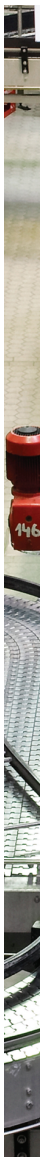
Network Overviews

The Network Overview Guide endeavors to provide a high level overview of the common network protocols supported by TURCK Distributed I/O. Each network overview gives a summary of the key specifications for that protocol. The overviews provide standard network topologies, maximum ratings and physical media options to educate on basic design and product selection.



Ethernet

At-A-Glance

What is it?
Industrial Ethernet is the result of applying traditional Ethernet standards for data communication to industrial applications

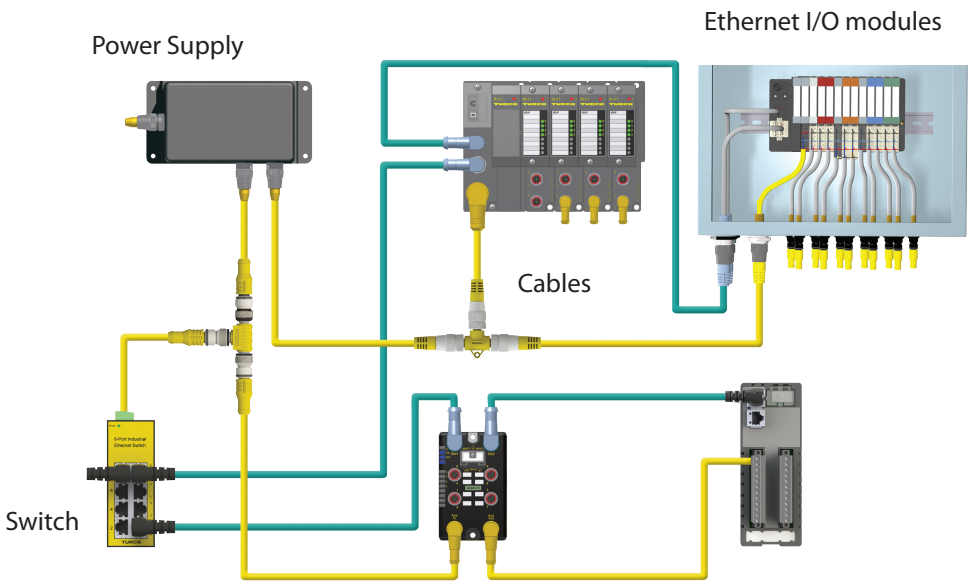
What are its basic components?
I/O slaves (Servers), masters (Clients), communication cable and power supply and cable

Where is it used?
Industrial automation, mobile equipment, transportation, medical, military and PLC to PLC communication

Who is responsible for it?
Ethernet physical layer is standardized in IEEE 802.3. Application layers like EtherNet/IP, PROFINET and Modbus TCP are open standards with independent governing bodies.

Overview

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. Industrial Ethernet is primarily used to connect PLCs, computers, HMI displays and other high-level components. 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 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 electrical structure is the same.



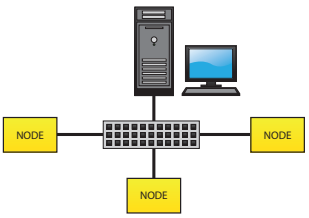
Basic Parts List

A typical system consists of the following parts:

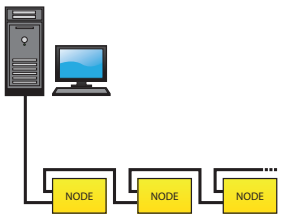
- Power Supply
- Ethernet I/O modules
- Cables
- Switch

System Configuration

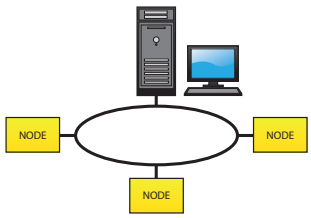
Ethernet I/O modules act as servers on a network. A client device is needed to retrieve data from and post data to the server. This is analogous to an office network, where the client PC on a user's desk may actively connect with multiple servers to access information in different areas of the enterprise. TURCK industrial Ethernet stations are designed to be fully compatible with established Ethernet standards for industrial use.
There are a variety of topologies that can be used for Ethernet configuration such as star topology, line topology and ring topology:



STAR TOPOLOGY



LINE TOPOLOGY



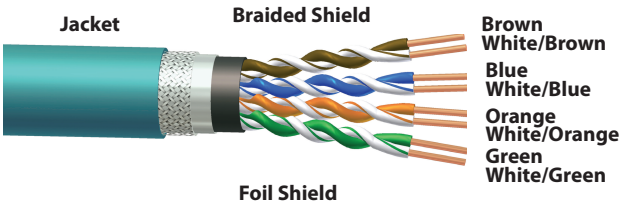
DEVICE-LEVEL RING (DLR) TOPOLOGY

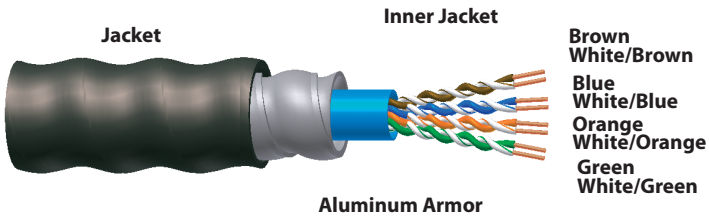
Addressing

Industrial Ethernet stations use the IP addressing scheme. An address defined by this scheme consists of four byte values usually displayed in decimal form, for example, 192.168.1.254. Various classifications of networks require different portions of this address to be constant for all devices on the network (referred to as a "subnet"). This means that the number of stations allowed on a particular network varies depending on what class of subnet is being used. If the first three bytes of the IP address are constant (which is common), then the remaining byte may be addressed between 2 and 254, resulting in 253 possible addresses.

Maximum Ratings

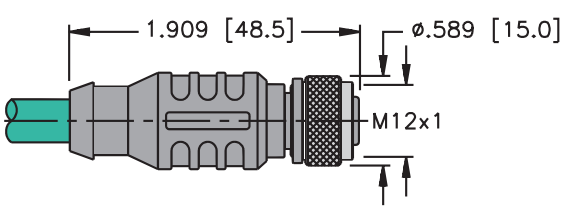
Ethernet allows different maximum cable lengths depending on the type of cable being used. Generally, an Ethernet segment may be as long as 100 m, where 90 m must be solid core cable and the remaining 10 m can be stranded patch cords.



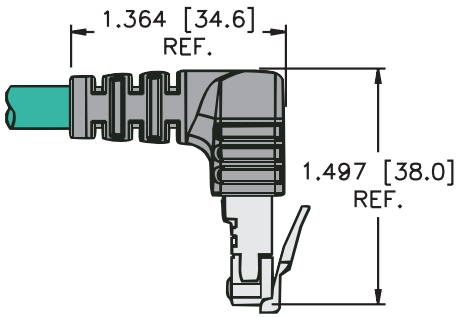


Cordsets

TURCK offers a complete line of molded Ethernet cordsets to facilitate network installation, resulting in faster start-up and fewer wiring errors. Cables are available with stranded or solid-core conductors, and with or without shielding. Most TURCK Ethernet equipment uses the 4 or 8-pin (M12) eurofast® connector specifications. These connectors provide a tough, rugged seal and are IP67-rated. In some cases, (mainly in the control cabinet) a traditional RJ45 Ethernet connector needs to be used. TURCK provides RJ45 cordsets, as well as a variety of devices made to convert between RJ45 and eurofast connectors. TURCK cordsets for the Ethernet system are available in standard lengths, in addition to custom lengths through the company's sales representatives.



eurofast **connector**



RJ45 connector

Diagnostics

Industrial Ethernet stations support diagnostics information, which is based on their complexity and functionality. The common ground for all devices is that they provide visual diagnostic information using either a pair of status LEDs called MOD and NET LEDs or a single combined MOD/NET LED. Industrial Ethernet stations may also include an embedded webserver that can be accessed by a web browser, such as Internet Explorer. This embedded webserver can be accessed to provide diagnostic information anywhere in the world. TURCK discrete IO modules provide diagnostic data as a part of input data map. Standard stations support group diagnostics, where a single alarm bit is set if any IO is faulted. Deluxe station support individual IO diagnostic data, including open wire and short wire alarm bits.

EtherNet/IP

Overview

EtherNet/IP is a communication protocol supported by the ODVA and is designed for use in industrial automation and process control applications. 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.

Supported Features:

- ACD – Address Conflict Detection – This supported feature will detect if another device on the network has the same IP address. If a conflict is detected, the device will go into a recoverable fault state and set the status LEDs to indicate a fault
- DLR – Device Level Ring – Device Level Ring (DLR) is a fault tolerant network allowing continuous system operation when a single fault occurs in the end node, its network interface or cable system. The adoption of an integrated Ethernet switch in the multiprotocol products allows support for DLR across all product families
- Quick Connect

Addressing Options:

- Rotary Mode – IP address is preconfigured
- Programmable
- Webserver
- Boot-P
- DHCP

Configuration Options:

- Generic Ethernet Device – Standard setup of Ethernet products in Logix 5000 that are not Rockwell made products
- EDS support – Contrologix v20 and Omron
- CIP Bridge – Allen Bradley PLCs only – This features allows total setup and configuration of supported multiprotocol products within the Rockwell software (Logix 5000)
- IO Assistant –This free software is a FDT/DTM based technology for engineering, configuring, commissioning and diagnosing multiprotocol products

PROFINET

Overview

PROFINET is a communication protocol that was developed by Siemens and the PROFIBUS User Organization (PNO) 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.

Supported Features:

- Fast start-up
- GSDML file support
- Topology detection support
- Automatic address assignment – LLDP
- GSDML function configuration

Addressing Options:

- Rotary mode
- PROFINET name assignment
- Programmable
- DNS-PGM – (x600)
- Webserver

Configuration Options:

- The PROFINET cordset line offers both M12 Ethernet D-coded and RJ45 connector options, allowing users the option to mix-and-match any connector combination to meet unique application needs

MODBUS TCP/IP

Overview

Modbus TCP/IP is the Modbus RTU protocol with a TCP interface running on Ethernet. Modbus was originally designed by Modicon (Schneider Electric) and is now managed by the Modbus-IDA User Organization. TCP/IP refers to Transmission Control Protocol and Internet Protocol, which provides the transmission channel for Modbus TCP/IP messaging. Modbus TCP/IP 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/IP 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.

Supported Features:

- Bit register and function codes
- 6 parallel Modbus connections
- PACTWARE FDT/DTM configuration and mapping
- Embedded webserver for diagnostics and configuration

Addressing Options:

- Rotary mode – IP address is preconfigured
- Programmable
- Webserver
- Boot-P
- DHCP

Configuration Options:

- Controllers can be setup to communicate on standard Modbus networks using either of two transmission modes: ASCII or RTU
- Users select the desired mode, along with the serial port communication parameters (baud rate, parity mode, etc.), during configuration of each controller

TURCK Multiprotocol

Overview

TURCK provides a complete line of industrial Ethernet products, including on-machine, in-cabinet, block, and modular I/O. The most recent innovation is the Multiprotocol Industrial Ethernet concept. TURCK's innovative approach to industrial Ethernet I/O makes moving from another protocol, or simply implementing a fieldbus for the first time, plug-in simple. TURCK's Multiprotocol products are self- configuring and offer a seamless transition to Ethernet, whatever Ethernet that may be.

1 Device = 3 protocols

- Ethernet/IP, PROFINET and Modbus TCP/IP
- Gateway (slave) recognizes the master upon power-up and self-configures for master protocol
- Supports ODVA quick-connect and Device Level Ring (DLR)
- PROFINET options include: PROFINET RT, and PROFINET Fast Start-up (FSU)
- PROFINET IRT available in standard product configuration
- Embedded web server for device configuration and diagnostics

Notes:

PROFIBUS®

At-A-Glance

What is it?
PROFIBUS® is an industrial network protocol that connects field I/O devices in order to eliminate hard wiring.

What are its basic components?
Master, slaves, communication cable, power supply and power cable (PROFIBUS-DP)

Where is it used?
Machine control applications, process and hazardous area situations

Who is responsible for it?
PROFIBUS is maintained by the international governing body: PI (PROFIBUS & PROFINET INTERNATIONAL)

Overview

PROFIBUS® is an industrial network protocol that connects field I/O devices in order to eliminate hard wiring. The network connection increases device-level diagnostic capabilities, while also providing high-speed communication between devices.

PROFIBUS-DP

PROFIBUS-DP is the version of PROFIBUS that is generally used for factory automation and machine control solutions. It is based on the RS-485 serial data transfer standard. In most cases, the termination and physical media rules for PROFIBUS-DP are the same as those required for RS-485 communication. A PROFIBUS-DP network supports up to 126 nodes and virtually an unlimited variety of I/O. The bus uses a trunkline/dropline topology. Power and communication are provided via separate cables, allowing easy segmentation of the power structure to avoid overloading.

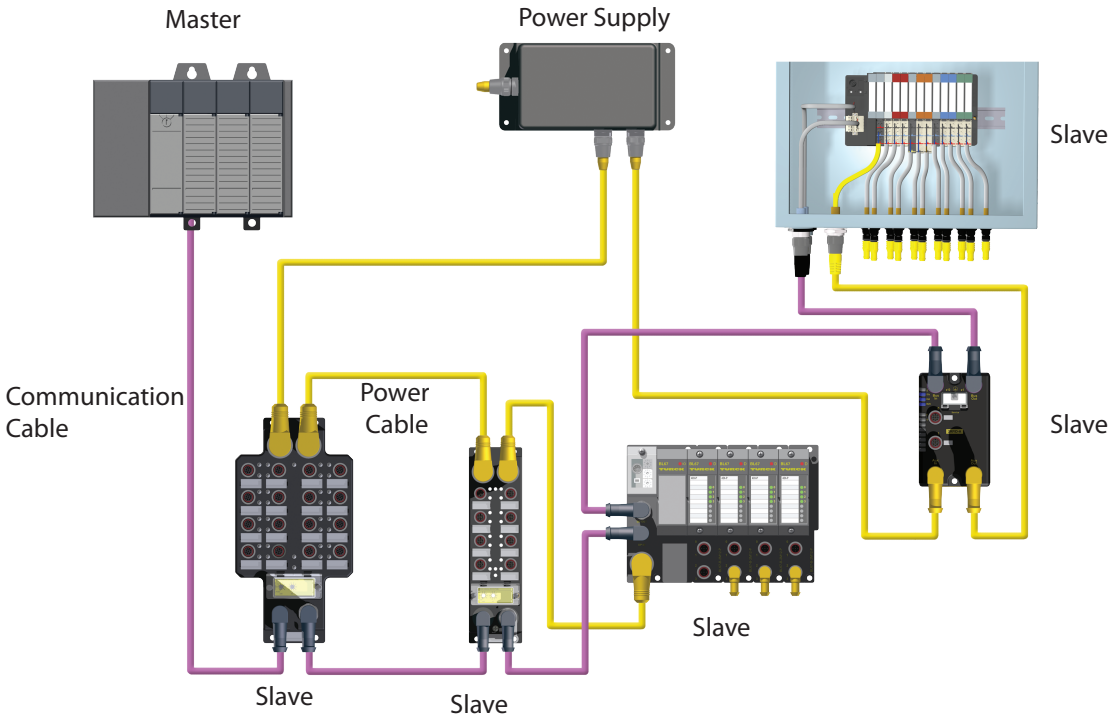
PROFIBUS-DP is capable of running at data rates as high as 12 Mbaud. When used at high data rates, the cable drop length from the trunk to a node is severely limited. For example, when used at 12 Mbaud, nodes must be directly connected to the trunk, with no drop length allowed.

Although PROFIBUS-DP is well suited to machine control applications, it is also useful for process and hazardous area situations (in fact the name PROFIBUS is an abbreviation of Process Field BUS). TURCK's excom system allows connection from a PROFIBUS-DP network directly to I/O devices in classified areas, resulting in a huge potential savings on barriers and wiring.

PROFIBUS-PA

PROFIBUS-PA is another version of PROFIBUS, designed for hazardous area usage though it may also be used in non-hazardous areas due to a variety of reasons such as topology and device parameterizations. It operates as an extension from the PROFIBUS-DP system. Using the same media specification as FOUNDATION™ fieldbus (IEC 61158-2), it allows network communication directly in hazardous areas. All devices on a PROFIBUS-PA system are controlled by the PROFIBUS-DP master. The conversion from DP to PA is accomplished by a linking or gateway device, which converts from the high speed RS-485 DP communication to the lower speed (31.25 kbps) IEC 61158-2 communication required for PROFIBUS-PA. The logical communication structure is identical between the systems; only the physical media is different.

A typical PROFIBUS-PA network, connected to a higher-level PROFIBUS-DP system



PROFIBUS® Structure

A typical PROFIBUS system consists of the following parts:

- Master
- Slaves
- Communication cable
- Power supply
- Power cable (PROFIBUS-DP)

PROFIBUS stations require a network master (also called a scanner) to interface the stations to the host controller. TURCK PROFIBUS-DP stations are designed to be fully compatible with PROFIBUS-DP equipment from other manufacturers.

Communication Rate/Cycle Time

PROFIBUS-DP specifications define multiple transmission speeds ranging from 9.6 kbaud to 12 Mbaud. All nodes on a network must communicate at the same rate. The complete cycle time of a PROFIBUS-DP system is affected by several factors:

- Number of nodes being scanned
- Amount of data produced and consumed by the nodes
- Network communication rate
- Cycle time of the control program
- Number of masters present

All of these factors must be considered when calculating the cycle time of a particular network.

Maximum Ratings

The PROFIBUS-DP bus uses a trunkline/dropline topology. The trunk is the main communication cable and requires the appropriate RS-485 active termination at both ends of the network. Active termination requires a bias voltage, typically supplied by the network nodes, to function. Turck offers these terminating resistors as a plug-in eurofast(R) unit or built into their D9 connectors. If terminating at the end of the cable in desired, Turck offers a special Terminating resistor in an IP67 form factor that can be supplied externally with this bias voltage.. The length of the trunk depends on the communication rate. Drops or branches off the trunk are allowed, but are greatly limited as the communication rate increases. The table shows the maximum ratings for a PROFIBUS-DP trunk at different communication rates.

COMMUNICATIONS RATE	MAX. SEGMENT LENGTH
9.6 kbps	1200 m
19.2 kbps	1200 m
93.75 kbps	1200 m
187.5 kbps	1000 m
500 kbps	400 m
1.5 Mbps	200 m
12 Mbps	100 m

PROFIBUS-PA has the same physical limitations as FOUNDATION fieldbus, identified in this table

CABLE	NUMBER OF DEVICES	MAXIMUM SPUR LENGTH
Trunk	25-32	0 m (0 ft.)
	19-24	30 m (98 ft.)
	15-18	60 m (197 ft.)
1900 meters	15-18	60 m (197 ft.)
	13-14	90 m (295 ft.)
	2-12	120 m (394 ft.)

Diagnostics

TURCK network stations provide increased diagnostics over using traditional hard-wired I/O systems. TURCK stations also serve as a buffer between I/O devices and the PROFIBUS-DP network by detecting short circuits without disrupting communication. The PROFIBUS-DP system includes a provision for special diagnostic data messages. These messages are triggered when a fault occurs at the station (for example a short circuit on a sensor). When the master asks the station for data, the station responds and includes a flag to indicate that diagnostic data is present. The master then asks for the diagnostic data, which is mapped to a special location in the controller's memory.

Addressing

The valid range of PROFIBUS node addresses is 0 to 125. TURCK station's addresses are usually set via rotary dials or switches on the node. Changes to the address settings take effect when the station power is cycled or when the station receives a software reset. Care must be taken to prevent the same address from being assigned to more than one node in a system. Bihl+Wiedemann PROFIBUS-DP to AS-i gateways addresses are set in software using the on-unit display.

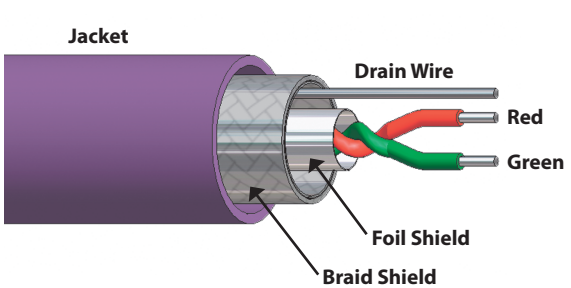
Cordsets

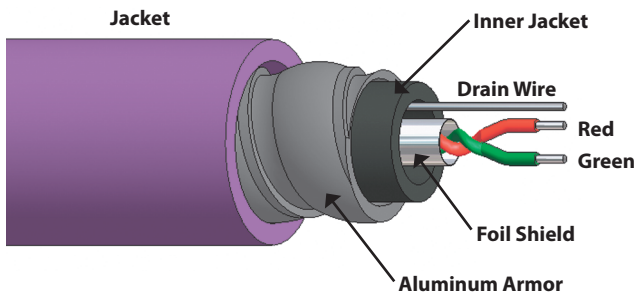
TURCK offers a complete line of molded PROFIBUS-DP and PROFIBUS-PA cordsets to facilitate network installation, resulting in a faster start-up and fewer wiring errors. The bus and drop cables are specially designed foil-shielded, high-flex cables with very low inductance and capacitance to minimize propagation delay time. PROFIBUS-DP cables consist of a shielded and twisted data pair with a bare drain wire. PROFIBUS-PA cables feature a shielded, twisted pair for data and bus power and a drain wire.

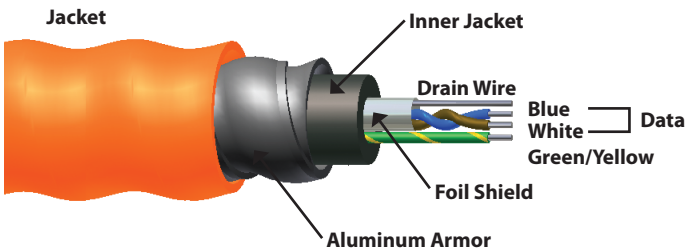
In most cases, connections of the bus cable to the stations are made using 5-pin reverse-key *eurofast* (M12) connectors for PROFIBUS-DP. A variety of stations are also available that support D9 type connections. Power for most stations is provided through one or two 5-pin *minifast*® (7/8-16UN) connectors.

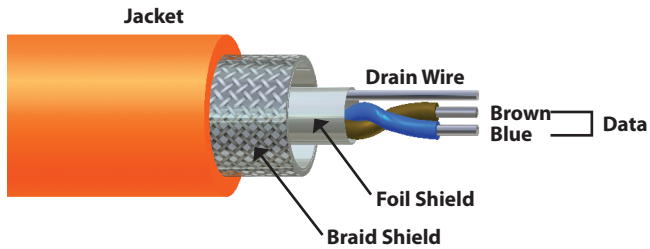
PROFIBUS-PA connections are typically made with minifast style connectors, though eurofast connections are available as well.

TURCK cordsets for the PROFIBUS system are available in standard lengths. Please contact your local sales representative to order custom lengths.









GSD Files

GSD files contain detailed information about a PROFIBUS-DP device, including I/O data size and the devices configurable parameters. The information in a GSD file, when used with a PROFIBUS-DP configuration tool, guides a user through the steps necessary to configure a device.

FOUNDATION™ Fieldbus

At-A-Glance

What is it?
FOUNDATION fieldbus is an all-digital, serial, two-way communications system for use in applications using basic and advanced regulatory control

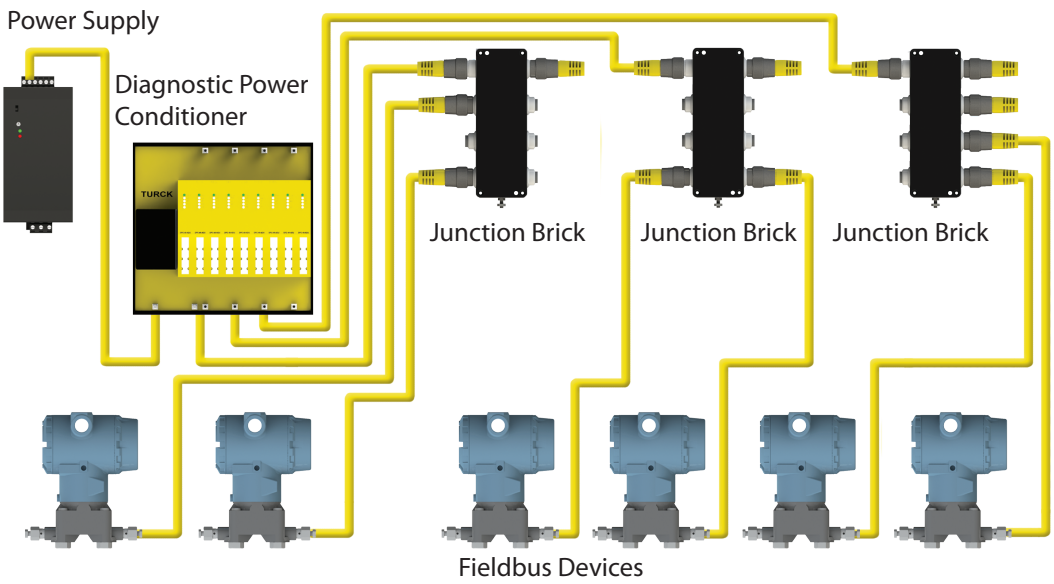
What are its basic components?
H1 fieldbus interface card, fieldbus power supply and signal conditioner, bulk power (Vdc) to fieldbus power supply, terminator and fieldbus devices

Where is it used?
Plant automation, factory automation, basic and advanced regulatory control, discrete control, process industries, power plants

Who is responsible for it?
FOUNDATION fieldbus is an open architecture, developed and administered by the Fieldbus Foundation

Overview

FOUNDATION™ Fieldbus is an all-digital, serial, two-way communications system for use in applications using basic and advanced regulatory control. TURCK's diagnostic power conditioner (DPC) system stores and monitors information concerning the components of the control system and field devices. Information on assets that make up the communication infrastructure (physical layer components) have been simply stored in an asset management system. With the DPC system, the physical layer components are continuously monitored providing virtually instantaneous information regarding the quality and the status of the communication link. This aspect of the system is the key to achieving the main objective of asset management to minimize maintenance and lower system operating costs.



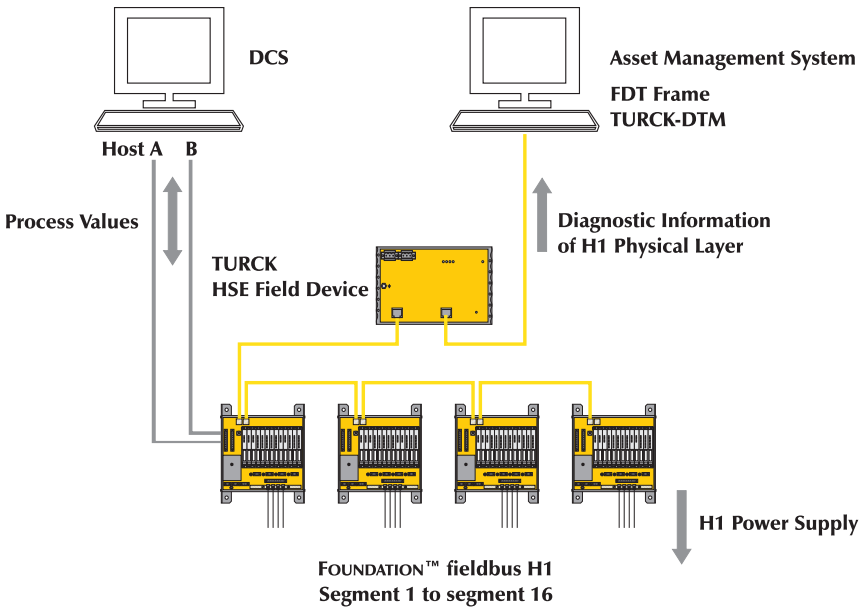
Basic Parts List

A typical system consists of the following parts:

- Power supply
- Diagnostic power conditioner
- Junction bricks
- Fieldbus devices

System Configuration

TURCK has drastically improved on existing physical layer components for use in FOUNDATION fieldbus applications. The introduction of the DPC system allows the continuous monitoring of every physical layer component, thus treating the entire physical layer as an asset and providing the means for it to be managed as such.



The DPC System detects errors that may develop over an extended period of time or through typical failure modes. These changes can occur due to many factors, such as environmental changes, deterioration of components over time and any other factors that may affect the physical components of a fieldbus segment. Some of these factors may appear as changes in jitter, hum, noise levels etc. Alarm strategies may be employed that will warn of typical asset errors, potential errors or failures. Preventive measures can be implemented well in advance of a potential system failure. Most common failures can be completely avoided when a preventive maintenance schedule is implemented.

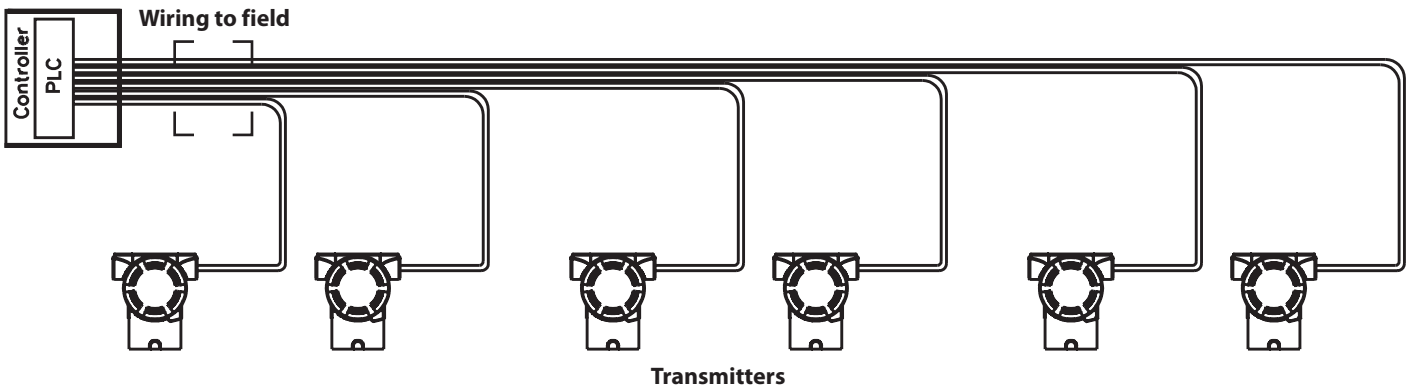
The DPC system also supports the set-up of fieldbus assets by using expedient localization of error sources, as well as documentation indicating a "good condition" of the segment structure.

The DPC system provides an option for redundant segment supplies. The system, fully loaded, can accommodate up to 16 fully redundant FOUNDATION fieldbus segments each with an output of 800 mA and 30 VDC. Diagnostic date is available via a DTM, standard FOUNDATION fieldbus function block libraries or an embedded web server in the HSE field device.

FOUNDATION™ Fieldbus

Conventional Control System

In a traditional control system, I/O devices in the field are individually wired to a central controller, which is responsible for all control function processing in the system. This type of system typically consumes a lot of physical space (due to the amount of wire and the number of I/O cards in the PLC or DCS) and requires a lot of design and labor to install. Additionally, finding errors in this kind of system can be very time consuming because of the number of possible error points (each physical wire termination).

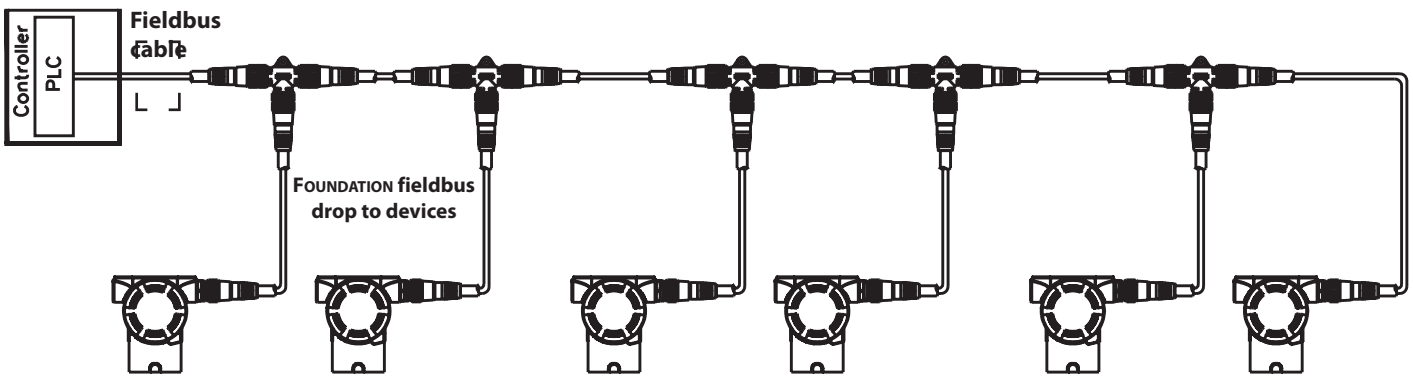


FOUNDATION™ Fieldbus System

In the fieldbus system, the I/O devices are wired to a trunk line (segment) using tee connectors or multi-drop boxes. Rather than separate pairs of wires carrying data to and from each I/O device, the devices use a common pair of wires for communication, with each having a turn to "talk" on the network. Instead of performing all the control functions in the host, the FOUNDATION fieldbus system allows for control blocks to be executed in the field devices themselves, creating an efficient, high integrity system. One device on the network is responsible for scheduling communication between the various devices on the system. This is called the Link Active Scheduler (LAS). It can be the host interface or a device in the field. In most FOUNDATION fieldbus systems at least one backup LAS is defined as well. This allows communication and control to continue in case the original LAS device fails. Most FOUNDATION fieldbus devices are powered completely from the network supply. In some cases a device may draw enough current to make it impractical to power it from the network. In these cases the device is typically powered from a separate (auxiliary) supply.

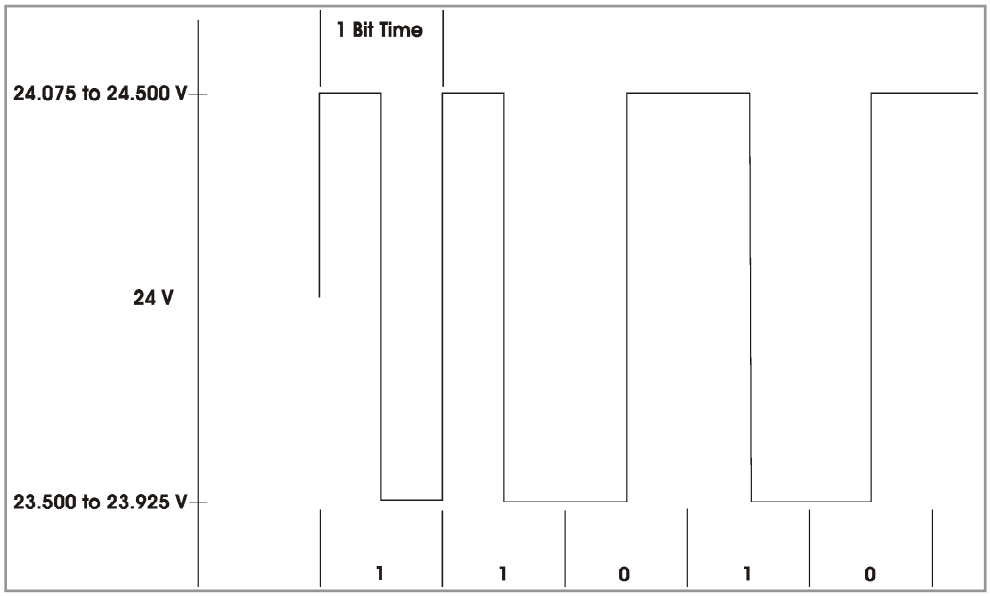
Another key benefit of using FOUNDATION fieldbus is the ease of adding I/O devices to the system in the future. Because it is a serial bus where all devices use the same wires for communication, a device can be added by simply splicing it onto the network. This eliminates the need to pull a new wire pair all the way back to the controller.

FOUNDATION fieldbus devices also typically include a multitude of parameters and diagnostic information, all accessible over the network. Advanced diagnostics and maintenance scheduling are made much easier with this feature.



Communication Signal

The FOUNDATION fieldbus H1 communication signal is a square waveform superimposed on a DC carrier. The frequency of the signal is 31.25 Khz. Although it is not a requirement, most devices derive their supply power from the fieldbus communications cable. The fieldbus specification states that devices must not be polarity sensitive. However, it is good electrical practice to have all devices wired with the same polarities. The voltage range allowed for proper operation is 9 to 32 VDC. A typical fieldbus device will consume 20 mA of current.

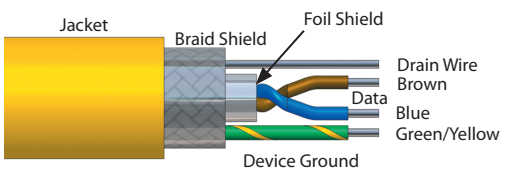


Idealized FOUNDATION fieldbus communication signal

Fieldbus Cable Specifications

The specifications for fieldbus H1 physical media are defined by IEC 61158-2 and the ISA-S50.02 Part 2 Physical Layer Standards. The same standard is also listed in the FOUNDATION fieldbus specifications under 31.25 Kbps Physical Layer Profile FF-816-1.4. There are essentially four types of cable designations for fieldbus. Type A cable preferred for new installations, because it allows for the most versatile lengths. The other cable types are for installations where cable already exists from 4-20 mA systems. See table 1.

TYPE	CABLE DESCRIPTIONS	CONDUCTOR SIZE	MAXIMUM LENGTH
Type A	Shielded, Twisted Pair	18 AWG	1900 m (6232 ft.)
Type B	Shielded, Multi Twisted Pair	22 AWG	1200 m (3936 ft.)
Type C	Unshielded, Multi Twisted Pair	26 AWG	400 m (1312 ft.)
Type D	Shielded, Untwisted Pair	16 AWG	200 m (656 ft.)



TURCK offers type A cables with both two conductors and three conductors, with the third conductor available for a centralized ground of devices if needed. TURCK cables meet or exceed the specifications of ANSI/ISA-SP50.02-1992, the fieldbus standard for use in industrial control systems. The maximum spur length is determined by the number of devices in the segment.

CABLE	NUMBER OF DEVICES	MAXIMUM SPUR LENGTH
Trunk	25-32	0 m (0 ft.)
	19-24	30 m (98 ft.)
	15-18	60 m (197 ft.)
1900 meters	15-18	60 m (197 ft.)
	13-14	90 m (295 ft.)
	2-12	120 m (394 ft.)

Termination

The FOUNDATION fieldbus communication signal requires that each end of the system be terminated with a 1 µF capacitor in series with a 100 W resistor across the communication lines. This termination must be installed at each extreme end of the network segment. Do not use more than two terminators on a communication segment.

Hazardous Area Usage

FOUNDATION fieldbus networks may be used in hazardous areas as long as required energy limitations for the specific area are observed. One way to achieve this is to use the "entity" concept, which requires the network designer to calculate the voltage and current requirements for each device and determine the system limitations. A simpler option is to use the Fieldbus Intrinsic Safety Concept (FISCO) or Fieldbus Non-Incendive Concept (FNICO). These concepts define the limitations required for devices on a network system to be used in a hazardous area (Class I, Div 1 for FISCO and Class I, Div 2 for FNICO). Many newer FOUNDATION fieldbus devices are rated to meet the requirements of FISCO and/or FNICO. As long as the devices used and the power supply are marked with FISCO or FNICO they may be connected together in the appropriate hazardous area. It is important to note that the cabling used must still meet the defined parameters.

Using Connectorization

Plug-and-play connectorization has been standard practice for many years in industries ranging from appliance manufacturers to industrial sensors. These industries have found it necessary to compete in a business climate where speed and consistency of connection is king. Connectorization is the perfect complement to fieldbus systems. The concepts and goals are identical: reduce installation time, reduce troubleshooting and easy expansion. The fieldbus system minimizes point-to-point wiring that can be time-consuming and difficult to troubleshoot. Connectorization takes that one step further, almost completely eliminating troubleshooting. Plants that have implemented plug-and play connectorization claim up to a 75 percent reduction in start-up. This directly translates into real cost savings.

Cost Savings

The initial capital cost is the major factor in selecting a method of connecting devices. These costs include material and installation. The cost of incorporating plug-and-play connectivity will be 10 to 60 percent less. Actual savings will depend on the size and complexity of the installation. Other cost saving factors include reduced design cost, reduced maintenance cost, reduced troubleshooting cost and reduced expansion costs. Some of these cost savings are difficult to determine until the condition exists. However, these costs can quickly change from potential cost savings to real cost savings when the installation begins.

Design Cost Savings

Most projects begin with a rough definition to develop the capital scope and then progress to detailed development. Development of the capital scope is often expressed in terms of segments, transmitters and tanks. The cabling can be expressed in the same way. Each transmitter requires one device gland and one cordset. Each tank requires one tee, one drop cordset and typically one brick. The home run or trunk cable can run in either conduit or cable tray, so either a field wireable tee or a conduit adapter is required at each tank. A terminating resistor is needed at the beginning and end of the network. A simple estimated bill of materials can be developed as follows:
For: 4 segments, 50 transmitters, 10 tank process

DESCRIPTION	PRODUCT NUMBER	QUANTITY
Device Glands	RSFV 49-0.3M/14.5	50
Cordsets	RSV RKV 490-6M	60 (50 Transmitters + 10 Drops)
Multiport Bricks	JBBS-49SC-M613	10
Field Wireable Tee	SPTT1-A49	10
Terminating Resistor	RSV-49-TR	8
Bulk Cable	CABLE, 490-300M	1

Often for estimating purposes, an average length of cordset and segment length is assumed. In this example, 6 m (20 ft.) cordsets and four 75 m (250 ft.) segments are estimated. The cost and time of coping with continuous changes during the engineering design phase can be very expensive. However, with this model the changes are limited to the length of the cordset and spool of bulk cable. Design changes can even wait until all the transmitters are mounted. Simply taking physical measurements is as valid as any other design method.

Material Costs

The cost of cordsets and bricks will be slightly lower than the cost of termination in enclosures. The plug-and-play junction bricks are IP67 rated (equivalent NEMA 4X). This means they can be mounted indoors or outdoors without any secondary enclosures. A NEMA 4X enclosure can cost anywhere from $75 for steel to $275 for stainless steel. The cost can increase by another $40 to $60 for the design and installation time required to put mounting holes in the enclosure and installing cable glands. A cage clamp style termination block costs $200 to $450 depending on whether is has short circuit protection. The plug-and-play bricks cost only $322 and $486 depending on whether they have short circuit protection. A set of six cordsets costs only $264 (RSV RKV 490-1M)*. The material cost comparison for a stainless steel installation is as follows:

FIELD WIRING	
NEMA 4X box (Hoffman® or equivalent	$ 275
Cage clamp termination block	450
Installation of blocks in box	50
Bulk cable (6 meters)	12
Device gland (1/2 NPT fitting = $8.00)	48
TOTAL	**$ 835**

PLUG AND PLAY	
Junction brick (JBBS-49SC-M613)	$ 486
Cordsets (six RSV RKV 490-1M = $44.00)	264
Device gland (RSFV 49-0.3M/14.5 = $30.30)	181
TOTAL	**$ 931**

A junction brick system that is completely encapsulated for use indoors or outdoors is equivalent to or approximately 10 percent more expensive than a termination block mounted in an enclosure. The real savings are in the speed and ease of installation.

** Costs given are examples only, and are subject to change.*

CANopen

At-A-Glance

What is it?
CANopen is a communication protocol and device profile specification for embedded systems in automation applications

What are its basic components?
Controller, power supply, CAN cable, CANopen I/O nodes and terminating resistors

Where is it used?
Industrial automation, mobile equipment, transportation, medical, military and building automation

Who is responsible for it?
CAN in Automation (CiA), the international users' and manufacturers' organization, develops and supports CAN-based higher-layer protocols

Overview

CANopen is a higher layer open protocol implemented using the CAN (controller area network) lower level protocol. The CANopen standards, as defined by the CiA (CAN in Automation) organization, are split between communication profiles and device profiles. Communication profiles define the various communication mechanisms and objects used within the CANopen environment. Device profiles provide specific requirements for similar device types from different manufacturers to ensure that the implementation of those devices remains consistent.

Components

CANopen utilizes an object based structure. Each node stores I/O and parameter data within index locations mapped in the device's OD (object dictionary), as defined by the device profile. These objects can be accessed via SDO (Service Data Object) or PDO (Process Data Object) messages.

Service Data Object (SDO)

SDO messages are primarily used for node configuration and parameterization. Point-to-point SDO messaging allows access to a single entry in the object dictionary and consists of both a request and response message.

Process Data Object (PDO)

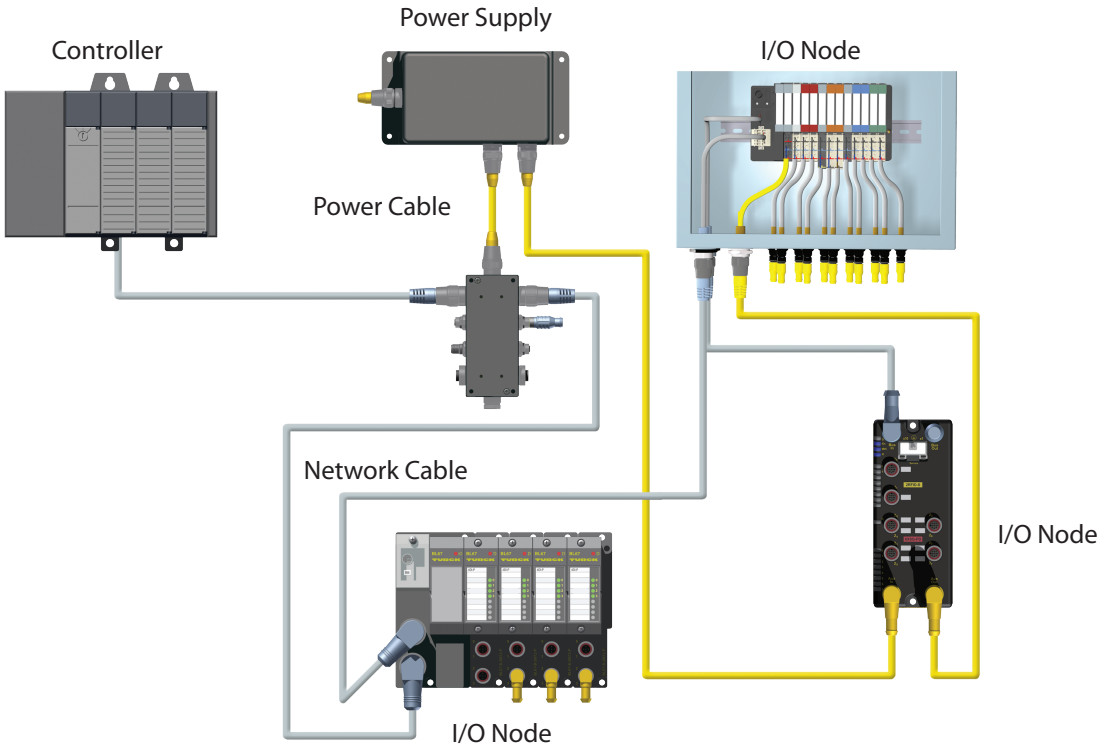
PDO messages are used to transmit process I/O data. These non-confirmed messages can be configured to transmit multiple data objects, up to 8 bytes, within a single message.

Communication modes available for PDO transmission include:

- Event Controlled: The PDO transmission is triggered by COS (Change of State) of data contained within the objects mapped into the PDO
- Time Driven: The PDO is generated on a fixed time interval
- Request Controlled: Polled PDO transmission occurs in response to a remote request frame from a master or another node
- Cyclic Synchronized: Nodes apply output data received and store input data (to be sent as the bus becomes available) upon transmission of a SYNC message. Often used in motion applications, this mode allows process data to be triggered and/or collected from multiple nodes at a single moment in time

The NMT (Network Management) master uses NMT messages to control the operational state of each node (e.g. pre-operational, operational, reset). Heartbeat and node guarding are also functions of NMT messaging.

Data rates available for CANopen include 1Mbit, 800kbps, 500kbps, 250kbps, 125kbps, 50kbps, 20kbps and 10kbps. A maximum of 127 devices are possible on a typical CANopen network (11-bit CAN message identifiers).



Basic Parts List:

A typical system consists of the following basic components:

- Controller
- Power Supply
- CAN Cable
- CANopen I/O Nodes
- Terminating Resistors

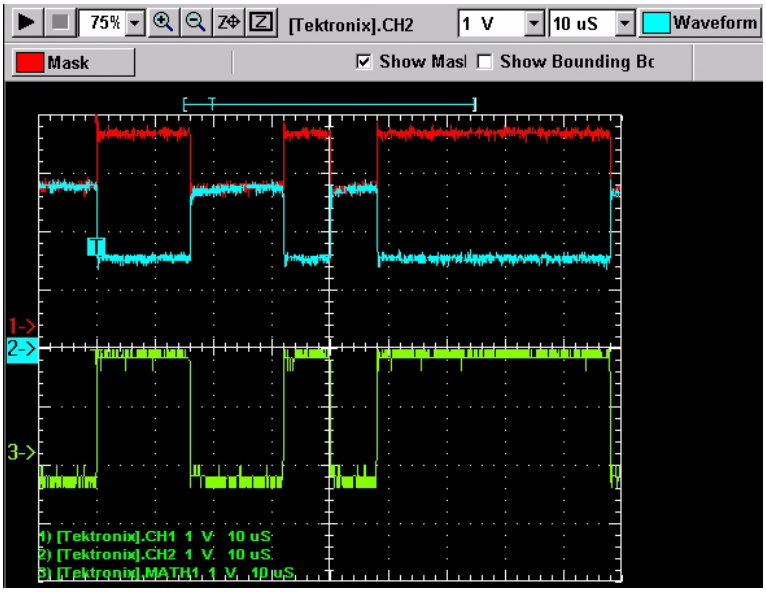
Physical Requirements and Maximums

CANopen is implemented based off the trunk and drop topology. It is recommended that a cable be used with 120Ω characteristic impedance. Both ends of the trunk are to be properly terminated with a resistance representing the characteristic impedance of the transmission line (120Ω).

BIT RATE	BUS LENGTH	MAX. DROP LENGTH	ACCUMULATED DROP LENGTH
1 Mbit/s	25 m	1.5 m	7.5 m
800 kbit/s	50 m	2.5 m	12.5 m
500 kbit/s	100 m	5.5 m	27.5 m
250 kbit/s	250 m	11 m	55 m
125 kbit/s	500 m	22 m	110 m
50 kbit/s	1000 m	55 m	275 m
20 kbit/s	2500 m	137.5 m	687.5 m

Communication Signal

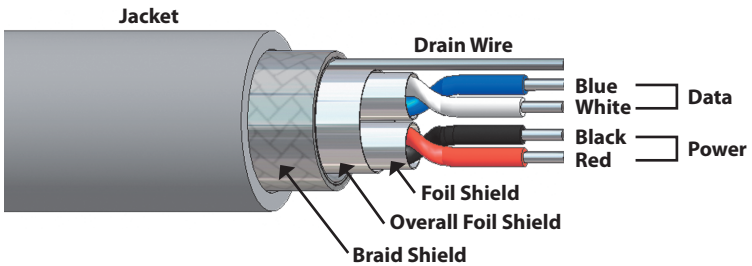
CANopen signals conform to the Controller Area Network (CAN) standard as defined by ISO 11898. The signal type is a differential square wave, allowing for common mode noise rejection.



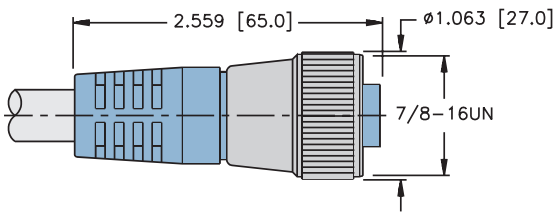
Oscilloscope capture of the differential CAN signal. The CAN high and low components are shown with the resulting difference below.

Cordsets

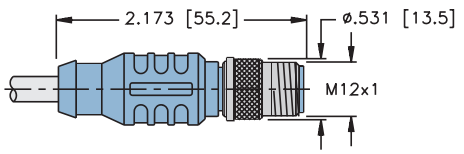
Although the CANopen specification requires cables to only contain CAN High, CAN Low and a CAN ground conductor, it is also acceptable to include a shield, V+ and V- (device power). The addition of device power bundled within the CAN cable becomes particularly useful within industrial automation as it saves both the added complexity and cost of running separate cables for CAN and device power. TURCK CANopen cables include the required signal conductors, as well as the shield and power pair, with V- also used as the CAN ground.



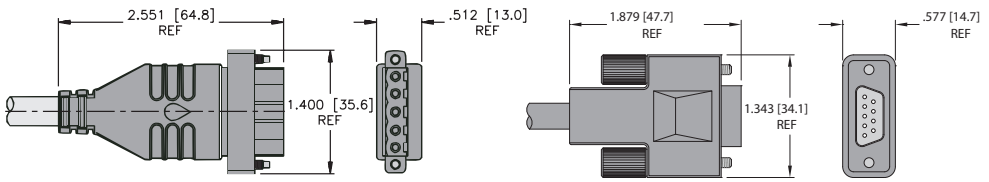
There are many different standardized connectors specified for CANopen (as defined in CiA DR 303-1). TURCK offers cordsets with *minifast*® (7/8-16 UN), *eurofast*® (M12) and open style options. Cables are available in different physical sizes for more flexibility (thin cable) or longer trunk lengths (thick cable). Cordsets are available in standard lengths, but can also be customized through your local sales representative.



***minifast* connector**



***eurofast* connector**



Open Style Connector

AS-Interface®

At-A-Glance

What is it?
AS-Interface, short for Actuator Sensor Interface, is an industrial networking solution used in PLC, DCS and PC-based automation systems that reliably connects field I/O devices.

What are its basic components?
One network master (i.e. gateway), network slaves (i.e. input and output modules, one power supply and wiring infrastructure

Where is it used?
Automation applications, including conveyor control, packaging machines, process control valves, electrical distribution systems, airport carousels and elevators

Who is responsible for it?
AS-International, a member funded organization located in Germany

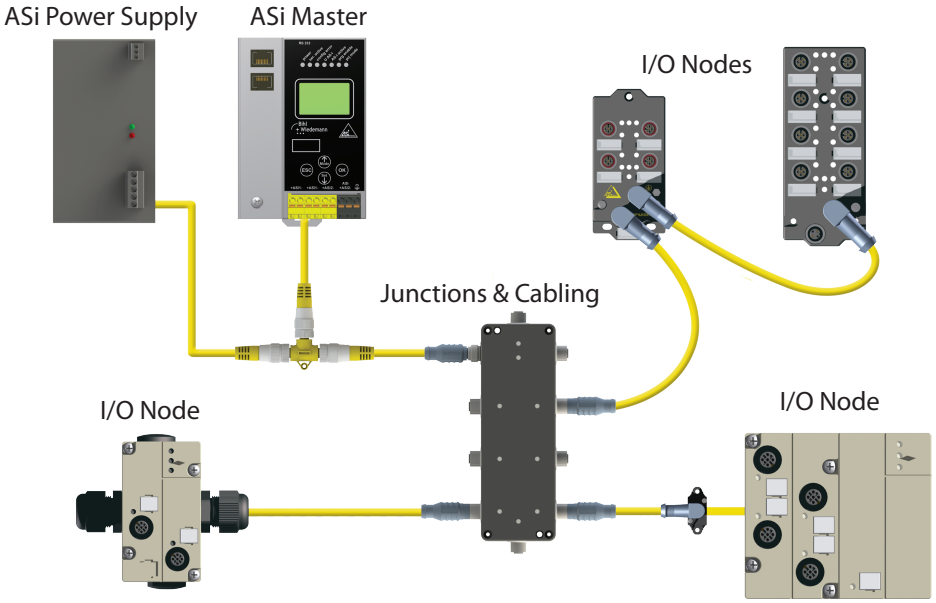
Overview

Actuator Sensor Interface, commonly referred to as AS-interface or AS-i, is a low-level industrial I/O communication protocol. It was originally intended to be a simple, low cost system that would be easy to install and maintain. With that philosophy in mind, the original developers designed AS-i as a discrete-only two-wire system. It incorporated features such as automatic station addressing, and power and data were carried on a single untwisted pair of wires.

As the demand for AS-i grew, so did the demand for more complex devices. The next major version of AS-i, v2.1, extended the protocol to include seamless transfer of analog data, transmission of simple diagnostic data and an extended addressing scheme that effectively doubled the number of stations allowed on the network. The newest version of AS-i, v3.0, has gone even further, allowing more options for analog data and much more detailed diagnostic information to be communicated. New AS-i masters are backwards compatible with nodes from previous versions.

Through the addition of the Safety at Work (SaW) concept to the AS-i specification, it became one of the first industrial protocols to incorporate safety functionality. It is possible to combine both standard I/O along with safety communication and control on a single AS-i network.

AS-interface is usable as a standalone network, or can be used through a gateway as a subnet to a higher level protocol, such as Ethernet-IP or PROFINET. Gateways are a node to the higher level protocol and a master to the AS-i system.



Typical System Configuration:

-Part List:

A typical system consists of the following parts:

- ASi Power Supply
- ASi Master
- I/O Nodes
- Junctions and Cabling

Maximum Ratings

The AS-i system uses a freeform topology. AS-i segments up to 100m in total length are possible without any termination. Through the use of a network terminator that length is extended to 200m; active tuners alternatively provide up to 300m total length. Only one terminator or tuner may be used in a segment. Further extension is possible with repeaters. No more than two repeaters may be used in a single direction from the master.

Communication Signal and Power

AS-i communication uses a Manchester II encoded data signal, which results in a very noise immune system. The communication media is a simple two-wire untwisted unshielded cable. Both power and signal are carried over the same pair of conductors. This requires that the DC supply be 'decoupled' from the network to maintain signal integrity. Special AS-i power supplies are available which incorporate the supply and decoupling feature in a single package. Alternatively, a separate AS-i decoupler unit or a gateway with internal decoupling can be used, allowing the use of a standard 30 VDC supply.

In many cases the AS-i power supply is insufficient for devices with higher current requirements (particularly output devices). In these cases most manufacturers provide AS-i nodes that draw I/O current from a separate auxiliary supply. The station electronics are generally still powered from the AS-i bus.

Addressing

The original AS-i system allowed only 4 bits of data to be transferred in each message for a fast and efficient data transfer system. Nodes could be addressed from 1 to 31, but with the growth of the network more than 31 stations were often required. Beginning with AS-i v2.1 stations were available with extended 'AB' addressing. This scheme allows the station to be addressed from 1A to 31A or 1B to 31B, allowing 62 total nodes with four discrete inputs and three discrete outputs each. The extended address range (and the limitation to three outputs) is achieved by using one output bit for AB selection.

When both A and B addressed nodes are on the same network, they are scanned on alternating cycles (first all the A nodes are scanned, then all the B nodes). Both AB and single-address nodes can be on the same network. In this case the single-address (non-AB) nodes are scanned every cycle. It is important to note that not all v2.1 nodes use the extended addressing scheme.

Analog Data

Although the original AS-i version only allowed discrete data transfer, v2.1 and higher support seamless analog data transfer. This is accomplished by sending a portion of the analog data on each of several consecutive network cycles; for example, a 16-bit word of data requires seven network cycles. Furthermore, AS-i v3.0 allows analog data transfer in a single cycle by consuming more than one address for the analog node.

AS-interface® Safety at Work

AS-interface offers the ability to implement communication and control of Safety data up to SIL 3/ Cat. 4 levels. Safety devices can be implemented on the same network with standard I/O. A safety monitor performs the logic for the safety system. These safety monitors are available as an add-on device or as an integrated feature in many gateways. Programming of the monitor is accomplished through the ASIMON software. There are a wide variety of safety input and output nodes available to complete the system.

Diagnostics

AS-i has limited field diagnostic capability, due to the limited amount of data transferred in each message. With v2.1, a peripheral fault bit can be reported by a particular node to indicate a fault within the device. This allows the user to easily determine the location of a fault down to the node level. AS-i v3.0 supports expanded diagnostic capabilities; allowing asynchronous 'mailbox' messaging for more detailed error information.

Communication Rate/Cycle Time

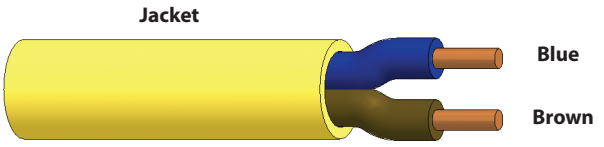
AS-i communicates at a fixed data rate of 167 kbps. The cycle time of the system is very predictable because of the simple communication scheme and fixed data rate. A network with 31 nodes will have a cycle time of less than 5ms. A fully loaded network with 62 nodes (all A and B addresses used) will have a cycle time of less than 10ms. If analog nodes are being used, the cycle time of those values will increase as a result of the analog values being spanned across multiple network cycles.

TURCK & Bihl+Wiedemann

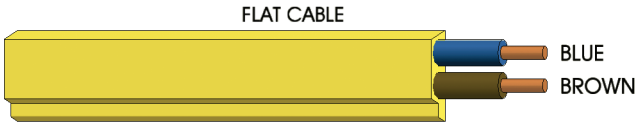
Bihl+Wiedemann is the leading supplier of AS-i master and gateway products. Their broad product range enables users to select from a wide variety of higher level fieldbuses or PC/PLC control solutions. TURCK has partnered with Bihl+Wiedemann to distribute and support their products in North America. Additionally, both Turck and Bihl+Wiedemann offer a variety of analog and discrete AS-i nodes, PCB devices for OEMs, and sophisticated accessory products.

Cordsets

TURCK offers a complete line of molded AS-i cordsets to facilitate network installation, resulting in a faster start-up and fewer wiring errors. AS-i cables consist of a single untwisted and unshielded wire pair that carries both 30VDC power and the network data. AS-i was originally designed for use with flat cable using an insulation displacement connection, but the use of round cables with sealed connectors has become more common. TURCK provides both cable options.



Typical AS-i cable



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Notes:

DeviceNet™

At-A-Glance

What is it?
DeviceNet is a low-level fieldbus network that eliminates hard wiring and connects industrial devices to higher level programmable controllers

What are its basic components?
Scanner, DeviceNet cables and cordsets, I/O nodes, terminating resistors, power supply and grounding wire

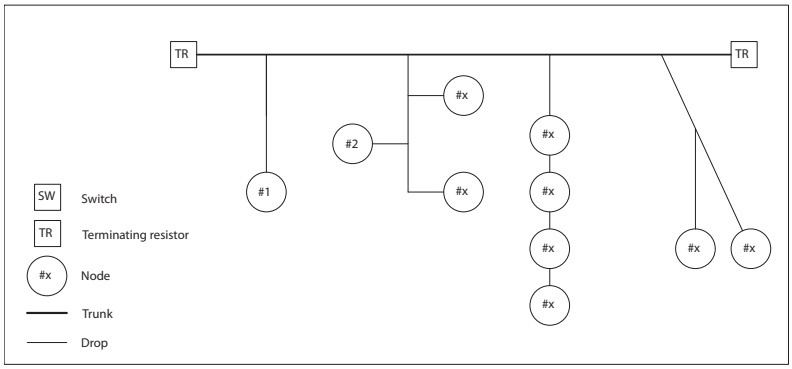
Where is it used?
Automation, safety devices and large I/O control networks

Who is responsible for it?
DeviceNet was originally developed by American company Allen-Bradley (now owned by Rockwell Automation).

Overview

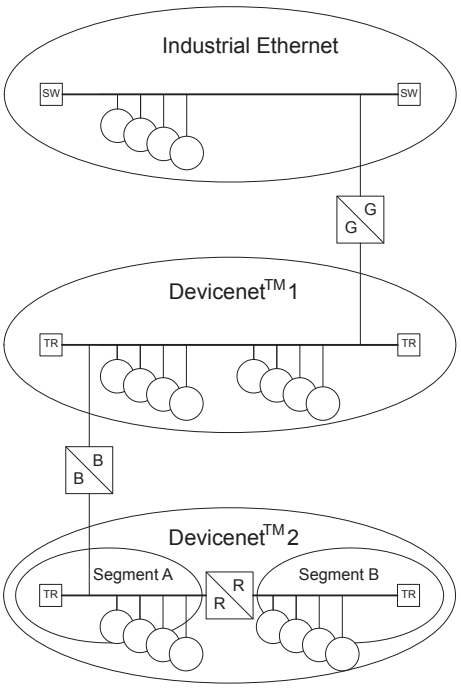
The DeviceNet™ is a low-level fieldbus network that eliminates hard wiring and connects industrial devices such as limit switches, photoelectric sensors, valve manifolds, motor starters, process sensors, bar code readers, variable frequency drives, panel displays and operator interfaces to higher level programmable controllers. It supports 64 nodes, attached to the network in trunkline/dropline topology, as shown on Figure 1. The trunk is the main communication cable that distributes 24VDC power and communication data to all nodes through the DeviceNet media: cables, cordsets, tees, multiport junction boxes, power taps and terminating resistors.

The length of the trunk depends on the data rate and type of cable. The common practice is to use a thick cable for the trunk, whose length is limited to 1,640ft (500 meters). A thin cable is used for the drops. The length of the drop is limited to 20 ft. (6 meter). It is measured from the trunk to the farthest node at the drop. The ends of the trunk are terminated using two 121 Ohm terminating resistors. The network must be grounded at a single location only. Multiple power supply units are allowed but only one of them is grounded. The best location to ground the DeviceNet is in the middle of the network.



The DeviceNet is a connection-based network. There are two types of connections, the Explicit connections (point-to point or peer-to-peer) and IO connections. The Explicit messages are used for the network configuration, node commissioning and IO connection initialization. They are determined by a service code (command) and destination designators: Class, Instance and Attribute. Once the command is executed, the connection is closed. The IO connections (Bit-strobe, Poll, Change-of-state/COS and Cyclic) are used for the continuous IO data exchange between a scanner and nodes. All messages are organized in 4 groups, where group 1 has the highest priority on the bus and group 4 the lowest.

Each DeviceNet device has integrated a CAN controller which is used for communication. It generates noise immune, differential, communication signals that carries data over the network. CAN uses a bitwise arbitration method called CSMA/BA (carrier sense multiple access / bitwise arbitration), that assures the highest priority message always gets access to the bus in the event of multiple device requests for data transmission. The CAN stands for the Controller Area Network as defined by the Bosch CAN Specification V2.0 and ISO 11898-1 standard. These standards are the foundation of the Common Industrial Protocol (CIP), the DeviceNet adaptation of CIP (the DeviceNet Specification), by Open DeviceNet Vendor Association, Inc. (ODVA).



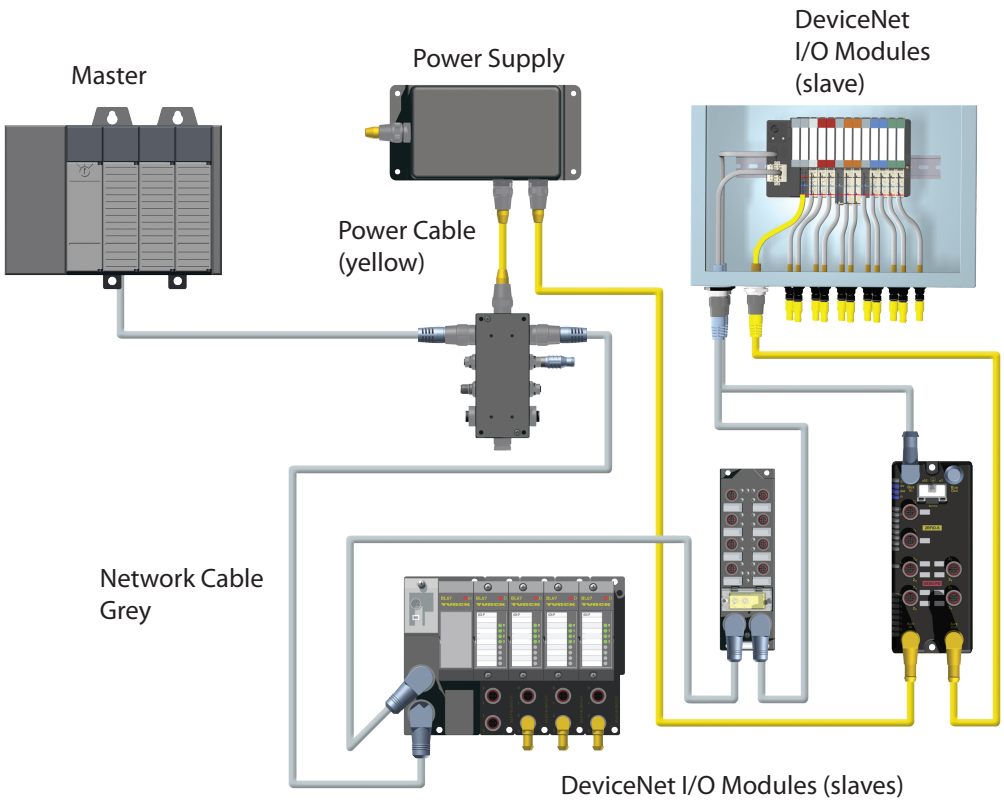
Interacting With DeviceNet™

There are three levels of interaction involving DeviceNet applications:

Gateway (G/G) makes data exchange between DeviceNet and other fieldbus networks possible. They are used as alternative or supplemental devices to reduce the load on the standard networking techniques or to simplify interconnections. A few examples are: DeviceNet/EtherNet IP, DeviceNet/PROFINET and DeviceNet/ASi. A gateway usually appears as a single node on a higher level network and as a scanner on a lower level network. ASi gateway appears as a single node on the DeviceNet and a master on the ASi network.

Bridge (B/B) provides simple and the least expensive way to exchange data between two DeviceNet networks. The bridge, also called a Spanner, consists of two DeviceNet nodes which are electrically and optically isolated from each other. Each node is configured with a scanner where is resides. Each node has individual address switches and Autobaud capability. The data size exchanged between bridge nodes is flexible and may be selected during node configuration.

Repeater (R/R) or bus extender is used to extend the length of the network drop beyond 20ft limitation. The Repeater may be used to create Y shape network or in a warehouse facility multiple extended drops each up to 1640ft long at 125kB. The DeviceNet design rules apply to the extended network segment (B) the same way as they apply to the main network segment (A). The extended segment must have a separate DeviceNet power supply unit; it must be terminated at both ends and grounded at a single point. Each network segment may have multiple nodes, whose addresses are unique for the entire network. All nodes are set to the same data rate. The total number of nodes on all network segments cannot exceed 64 nodes. The number of the repeaters is not limited; do not cascade repeaters as each one introduces 2ms transmission delay.



Basic Parts List

A typical system consists of the following parts:

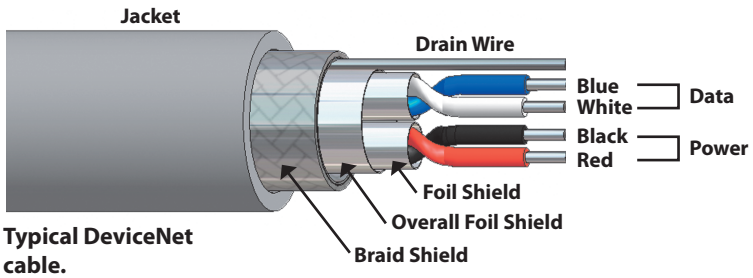
- Master
- Power Supply
- DeviceNet I/O Modules (slaves)
- Power Cables
- Network Cables

System Configuration

DeviceNet stations require a network master (also called a scanner) to interface the stations to the host controller. TURCK DeviceNet stations are designed to be fully compatible with DeviceNet equipment from other manufacturers.

DeviceNet Cables

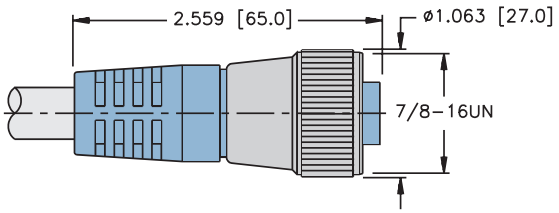
DeviceNet cables consist of a shielded and twisted data pair, as well as a shielded and twisted power pair for the 24 VDC bus power, with an additional outer shield. The drain wire, together with multiple layers of foil and/or braid that surround data and power pairs, create network shield sufficient to withstand harsh industrial environment. A key benefit of carrying supply voltage in the network cable is that many DeviceNet stations do not need a further supply, allowing the user to only need to run one cable to the station. Some stations, particularly those with high current outputs, can draw too much power from the DeviceNet power supply. These stations typically have an auxiliary power connection, allowing the user to use a second power supply for just the I/O. The bus power supply still powers the DeviceNet communication electronics.



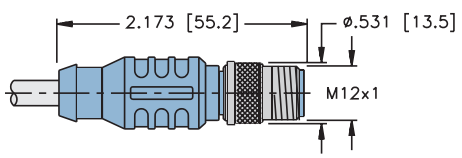
Typical DeviceNet cable.

Cordsets

TURCK offers a complete line of molded DeviceNet™ cordsets to facilitate network installation, resulting in a faster start-up and fewer wiring errors. The bus and drop cables are specially designed foil-shielded, high-flex cables with very low inductance and capacitance to minimize propagation delay time. In most cases, bus cable connections are made using 5-pin *minifast*® (7/8-16 UN) or *eurofast*® (M12) connectors. A variety of stations are also available that support terminal-block type connections. TURCK cordsets for the DeviceNet system are available in standard lengths.



***minifast* connector**



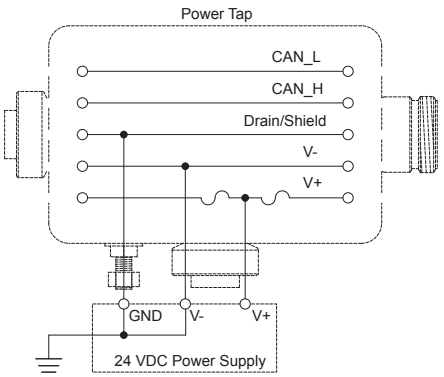
***eurofast* connector**

Network Power

The DeviceNet power may be provided by single or multiple power supply units. The nominal voltage and current rating of all power supply units are: 24VDC +/- 1%, up to 16A continuous feed. The output has to be isolated from AC and a chassis ground. It should be protected against over voltage or over current. The power supply units have a rise time less than 250ms to reach 5% of its rated output voltage. When multiple power supply units are used in an application, V+ is broken between them and only one is grounded.

Networking Grounding

The DeviceNet is grounded at a single point according to the Figure 4. The shield and the common (V-) of the power supply unit are brought to the same earth-ground point using a copper braid or #8 grounding wire. The shield must be continuous and serves as only protection against electrostatic discharge (ESD) and fast electromagnetic interference transients (EMI), the common source of network communication problems. The location of the grounding point, affects, the same way as location of the power supply unit, a quality of the CAN signal and data transmission. The middle of the network load is considered to be the best possible location for the network grounding.



A common mode voltage (CMV) also depends on the location of the network power supply. The higher common mode, more communication errors is generated. The maximum CMV is 9.3V.

Electronic Data Sheets (EDS) Files

Electronic Data Sheet (EDS) is the DeviceNet configuration file that contains information about a device: identity, I/O data size and the device's configurable parameters. The information provided by EDS files is imported into network configuration tools and guide a user through the steps necessary to configure a device. EDS files are available on www.turck.com

Diagnostics

The DeviceNet stations support different diagnostics information which depends on their complexity and functionality. The common ground for all devices is that they have to provide visual diagnostic information using either a pair of status LEDs called MOD and NET LEDs or use a single combined MOD/NET led. The behavior of these LED is described hereafter.

TURCK discrete IO modules provide diagnostic data as a part of input data map. The standard stations support group diagnostics, where a single alarm bit is set if any IO is faulted. The deluxe station support individual IO diagnostic data, like open wire and short wire alarm bits. All TURCK devices support MOD and NET LED diagnostics as follows:

MOD – Module Status LED

INDICATES INTERNAL STATUS OF THE DEVICE		
LED COLOR	**STATUS**	**INDICATION**
Off	Not Powered	There is no power applied to the device.
Flashing Green	Device in Standby state. Autobaud detection not completed.	• Device needs commissioning due to configuration missing, incomplete or incorrect. • Device is not in a scan list. Configure device. • Autobaud detection not completed. Check CAN lines.
Green	Device Operational	Device operating normally.
Flashing Red	Minor Recoverable Fault	Recoverable fault. For devices with group diagnostic it indicates I/O fault. Check I/O for short.
Red	Major Unrecoverable Fault	The device has an unrecoverable fault; may need replacing.
Flashing Red-Green	Device is powered and in self-test mode.	Self-test mode during power-up sequence.

NET – Network Status LED

INDICATES INTERNAL STATUS OF THE DEVICE		
LED COLOR	**STATUS**	**INDICATION**
Off	Not Powered, Not On-Line	• No network power. • Device may not be powered. • Device has not completed DupMacID test yet.
Flashing Green	On-Line, Not Connected	Device has passed DupMacID test, it is online, device is not allocated to a master. Device is not in a scan list.
Green	Device Operational, On-Line and Connected	Device is configured, connected and communicating.
Flashing Red	Connection Time-Out	One or more I/O connections are in timed out state.
Red	Critical Fault or Critical Link Failure	Failed communication device. The device has detected an error that has rendered it incapable of communicating on the network. Bus-off.
Flashing Red-Green	Device is powered and in self-test mode.	Self-test mode during power-up sequence.

Addressing

The DeviceNet™ supports 64 nodes, which are assigned addresses from 0 to 63. The address 0 is usually assigned to a scanner, addresses 1 through 61 may be assigned to different nodes, address 62 is reserved for a configuration tool, address 63 must be always free and it is reserved for node commissioning. The station's default node address (out of box) is 63. Each node's address must be initially set, usually via rotary dials or switches on the node. The address can also be set with a DeviceNet configuration tool. Changes to the address settings take effect when the station power is cycled. Every device supports duplicate address detection mechanism (DupMACID) that prevents multiple nodes to occupy the same node address. The DupMACID is run at the device power up. The Device shuts down (goes into bus-off state) when it detects that there is another device at the same node address.

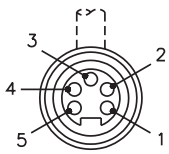
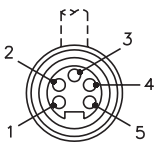
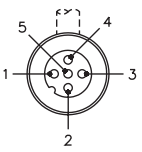
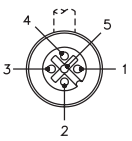
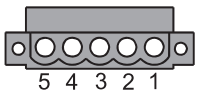
Data Rate

The data rate or baud rate is the speed of data transmission over the DeviceNet. The DeviceNet operates at three data rates: 125kbps, 250kbps and 500kbps (kilobits per second). All devices must be set to the same data rate in order to have functional network. A failure to do so may result in a critical network fault, forcing entire network or some devices to go into bus-off state. The bus-off state is a state of a device (i.e. CAN chip) when it detects an error that has rendered it incapable of communication on the network.
The data rate is selected using a data rate switch. In general, the switch may have 4 positions marked: 125, 250, 500 and PGM (programmable mode). Instead of the data rate switch, many devices support Autobaud detection mechanism that automatically detects network data rate during power up and sets the device baud rate accordingly. The Autobaud and data rate are supported by the device parameters that can be enabled/disabled and set using the device EDS file (Electronic Data Sheet).

Network Length

The DeviceNet bus uses trunk and drop topology. The trunk is the main communication cable, and requires a 121 ohm resistor at both ends. The maximum length of the trunk depends on the communication rate and the cable type. Drops are branches off the trunk, and may be from zero to 6 m (20 ft) in length. The cumulative drop lengths are dependent on the communication rate. The following table shows the maximum ratings for a trunk using the most common cable types as defined by the DeviceNet specification.

COMMUNICATION RATE	THICK TRUNK LENGTH (MAXIMUM)	MID TRUNK LENGTH (MAXIMUM)	THIN TRUNK LENGTH (MAXIMUM)	FLAT TRUNK LENGTH (MAXIMUM)	DROP LENGTH (MAXIMUM PER DROP)	DROP LENGTH (CUMULATIVE)
125 kbps	500 m (1640 ft.)	300 m (984 ft.)	100 m (328 ft.)	420 m (1378 ft.)	6 m (20 ft.)	156 m (512 ft.)
250 kbps	250 m (820 ft.)	250 m (820 ft.)	100 m (328 ft.)	200 m (656 ft.)		78 m (256 ft.)
500 kbps	100 m (328 ft.)	100 m (328 ft.)	100 m (328 ft.)	75 m (246 ft.)		39 m (128 ft.)

minifast		Pinouts	eurofast		Combicon
Male	Female		Male	Female	
		**1 = Bare (Drain)** **2 = Red (V+)** **3 = Black (V-)** **4 = White (CAN-H)** **5 = Blue (CAN-L)**			 5 4 3 2 1 **Female Front** **1 = Black (-Voltage)** **2 = Blue (CAN_L)** **3 = Bare (Shield Drain)** **4 = White (CAN_H)** **5 = Red (+Voltage)**

Warranty terms and conditions

RISK OF LOSS

Delivery of the equipment to a common carrier shall constitute delivery to the Purchaser and the risk of loss shall transfer at that time to Purchaser. Should delivery be delayed due to an act or omission on the part of the Purchaser, risk of loss shall transfer to the Purchaser upon notification by TURCK Inc. that the order is complete and ready for shipment.

WARRANTIES

TURCK INC. (hereinafter "TURCK") offers five (5) WARRANTIES to cover all products sold. They are as follows:
1) The **12-MONTH WARRANTY** is available for the products listed - generally those not covered by **LIFETIME**, **5-YEAR**, **24-MONTH** or **18-MONTH** warranty. No registration required.
2) The **18-MONTH WARRANTY** is available for the products listed - generally those not covered by **LIFETIME** or **5-YEAR WARRANTY**. No registration is required.
3) The **24-MONTH WARRANTY** is available for the products listed - generally those not covered by **LIFETIME**, **5-YEAR** or **18-MONTH**. No registration is required.
4) The **5-YEAR WARRANTY** is available generally for the products listed. No registration is required.
5) A **LIFETIME WARRANTY** is available for the products listed. It becomes effective when the accompanying TURCK **LIFETIME WARRANTY REGISTRATION** is completed and returned to TURCK.

GENERAL TERMS AND CONDITIONS FOR ALL WARRANTIES

- **12-MONTH STANDARD WARRANTY**
- **18-MONTH STANDARD WARRANTY**
- **24-MONTH STANDARD WARRANTY**
- **5-YEAR WARRANTY**
- **LIFETIME WARRANTY**

TURCK warrants the Products covered by the respective WARRANTY AGREEMENTS to be free from defects in material and workmanship under normal and proper usage for the respective time periods listed above from the date of shipment from TURCK. In addition, certain specific terms apply to the various WARRANTIES.

THESE EXPRESS WARRANTIES ARE IN LIEU OF AND EXCLUDE ALL OTHER REPRESENTATIONS MADE - BOTH EXPRESSED AND IMPLIED. THERE ARE NO WARRANTIES OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE FOR PRODUCTS COVERED BY THESE TERMS AND CONDITIONS.

TURCK warrants that the goods sold are as described, but no promise, description, affirmation of fact, sample model or representation, oral or written shall be part of an order, unless set forth in these terms and conditions, or are in writing and signed by an authorized representative of TURCK. These WARRANTIES do not apply to any Product which has been subject to misuse, negligence, or accident - or to any Product which has been modified or repaired, improperly installed, altered, or disassembled - except according to TURCK's written instructions.

These WARRANTIES are subject to the following conditions:
1) These WARRANTIES are limited to the electronic and mechanical performance only, as expressly detailed in the Product specifications and NOT to cosmetic performance.
2) These WARRANTIES shall not apply to any cables attached to, or integrated with the Product. However, the **18-MONTH WARRANTY** shall apply to cables sold separately by TURCK.
3) These WARRANTIES shall not apply to any Products which are stored, or utilized, in harsh environmental or electrical conditions outside TURCK's written specifications.
4) The WARRANTIES are applicable only to Products shipped from TURCK subsequent to January 1, 1988.

ADDITIONAL SPECIFIC TERMS FOR:
(12-MONTH STANDARD WARRANTY) for Linear Displacement Transducers, EZ Track, RFID Products, Draw Wire Assemblies and Slip Rings.

(18-MONTH STANDARD WARRANTY) FOR Q-TRACK INDUCTIVE SENSORS, ULTRASONIC SENSORS, FLOW SENSORS, PRESSURE SENSORS, TEMPERATURE SENSORS, INCLINOMETERS, CABLES AND ALL NON-SENSING PRODUCTS SOLD BY TURCK INC. INCLUDING MULTI-SAFE, MULTI-MODUL, MULTI-CART AND RELATED AMPLIFIER PRODUCTS, RELAYS AND TIMERS.

(24-MONTH STANDARD WARRANTY) FOR ENCODERS excluding Draw Wire Assemblies.

5-YEAR WARRANTY FOR INDUCTIVE AND CAPACITIVE PROXIMITY SENSORS: The periods covered for the above WARRANTIES and Products shall be 12 MONTHS, 18-MONTHS, 24-MONTHS and 5-YEARS, respectively, from the date of shipment from TURCK.

LIFETIME WARRANTY (OPTIONAL - REGISTRATION REQUIRED) FOR INDUCTIVE, INDUCTIVE MAGNET OPERATED AND CAPACITIVE PROXIMITY SENSORS SOLD TO THE ORIGINAL PURCHASER FOR THE LIFETIME OF THE ORIGINAL APPLICATION.

Warranty terms and conditions

The following terms apply to the LIFETIME WARRANTY in addition to the General Terms:

1) This WARRANTY shall be effective only when the LIFETIME WARRANTY REGISTRATION has been completed, signed by the End User and an authorized TURCK Representative or Distributor and has been received by TURCK no later than six (6) months after installation in the End User's Plant, or two (2) years from the date product was shipped from TURCK, whichever is sooner.
2) This warranty is available only to TURCK's authorized Representatives, Distributors and to the Original User. (The term "Original User" means that person, firm, or corporation which first uses the Product on a continuous basis in connection with the operation of a production line, piece of machinery, equipment, or similar device.) In the event the ownership of the product is transferred to a person, firm or corporation other than the Original User, this WARRANTY shall terminate.
3) This WARRANTY is applicable only to the Original Application. In the event the machinery, equipment, or production line to which the Product is connected, or on which it is installed, is substituted, changed, moved or replaced, the WARRANTY shall terminate.
4) This WARRANTY shall be valid only if the Product was purchased by the Original User from TURCK, or from an authorized TURCK Distributor, or was an integral part of a piece of machinery and equipment obtained by the Original user from an Original Equipment Manufacturer, which itself, was purchased directly from TURCK or from an authorized Distributor.

PURCHASER'S REMEDIES

This Remedy shall apply to all WARRANTIES. If a TURCK Distributor desires to make a WARRANTY Claim, the Distributor shall, if requested by TURCK, ship the Product to TURCK's factory in Minneapolis, Minnesota, postage or freight prepaid. If the User desires to make a WARRANTY Claim, they shall notify the authorized TURCK Distributor from whom it was purchased or, if such Distributor is unknown, shall notify TURCK. TURCK shall, at its option, take any of the following two courses of action for any products which TURCK determines are defective in materials or workmanship.

1) Repair or replace the Product and ship the Product to the Original Purchaser or to the authorized TURCK Distributor, postage or freight prepaid; or
2) Repay to the Original Purchaser that price paid by the Original Purchaser; provided that if the claim is made under the LIFETIME WARRANTY, and such Product is not then being manufactured by TURCK, then the amount to be repaid by TURCK to the Original Purchaser shall be reduced according to the following schedule:

Number of Years Since Date of Purchase by Original Purchaser	Percent of Original Purchase Price To Be Paid by TURCK
10	50%
15	25%
20	10%
More than 20	5%

PURCHASER'S REMEDIES SHALL BE LIMITED EXCLUSIVELY TO THE RIGHT OF REPLACEMENT, REPAIR OR REPAYMENT AS PROVIDED AND DOES NOT INCLUDE ANY LABOR COST OR REPLACEMENT AT ORIGINAL PURCHASER'S SITE. TURCK SHALL NOT BE LIABLE FOR ANY CONSEQUENTIAL DAMAGES RESULTING FROM ANY BREACH OF ANY WARRANTY, EXPRESSED OR IMPLIED, APPLICABLE TO THE PRODUCT, INCLUDING WITHOUT LIMITATION, ANY DAMAGES RESULTING FROM PROPERTY DAMAGE, PERSONAL INJURY OR BUSINESS INTERRUPTION.

CONSIDER SAFETY AND PROTECTION PRECAUTIONS

TURCK takes great care to design and build reliable and dependable products, however, some products can fail eventually. You must take precautions to design your equipment to prevent property damage and personal injury in the unlikely event of failure. As a matter of policy, TURCK does NOT recommend the installation of electronic controls as the sole device FOR THE PROTECTION OF PERSONNEL in connection with power driven presses, brakes, shears and similar equipment and, therefore, the customer should build in redundancy or dual control using approved safety devices for these applications.

TURCK Inc. sells its products through Authorized Distributors. These distributors provide our customers with technical support, service and local stock. TURCK distributors are located nationwide - including all major metropolitan marketing areas.

For Application Support or for the location of your nearest TURCK distributor, call:

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