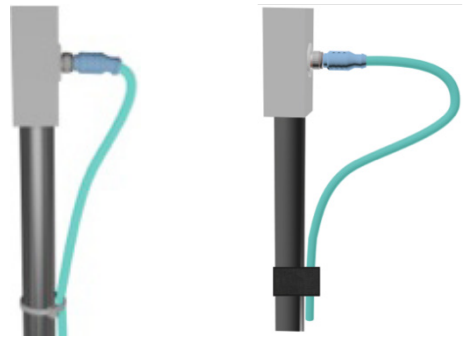


Incorrect **Correct**

Figure 1

Eliminating Stress Points in Cable Dress

Installing cables to allow for adequate stress loops and freedom of motion will increase the life of the cables. Turck cordsets incorporate molded strain reliefs that will assist in preventing stress (Figure 2).

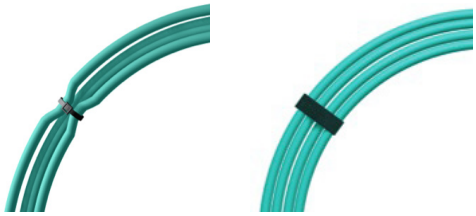


Incorrect **Correct**

Figure 2

Eliminating Stress Points in Cable Bundling

When bundling several cables together, always keep the bundle loose enough to move within itself. Tightly tied bundles create both compression and tension stress when the bundle is moved (Figure 3).



Incorrect **Correct**

Figure 3

Field Wireables

For some installations, it may be very nearly impossible to not use field terminations, but whenever possible, if a pre-molded connector can be used, it should be. The vast majority of commissioning errors occur due to field wiring. It takes a lot of practice (and errors) to excel at field terminating either RJ45s or M12s for Industrial Ethernet. Maintaining the twisted pairs and correctly terminating the shield on a field wireable can also add significant time to the initial setup of a network. The use of molded connectors, which are 100% tested at the factory (even certified tested for Category performance, upon request), can save significant setup and trouble-shooting time when commissioning a network.

Communication Protocol

The term "Ethernet" refers to the lower-level communication structure. Various versions, or implementations, of Ethernet are available, such as EtherNet/IP, PROFINET, and Modbus-TCP. It is important to note that while all of these different specifications use nearly the same physical communication method and can operate on the same cable simultaneously, they cannot necessarily communicate with each other. For example, Modbus-TCP devices cannot communicate with EtherNet/IP devices because the messages and communication protocol have been defined differently for these systems, even though the physical media structure is the same.

	2-Pair	4-Pair
EtherNet/IP	440, 441, 442, 443	Available, but not commonly used
PROFINET	421, 423	Available, but not commonly used
Modbus TCP	Available, but not used commonly used	840, 841, 842, 843
EtherCAT	441, 443, 4413	-

Commonly used Turck cable types for the major protocols

EtherNet/IP™ is a communication protocol supported by the ODVA for use in industrial automation and process control environments. It takes the Common Industrial Protocol (CIP) and implements it onto the foundation of Ethernet. CIP envelops a wide-ranging suite of messages and services for a variety of applications, including safety, control, configuration and information. EtherNet/IP provides users with tools to deploy standard Ethernet technology for industrial applications.

EtherNet/IP is very flexible with star, tree or line topology, but using managed switches is preferred in industrial applications. The use of managed switches allows the network to be configured to perform as close as possible to a real-time behavior that is often required in

industrial applications.

The physical layer is defined in Ch 8 of the "EtherNet/IP Adaptation of CIP", which includes specifications for the cables and connectors. This spec includes the D-code M12, X-code M12, and industrialized RJ45 (8P8C) as suitable connectors for EtherNet/IP. The spec defines component performance up to 100 Mbps, which means only two pairs are required (one pair for Tx, one for Rx). A four pair cable can be used, as long as all conductors are correctly terminated. CAT 5e cable is recommended; teal is a common jacket color, though the spec does not have a firm requirement. The conductor colors follow the T568 standard.

Per the ODVA, either shielded or unshielded cable can be used. When using shielded cable, the ODVA recommends tying shield to earth ground at one end only (typically, at the switch or panel, not the active device) to prevent ground loops. For in depth details on grounding methods, refer to the "ODVA Media Planning and Installation Manual".

Modbus TCP is the Modbus RTU protocol with a TCP interface running on Ethernet. Modbus is managed by the Modbus-IDA User Organization. TCP refers to Transmission Control Protocol, which provides the transmission channel for Modbus TCP messaging. Modbus TCP is used often in the industrial environment due to its ease of deployment and maintenance, and because it was developed specifically for industrial applications.

Modbus TCP can be used with star, tree or line network topology and can be implemented with Ethernet technology that has been adapted for use in the industrial environment.

Unlike EtherNet/IP, there is no specification for the physical layer media to use with Modbus TCP. Regardless, the devices designed for Modbus TCP utilize nearly identical cable and connectors as for EtherNet/IP: D-code M12, 8-pin M12 (A-code), and industrial RJ45s. Performance is intended for up to 100 Mbps with a two pair cable, so a minimum of CAT 5 is required; cable typically has a teal jacket color, and conductor colors follow the T568 standard. The cable can be shielded or unshielded. It is also recommended to tie shield to earth ground at one end only, to prevent ground loops.

PROFINET™ is a communication protocol managed by PROFIBUS and PROFINET International (PI) based on the open Ethernet standard. PROFINET features a modular design structure allowing users to select the cascading functions, including standard TCP/IP for applications not requiring real time performance, Real Time (RT) for applications requiring the transfer of critical information, and Isochronous Real Time (IRT) for applications using functionality like motion control.

PROFINET can be used with line, ring, star and tree network topology and uses Ethernet technology that has been adapted for use in industrial environments.

The media for PROFINET is detailed in "PROFINET Cabling and Interconnection Technology: Guideline for PROFINET". The same connectors used for EtherNet/IP are also used for PROFINET: the D-code M12, X-code M12, and industrial RJ45. The cable requirements are different, though. A minimum of CAT 5 cable is recommended; it can be solid or stranded. A two pair cable is 22 AWG, and a four pair cable can be 22-24 AWG. PROFINET does not allow for unshielded cables.

PROFINET utilizes equipotential bonding, to minimize the impact of electromagnetic interference. This requires connecting the cable shield to ground at both ends of a cordset (typically via shield tied to the coupling nut). Detailed explanation of grounding a PROFINET network can be found in the "PROFINET Installation Guideline for Cabling and Assembly".

PROFINET should never be more than 100 Mbps, so CAT 5 cable is sufficient . The cabling can consist of 2-pair or quad and be type A, B, or C.

Type A: Stationary with no movement after installation (Solid Cable).

Type B: Flexible, occasional movement or vibration.

Type C: Special applications including highly flexible, permanent movement, vibration or torsion.

Note: Turck PROFINET cable 423 is designed for use in both type B and type C applications, and is suitable for use in type A applications. This can be an added benefit to customers looking to minimize their inventory and simplify Bill of Materials.

EtherCAT™ is a communication protocol managed by the EtherCAT Technology Group (ETG). The technology uses a clear master/slave communication model.

EtherCAT is often referred to its ability to process data "on the fly." Unlike other Industrial Ethernet protocols, the master sends out a single message with data for all nodes. The message transmits to a following node while data is processed by the previous node. In this way, it maximizes use of bandwidth available, providing increased speed.

Also, unlike other Industrial Ethernet protocols, EtherCAT does not require the use of external switches or routers. EtherCAT devices use an embedded switch.

EtherCAT can be used with line, tree and star network topology.

An overview of EtherCAT media is detailed in "Infrastructure for EtherCAT/Ethernet". A minimum of CAT 5 cable is recommended. Again, communication is available up to 100 Mbps, so only two pairs (four wires) are needed. Cable can be solid or stranded. Similar to PROFINET, EtherCAT requires shielded cables only, and shield should be terminated to ground at both ends. EtherCAT utilizes the D-code M12, four pin M8, and industrial RJ45s.

Network Topology

Network topology is the physical arrangement of the components used in the layout of a network including devices and cabling.

A **Star topology** consists of each network node being connected to a central location (usually a switch) using a point-to-point connection (Figure 4). The physical layout of the network does not need to look like a star but rather each node must be connected to one central point. A star topology is the most common topology used because one faulty node does not cause an entire line to experience downtime.

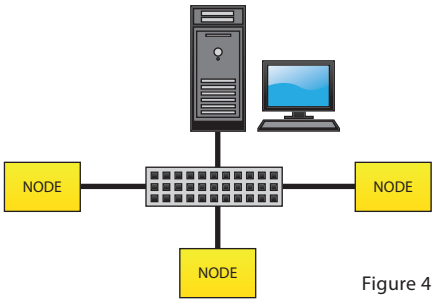


Figure 4

A **Line topology** is a network where each node is connected to a main line or trunk. The information travels in both directions to all nodes connected on the line until a match for the information is found (Figure 5). A line topology is typically used by integrators or by applications where low cost is a determining factor because it costs less to install than the other topologies.

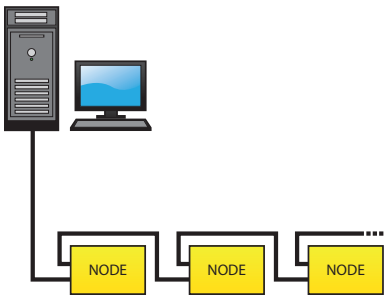


Figure 5

A **Ring topology** is a network that is connected in a circular fashion where data primarily travels in a single direction (Figure 6). In this topology, every node is critical as data travels through each device in the ring until it reaches the destination. It is not as commonly used as the other topologies as it often requires more cabling.

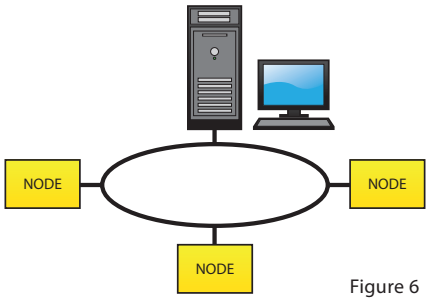


Figure 6

A **Tree topology** is a network that consists of a hierarchy of nodes. The first level in a network tree consists of a single node, also called a root (Figure 7). This node is then connected to either an additional single node or multiple nodes in a lower level in a point-to-point manner. The lower levels then connect in a similar manner. A tree topology is typically used by applications where frequent node additions are expected, as it provides for easy expansion.

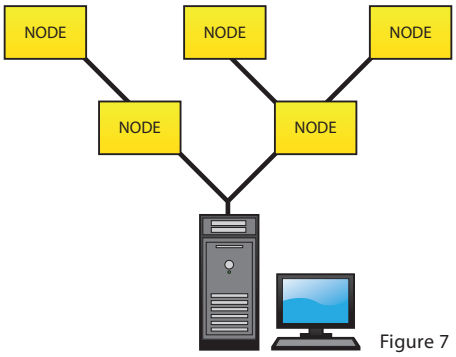


Figure 7

Summary

Ethernet technology will continue to evolve in providing faster transmission rates required by robotics and motion controls. Factory floor Industrial Ethernet requires special attributes for environmental conditions, including noise, oil and chemical exposure, motion, and temperature fluctuation. Referencing to resources including this guide will help ensure optimal system integrity and performance. Adhering to recommended installation lengths between hubs and device level will keep systems troubleshooting to a minimum.

Turck Industrial Ethernet: Bulk Cable

Type	Approvals	Data Pair AWG Color Code	Outer Jacket Material Color Nominal O.D.	Shields Type	Bulk Cable Part Number/ Weight/300 M	Flexlife Ratings
440 80 °C, 600 V	c(UL)us Type CM AWM	2UTPx24 AWG Stranded	TPE Teal 6.1 mm (.240 in)	-	RF51210 21 lbs. Flexlife	10xO.D. 1 million cycles 20xO.D. 10 million cycles
441 80 °C, 600 V	c(UL)us Type CM AWM	2UTPx24 AWG Stranded	TPE Teal 6.7 mm (.265 in)	Foil/Braid	RF51211 30 lbs. Flexlife	10xO.D. 1 million cycles 20xO.D. 10 million cycles
442 80 °C, 600 V	c(UL)us Type CM	2UTPx24 AWG Solid	TPE Teal 6.1 mm (.240 in)	-	RF51212 18 lbs.	-
443 80 °C, 600 V	c(UL)us Type CM AWM	2UTPx24 AWG Solid	TPE Teal 6.9 mm (.270 in)	Foil/Braid	RF51213 30 lbs.	-
421 80 °C, 600 V	UL ITC, PLTC AWM	2UTPx22 AWG Solid	TPE Green 7.8 mm (.305 in)	Foil/Braid	RF51604 49 lbs.	-
423 80 °C, 600 V	UL ITC, PLTC AWM	2UTPx22 AWG Stranded	TPE Green 8.1 mm (.317 in)	Foil/Braid	RF51216 49 lbs. Flexlife	10xO.D. 1 million cycles 20xO.D. 10 million cycles
840 80 °C, 600 V	c(UL)us Type CM AWM	4UTPx24 AWG Stranded	TPE Teal 6.3 mm (.118 in)	-	RF51460 29 lbs. Flexlife	10xO.D. 1 million cycles 20xO.D. 10 million cycles
841 80 °C, 600 V	c(UL)us Type CM AWM	4UTPx24 AWG Stranded	TPE Teal 7.7 mm (.303 in)	Foil/Braid	RF50893 43 lbs. Flexlife	10xO.D. 1 million cycles 20xO.D. 10 million cycles
842 75 °C, 300 V	c(UL)us Type CM	4UTPx24 AWG Solid	TPE Teal 6.1 mm (.240 in)	-	RF51462 26 lbs.	-
843 80 °C, 600 V	c(UL)us Type CM AWM	4UTPx24 AWG Solid	TPE Teal 7.3 mm (.287 in)	Foil/Braid	RF51463 41 lbs.	-

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