Introduction

What Is a Wiring System?

A Wiring System is a device that is used to convert a connection to a connector to connect (wire) a device or circuit. Converting connections to connectors makes it possible to connect and disconnect devices with just your hands or simple tools. This document classifies Wiring Systems used mainly in industrial equipment as follows.

Industrial Ethernet Cables

Industrial Ethernet Cables and Connectors support Industrial Ethernet (open networks) including EtherNet/IP™ and EtherCAT®. In factories, certainty of information transmission (transmission in real time) and noise tolerance are required. Therefore, unlike the LAN used in general offices and homes, connectors that are robust and water-resistant are used in factories. Also, the use of cables with a shielded structure ensures a high connection quality.

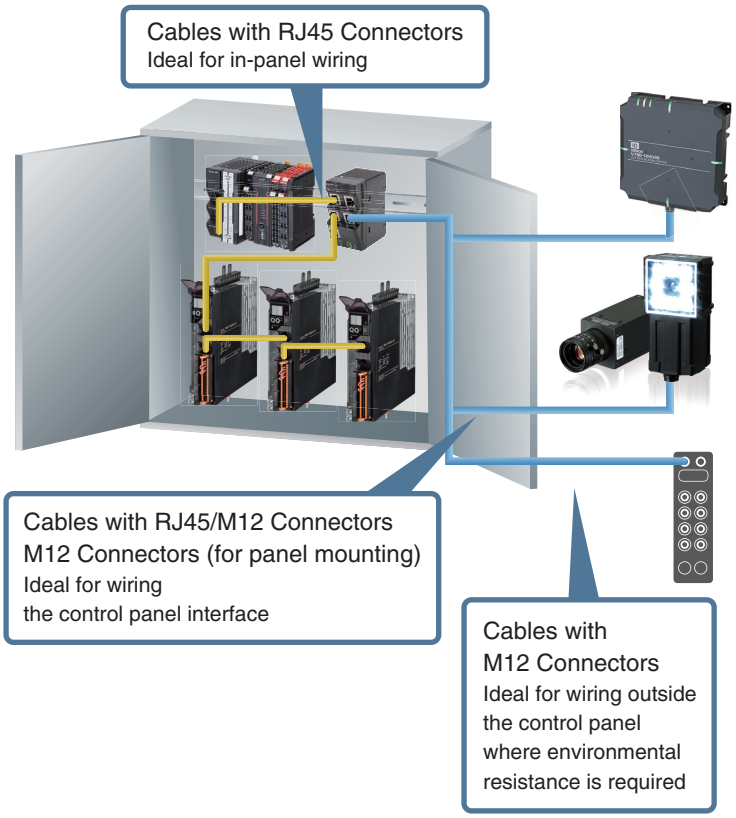
Sensor I/O Connectors

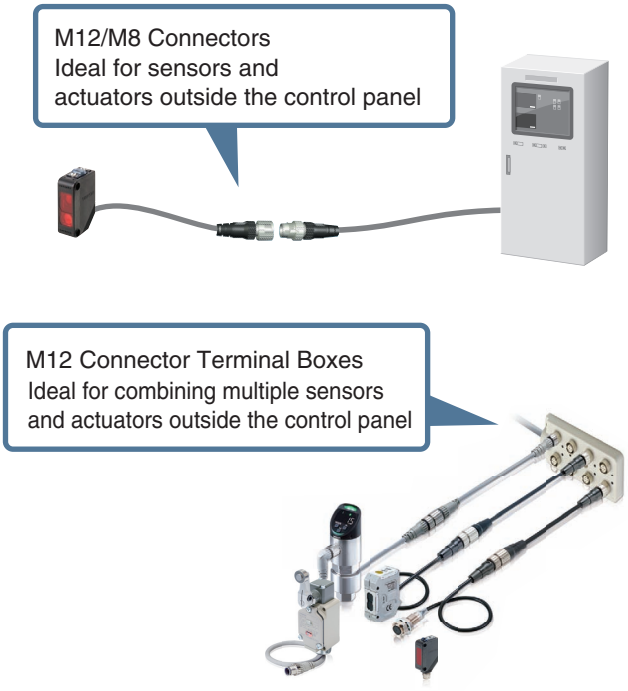
Sensor I/O Connectors are used to convert the wiring for input devices including sensors and actuators into a connector. At work-places that require a high connection reliability, round water-resistant connectors having excellent resistance to environment such as water and oil resistance are used.

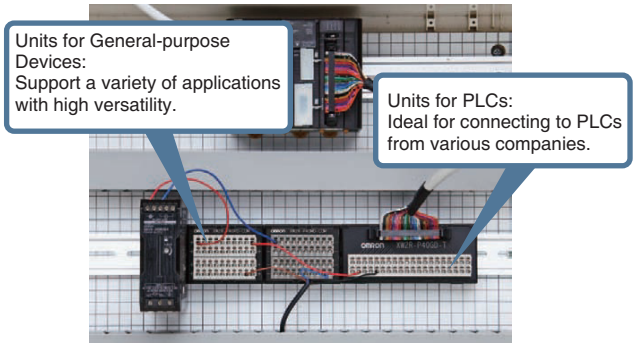
Connector-Terminal Block Conversion Unites

A Connector-Terminal Block Conversion Unit is a terminal block conversion unit with a prewired connector that can be used to wire all the I/O for a programmable controller (hereinafter, PLC) with a single cable.

Classifications

	Connection example	Main types
Industrial Ethernet Cables		Cables with RJ45 Connectors XS6□, XS5□-T  Cables with M12 Connectors (D-coding) for panel mounting XS5P-T  Cables with M12 Connectors (D-coding) XS5□-T 

	Connection example	Main types
Sensor I/O Connectors		M8 Connectors (A/B-coding) XS3□  M12 Connectors (A/B-coding) XS2□, XS5□  M12 Connector Terminal Boxes (A/B-coding) XW3□ 

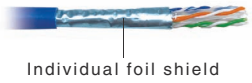
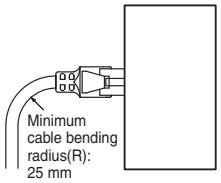
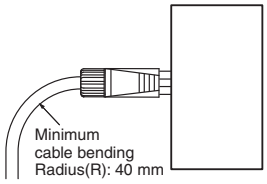
	Connection example	Main types
Connector-Terminal Block Conversion Unites		Units for PLCs  Units for General-purpose Devices 

Product Lineup and Features

Industrial Ethernet Cables

Industrial Ethernet Cables and Connectors support Industrial Ethernet (open networks) including EtherNet/IP™ and EtherCAT®. In factories, certainty of information transmission (transmission in real time) and noise tolerance are required. Therefore, unlike the LAN used in general offices and homes, connectors that are robust and water-resistant are used in factories. Also, the use of cables with a shielded structure ensures a high connection quality.
OMRON provides cables with RJ45 connectors for use in-panel, and cables with M12 connectors (round water-resistant connectors) for use outside the control panel where resistance to the environment is required.

Features of Cables with RJ45 Connectors

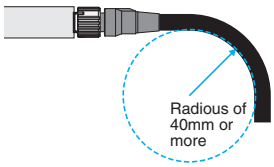
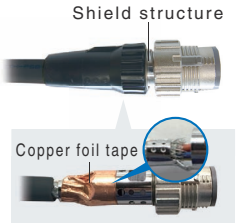
Series	Shape of Connector	Cable structure	Sheath material	Transmission characteristics✻1	Routing
XS6W-6LSZH	Compact RJ45 connectors reduce in-panel cable routing space 	Cable structure designed for reliable use in noisy environments.✻2 	LSZH✻3	Cat6A	Minimum cable bending radius(R):25 mm 
XS6W-5PUR		Double-shielded for use in hostile, noisy environments (XS5W-T cable) 	PUR	Cat5	
XS5W-T421-□MD-□□	RJ45 connectors with tough latch structure 		PVC	Cat5e	Minimum cable bending Radius(R): 40 mm 

✻1. For details on transmission characteristics, see *Ethernet Communication Speed and Standards* on page 4.
✻2. In spite of being a single-shielded structure, it satisfies the standard values of the communication and noise characteristics.
✻3. LSZH is the abbreviation for Low Smoke Zero Halogen. Fire-retardant, and does not generate poisonous gases even when burned.

Assembly Connectors

Enables easy on-site Ethernet cable assembly without crimp tools or other special tools.

Features of Cables with M12 Connectors

Series	Shape of Connector	Cable structure	Sheath material	Transmission characteristics✻1	Routing
XS5□-T42□-□M□-□□	Environment-resistant M12 connectors with IP67 protection 	Double-shielded for use in hostile, noisy environments 	PVC	Cat5e	Minimum cable bending Radius(R): 40 mm 
XS5W-T421-□M□-SS	In addition to the above features, copper foil tape added to connector portion for improved communication characteristics. 				

Note: All M12 Industrial Ethernet Connectors are D-coded. For details on coding, see *Information on Standards* on page 10.
Cables with RJ45/M12 Connectors are also available. For details, see *Industrial Ethernet Cables Catalog* (Cat. NO. G019-E1).

Ethernet Communication Speed and Standards

Be sure to use Ethernet Cables and Connectors that supports Ethernet speed (Band rate) you need. As the communication speed becomes faster, the frequency increases, and the signal tends to get distorted, because of which the required specifications become restrictive. For that reason check the Ethernet speed (Band rate) of your PLC, sensors, and any other component you plan to use and select cables and connectors that complies with the necessary standards.

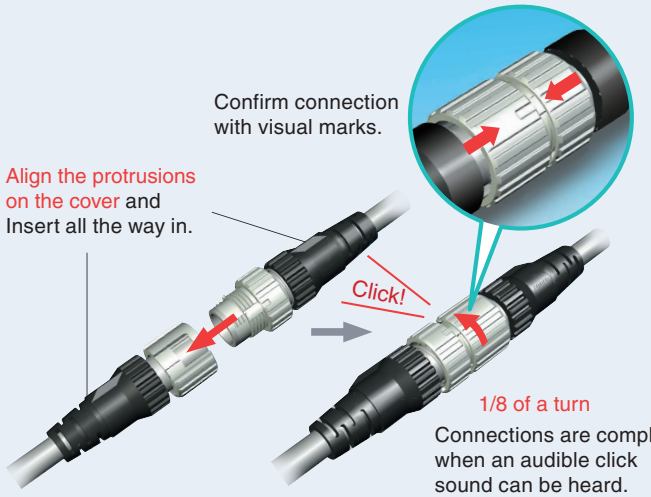
✓…Supported
✻ …Supported when cable length ≤ 37m

		Cables and Connectors standards			
		Cat5	Cat5e	Cat6	Cat6A
Ethernet speed (Band rate) Higher	10BASE-T	✓	✓	✓	✓
	100BASE-TX	✓	✓	✓	✓
	1000BASE-T	–	✓	✓	✓
	10GBASE-T	–	–	✓✻	✓

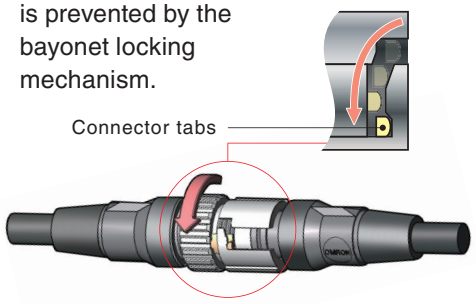
Note: For 100BASE-TX/10BASE-T, use a straight or cross STP (shielded twisted-pair) cable of category 5 or higher.
For 1000BASE-T, use a straight or cross STP cable of category 5e or higher with double shielding (aluminum tape and braiding).
For details on STP and straight/cross cables, see *Explanation of Terms* on page 7.

Smartclick

OMRON's M12 Connectors (Industrial Ethernet Cables XS5□-T Series and Sensor I/O Connectors XS5 Series) are Smartclick Connectors that enable completion of the connection by turning the connector approximately 1/8 of a turn.



Looseness in fixed parts is prevented by the bayonet locking mechanism.



Maintenance free

Machine vibrations do not loosen the connector, thus there is no concern over troubles occurring due to inflow of water.

Torque control is not required

Since the lock mechanism is operated manually, it does not depend on the skill of the operator, a fixed tightening torque is ensured, and a high connection quality is achieved.

Wiring work is reduced by 66%

As compared with the M12 screw connectors, the connection work is reduced to almost 1/3*.

✻ Comparison between OMRON M12 screw connector and Smartclick connector.
According to reference values obtained by OMRON.

Compatibility with M12 screws

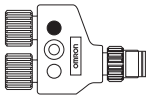
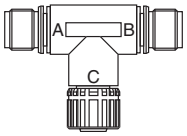
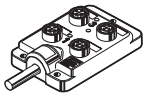
Can also be connected to M12 screw connectors used in the existing equipment

	XS5 Smartclick Plug Connector	M12 plug connector
XS5 Smartclick Socket Connector	One-touch connection	Screw connection
M12 socket connector	Screw connection	Screw connection

Note: All types of combinations can be connected. Screw connections will be made if connecting Smartclick with a screw type.

Sensor I/O Connectors

Sensor I/O Connectors are used to convert the wiring for input devices including sensors and actuators into a connector. At workplaces that require a high connection reliability, round water-resistant connectors (M12/M8 Connectors) having excellent resistance to environment such as water and oil resistance are used.
OMRON offers various models to suit different uses.

Type	Main use	Appearance (typical example)
Connector with Cable (M12/M8 Connectos)	Used for sensor and actuator wiring to relay sensor signals or the like.	
Connector Assembly (M12 Connectors)	Used to enable using connectors for sensor cables and relay cables.	
Sensor Connector Assemblies (M12/M8 Connectors)	Used to enable connectors to be integrated with the Sensor body.	
Panel-mounting Connector (M12/M8 Connectors)	Used to enable using I/O box connectors mounted to panels.	
Y-Joint (M12/8 Connectors)	Used to wire two sensors to a single cable.	
T-Joint (M12 Connectors)	Aggregate model: Used to wire two sensors to a single cable. Bifurcated model: Used when branching one sensor signal to two cables. Daisy-chain model: Two-wire sensors with contact output can be connected through a daisy chain to obtain AND output.	
M12 Connector Terminal Boxes	Used to wire multiple sensors to a single cable.	

Features of Pressure-welded Assembly Connectors

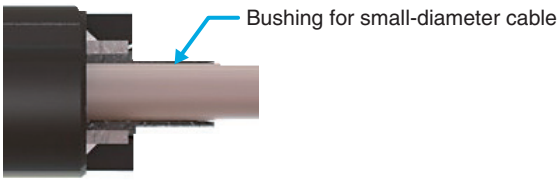
Clarifies Assembly Completion Position

Assembly is completed with any type of cable simply by pressing the cable all the way in. The tightened position is clear, so you can visually confirm assembly completion.

The tightened position is clear.

Wide Range of Cables

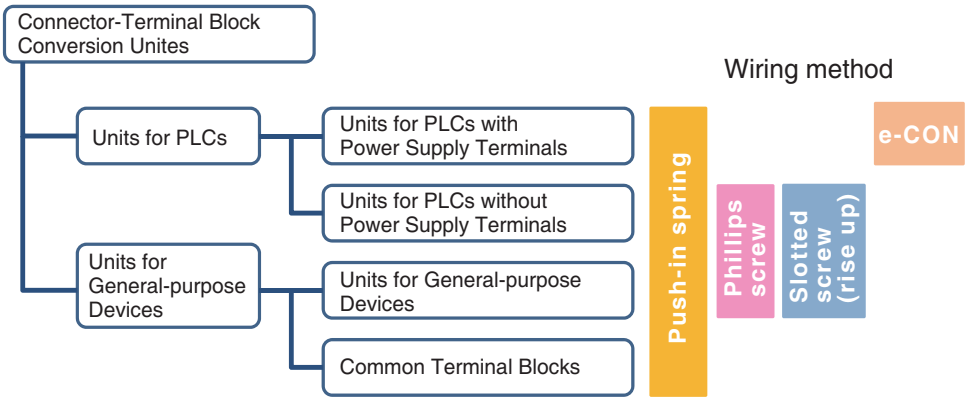
Two sizes of bushings (one for large-diameter cables and one for small-diameter cables) are provided to support cable diameters from 3 mm to 8 mm.



Note: Use an A-coded connector for DC Sensors and a B-coded connector for AC Sensors. For details on coding, see *Information on Standards* on page 10.

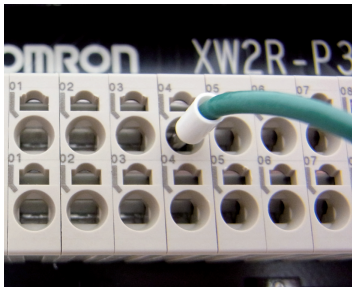
Connector-Terminal Block Conversion Unites

A Connector-Terminal Block Conversion Unit is a terminal block conversion unit with a prewired connector that can be used to wire all the I/O for a programmable controller (PLC) with a single cable.
OMRON provides Units for PLCs, which have wiring patterns specialized for PLC connections, and Units for general-purpose devices.
Recently, the use of devices with push-in terminal blocks has been increasing in order to improve work efficiency. In particular, push-in terminal blocks on Connector-Terminal Block Conversion Units that are used to connect to PLCs with their many signals make it possible to reduce space requirements and reduce wiring work.
OMRON's lineup also includes conventional Units with phillips screws or slotted screws, Units with e-CON specification, and more.

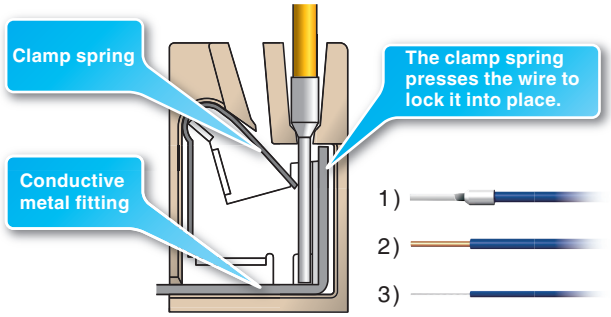


Features of Units with Push-in Terminal Blocks

Structure

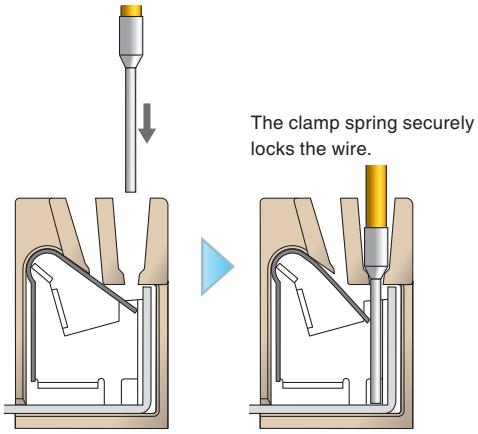


With a push-in terminal block, a wire is inserted and the clamp spring presses against the wire to lock it into place.
Three types of wire can be used: 1) wires with ferrules, 2) solid wires, and 3) stranded wires.



Connecting a Wire

If you use a wire with a ferrule, you can wire by inserting the ferrule into the push-in terminal block. Also, there is no need for retightening screws after shipping, so installation can be performed immediately.



Pullout Strength

The pullout strengths of push-in terminal blocks are specified in the JIS C 8201-7-1 or IEC 60947-7-1 standard.

Example: Pullout Strengths for Wires with Ferrules

Wire thickness (cross-sectional area)	Value in JIS standard
AWG20 (0.52 mm²)	20 N
AWG22 (0.33 mm²)	15 N

Refer to your OMRON website for details.

Explanation of Terms

Names

Contacts and Housing (Mold)

Contact: A metallic part or contact terminal for making an electrical connection

Housing (mold): An insulator that houses contacts in an appropriate array, and isolates a contact from other contacts or conductors.

Plugs and Sockets

Connectors are classified as plugs or sockets according to the shape of the contact section or according to the connector that has the contacts.

Plug: Same as male connector, pin header, or post.
A connector with fixed contacts.
Mates with the socket contacts to make electrical connections.

Socket: Same as female connector or receptacle.
A connector with moving contacts.
Mates with the plug contacts to make electrical connections.

Harness

A part with wires attached to connectors.

Minimum Packing Unit

The minimum number packed for shipment from the factory.

Number of Pins

The number of contacts.
A synonym for pin count.

Pitch (Between Rows)

The interval between terminals in the long direction (distance between the terminal centers).
There is also a pitch between rows, which indicates the interval (distance between terminal centers) between rows of terminals in the long direction.

Through Holes

Holes into which terminals are inserted in order to connect connector terminals to the PCB wiring pattern.
Connector terminals are inserted into these holes and soldered to make the electrical connections.
A through hole sometimes indicates a hole used to connect the front and rear side wiring patterns of a PCB.

AWG

AWG is an abbreviation for American Wire Gauge. It is a conductor standard that indicates the core cross-sectional area for wires generally used in the United States.

Plating

Surface treatment that covers the surface of a metal or other material with a thin metal film (examples: gold plating or tin plating).

Coding

Processing performed on the housing in order to prevent incorrect insertion during connector mating.

Solid Wire and Stranded Wire

Both solid wire and stranded wire are conductor structures of cables. A solid wire is made of a single conductor, and therefore, the cable is somewhat rigid and is used for long-distance transmission. A stranded wire is made by grouping together several thin conductors, which makes the cable flexible so that it can be easily routed. However, it is unstable for long-distance transmission. At OMRON, we mainly use stranded cables.

Cat (Category)

A standard for Ethernet Cables and Connectors that indicates the transmission characteristics (communication speed). As the category number increases, it becomes easier to support high-speed communication. Choose and use Cables with Connectors of the recommended category or higher for the connecting devices.

STP and FTP

A cable in which two wires are twisted in a pair is called a twisted pair cable. Such a cable is less susceptible to noise and is therefore most popularly used as a communication cable including an Ethernet cable. When used in production equipment at a factory (FA), it is further shielded to improve noise resistance, and is called as STP (Shielded Twisted Pair) or FTP (Foiled Twisted Pair).

UTP

UTP (Unshielded Twisted Pair) is an unshielded (without shield) twisted pair cable. It is different from a shielded STP or FTP.

Single-Shield and Double-Shield Cables

Generally, shielded STPs or FTPs are used as Ethernet cables in production equipment at factories (FA). Single and double indicate the number of shields. The shield construction is expressed as overall/individual shield TP (twisted pair) such as F/UTP in the case of single shield and S/FTP in the case of double shield.

Straight and cross Cable (Connection)

A cable in which the wires do not cross each other (same pin array on both sides of the cable) is called a straight cable, and a cable in which the wires cross midway (different pin arrays on both sides of the cable) is called a crossover cable. At OMRON, we mainly use straight cables (connection).

PoE

PoE (Power over Ethernet) enables the supply of power to PoE-compatible devices using Ethernet cables of category 5 or higher and is standardized by IEEE802.3at. It saves wiring as an AC adapter is no longer required.

Configurations and Structures

Bus Line Connection

A form of connection in which multiple devices are connected one at a time to a single main line. As compared with other forms of connection, a shorter cable is required and a relay device such as a hub is not needed, which has the advantage of a lower construction cost.

Daisy Chain

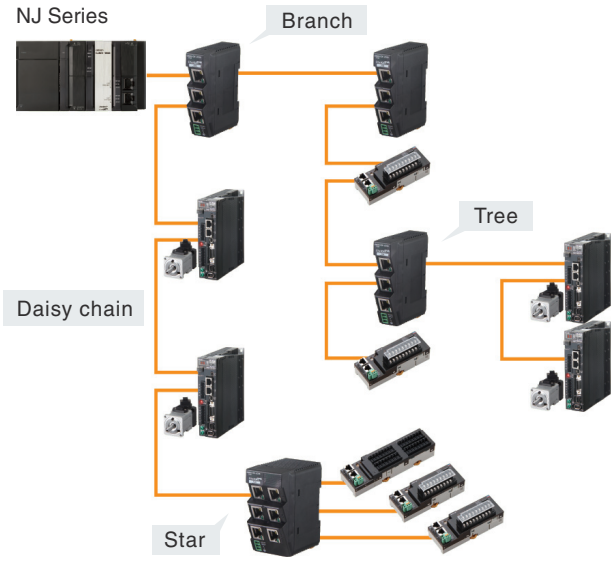
It is a technique of connecting peripherals or other devices with cables in which the devices are tied in a row. Wiring can be efficiently performed, and even if a cable fault occurs, it can be quickly replaced.

Tree Connection

A form of connection in which wiring and peripherals are connected on branches from one root node. Since the peripherals (nodes) are not mutually affected, this form of connection is strong against device failure.

Star Connection

A form of connection in which multiple peripherals (nodes) are wired in the shape of a spoke wheel through a switching hub. The degree of freedom of wiring is high and the cables connected to the switching hub are independent, because of which this form of connection has the advantage of being strong against device failure.



Electrical Performance

Rated Current

A current that serves as a reference for connector use.
The rated current is normally specified according to the temperature rise limit of the connector contact section, connection section, etc.

Rated Voltage

A voltage that serves as a reference for connector use

Contact Resistance

The electrical resistance between contacts when the connectors are mated in the normal usage state.
This electrical resistance is found by supplying the specified test current and measuring the voltage at the specified contact location. Therefore, this always includes the resistance of the contact conductors. Normally, a low-level contact resistance (measurement current: 100 mA max., open voltage: 20 mV max.) is given.

Insulation Resistance

The value of the resistance to the leakage current that flows through the insulator when the specified voltage is applied between adjacent contacts on the connector or between a contact and other adjacent metal.

Dielectric Strength

The limit to the voltage between adjacent contacts on the connector or between a contact and other adjacent metal for which no insulation breakdown, flashover, or other abnormality occurs within a certain time (normally, 1 minute).

Mechanical Performance

Insertion Tolerance

The minimum number of repeated connection (insertion) and disconnection (removal) operations that a connector can withstand.
The number of operations for which the base metal is first exposed is used as a guideline.

Note: This is not the number of operations that indicates the contact resistance rise limit.

Ambient Operating Temperature Range

The ambient temperature range around the connector in which it can be used in normal condition.
(There must be no condensation at low temperatures.)

Vibration

The range of mechanical vibration in which the connector satisfies its performance and characteristics requirements.

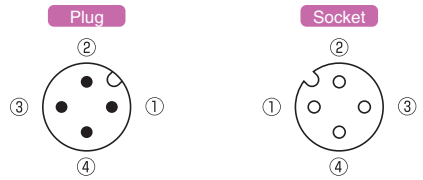
Information on Standards

IEC Standards: Specifications and Mating Dimensions

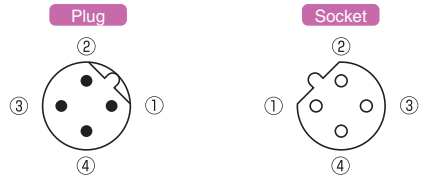
The specifications and mating dimensions of M12 Connectors comply with IEC 61076-2-101.

Coding Keys

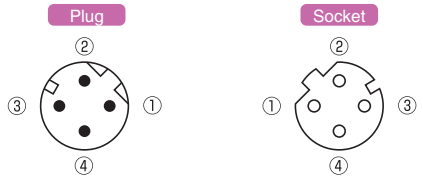
A-coding



B-coding



D-coding



Model Example

Model Example

For A-coding
XS5F-D421-C80-F
A-coding: For DC Sensors

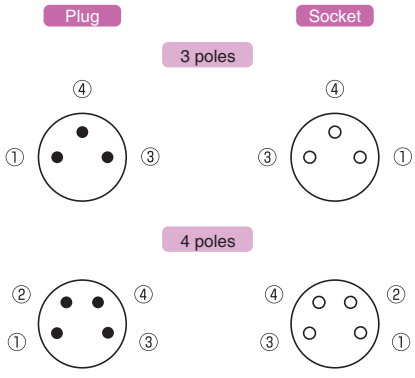
For B-coding
XS2F-A421-B90-F
B-coding: For AC Sensors

For D-coding
XS5H-T421-CM0-K
D-coding: For Industrial Ethernet

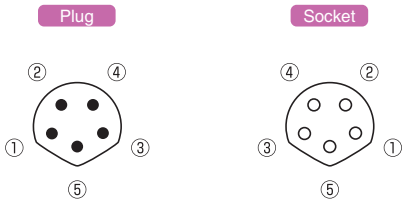
The specifications and mating dimensions of M8 Connectors comply with IEC 61076-2-104.

Coding Keys

A-coding (3, 4 poles)



B-coding (5 poles)



Model Example

Model Example

For A-coding
XS3F-M321-302-A
A-coding: 3 poles

XS3F-M421-402-A
A-coding: 4 poles

For B-coding
XS3F-M521-502-A
B-coding: 5 poles

Note: 1. Note that even if the coding is the same, the rated voltage and current value vary depending on the number of poles.

2. The pin arrangement is common for M12 connectors with 3, 4, and 5 poles.
Therefore, if coding is the same and "Number of poles of the plug < or = Number of poles of the socket", a connection can be achieved even with different number of poles (Example: An A-coded 4-pole plug can be connected to an A-coded 5-pole socket.).
In the case of an M8 connector, a connection cannot be completed if the number of poles is different.
Therefore always use a combination of a plug and socket having the same coding and number of poles.

3. In addition to the above, M12 connectors are available in 5-pole and 8-pole types. For details, see *DeviceNet Catalog* (Cat. NO. Q102-E1).

Cable Specifications

Industrial Ethernet Connectors

See *Product Lineup and Features* on page 3.

For the detailed information including standards, see *Industrial Ethernet Cables Catalog* (Cat. NO. G019-E1).

Sensor I/O Connectors

Cables with oil-resistance are used as standard (F-cable) for the XS5/2 Series cables.

Reference:

Cable specifications generally specify the following.

Example: Interpreting "UL AWM2464, 6-mm dia., 4 cores × AWG20 (0.08/110)" Standard Cable

- UL .....Indicates a UL-certified part.
- AWM2464 .....Specifies the rating, wire part name, and application.
- 6-mm dia. .....Specifies the cable outer diameter.
- 4×AWG20 .....Specifies that there are four core wires with a gauge of AWG 20.
  (0.08/110) .....Specifies that there are 110 wires with a diameter of 0.08 mm in the conductor section.
  (The smaller the wire diameter and the more wires there are, the higher the bending resistance.)

Technical Explanation for Push-In Plus Terminal Blocks

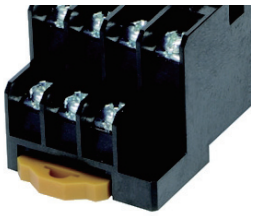
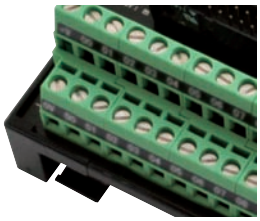
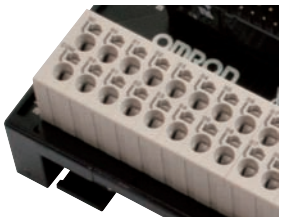
Introduction

What Is a Push-In Plus Terminal Block?

A push-in terminal block allows you to connect wires by just pushing them in. Reducing wiring work when building control panels can greatly reduce production work.
Push-In Plus Terminal Blocks were independently developed by OMRON for easier wire insertion and firmer wire holding ability than standard push-in terminal blocks.

Terminal Block Types and Connection Methods

General terminal block types and how to connect them are shown in the following table.

	Screw terminal blocks		Screwless terminal blocks	
Terminal block type	This type of terminal block is structured to connect and fasten wires or crimp terminals directly or with a washer at the bottom of the heads of the terminal screws.		This type of terminal block is structured to connect with the pressure of the spring directly or with a metal strip when you insert the wire between the conductive fitting and the spring.	
	For forked or round terminals	For pin terminals	Clamp type	Push-in type
Securing method	Screws		Springs	
Terminal blocks				
Applicable crimp terminals ✻1	Forked terminal, Round terminal 	Round pin terminal, Square pin terminal 	Ferrules ✻2 	
Connection steps	**Three-step connection** (1) Loosen the screw with the tool. (2) Insert the terminal. (3) Tighten the screw with the tool.		**Three-step connection** (1) Insert the tool. (2) Insert the ferrule. (3) Remove the tool.	**One-step connection ✻3** (1) Insert the ferrule.
Connection tool	Required		Required	Not required

✻1. Bare wires (solid or stranded) can also be used.
✻2. For details on ferrules, refer to *✻ What is a Ferrule?* on page 3.
✻3. A solid bare wire can be connected in one step, but a stranded bare wire requires three steps.

Mechanism of Screwless Terminal Blocks

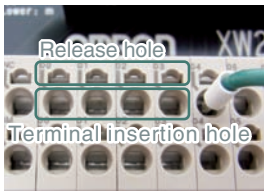
This section describes the mechanisms and connection methods for push-in and clamp type terminal blocks.

Push-in Type (Example for XW2R-P)

How to insert wire

Using Wires with Ferrules or Solid Wires

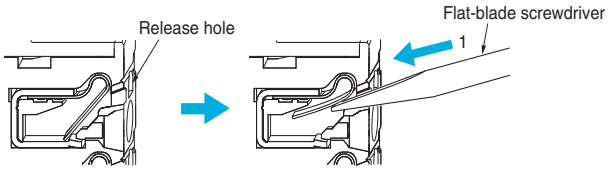
The wire should be pushed into the terminal block till stopping. The clamp spring opens automatically when the conductor is pushed in.
This applies the necessary force to the conductive fitting and the wire is held securely.



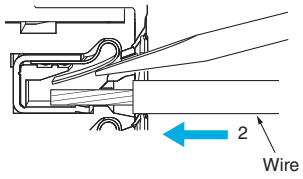
Using Stranded Wires

Wiring Completed in Three Steps

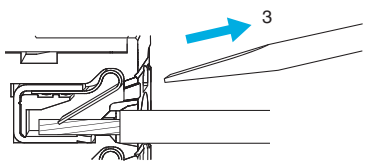
(1) Press the flat-blade screwdriver diagonally into the release hole.



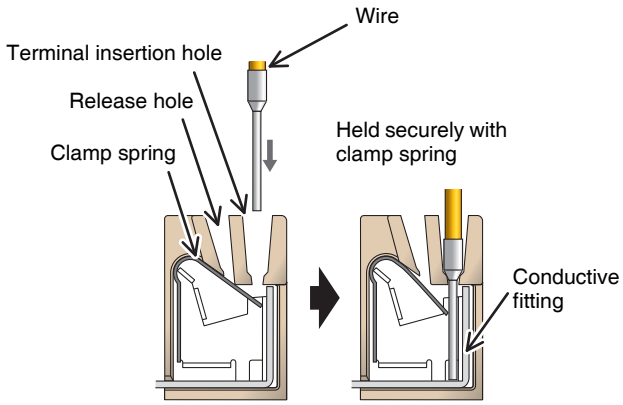
(2) Leave the flat-blade screwdriver pressed into the release hole and insert the wire into the terminal hole.
Insert the wire until the stripped portion is no longer visible to prevent shorting.



(3) Remove the flat-blade screwdriver from the release hole.
After you connect the wires, pull gently on the wire to make sure that it will not come off and the wire is securely fastened to the terminal block.

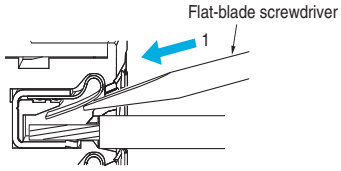


Wiring Completed in One Step

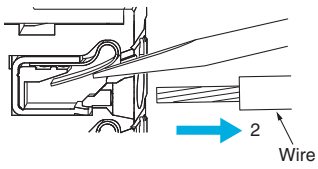


How to release wire (Same for Wires with Ferrules, Solid Wires, or Stranded Wires)

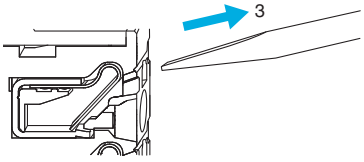
(1) Press the flat-blade screwdriver diagonally into the release hole.



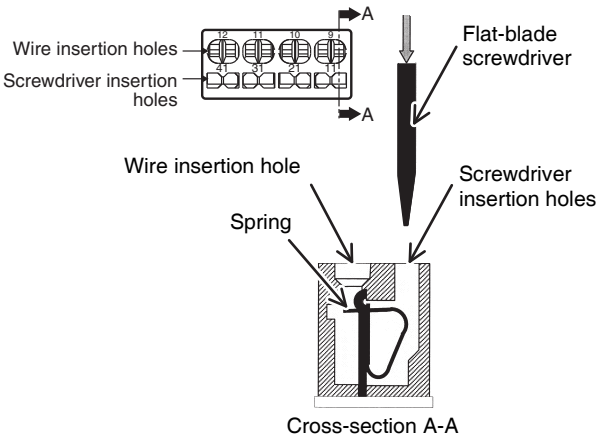
(2) Leave the flat-blade screwdriver pressed into the release hole and pull out the wire.



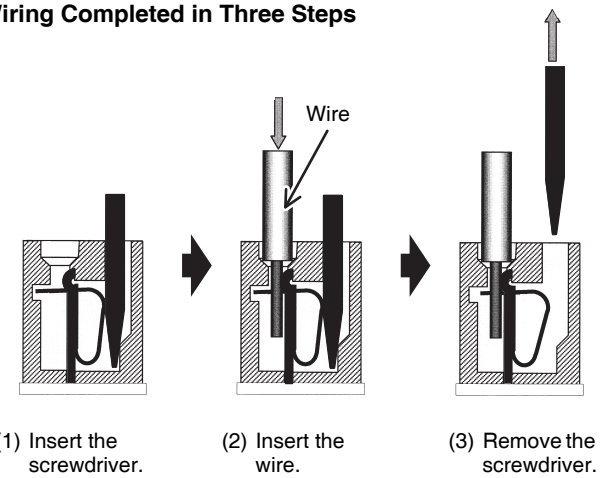
(3) Remove the flat-blade screwdriver from the release hole.



Clamp Type (Example for PYF□□S)



Wiring Completed in Three Steps



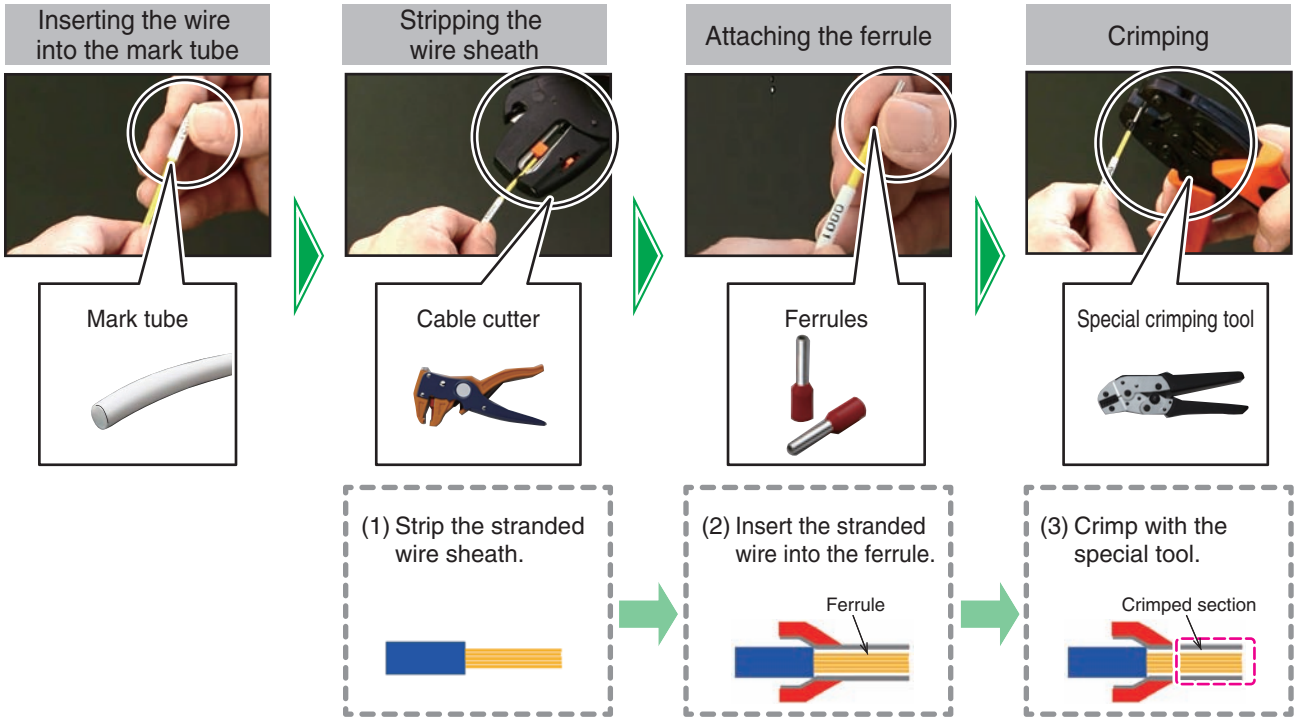
(1) Insert the screwdriver into the screwdriver insertion hole. (The spring at the back of the wire insertion hole will be open.)
(2) Insert the wire or terminal into the wire insertion hole.
(3) Remove the screwdriver. The spring will hold the wire.

✻ What is a Ferrule?

Ferrules are a European type of pin terminal to prevent unraveling of stranded wire and to stabilize the quality of electrical connections. They are smaller than standard pin crimp terminals and were designed to reduce the size of terminal blocks.

General Ferrules

<Reference Information>
The processing flow for wires with ferrules is as follows:



Note: 1. Attaching the ferrule to the wire requires a crimping tool.
2. For information on recommended ferrules and crimping tools, refer to the datasheet of individual products.

Differences between Push-In Terminal Blocks and Push-In Plus Terminal Blocks

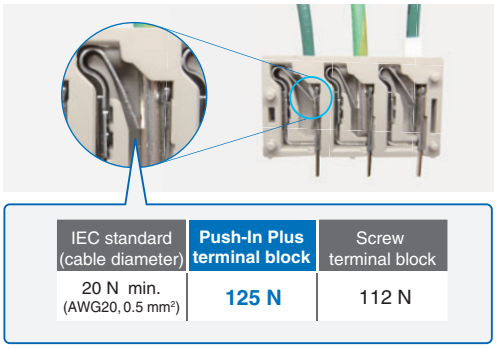
Push-In Plus Terminal Blocks use technology for easier wire insertion with firmer wire holding ability than previous push-in terminal blocks. They help reduce the time and work involved in wiring.

Easy to Insert

OMRON's Push-In Plus terminal blocks are as easy as inserting to an earphone jack. They help reduce the work load and improve wiring quality.

Held Firmly in Place

Even though less insertion force is required, the wires are held firmly in place. The advanced mechanism design technology and manufacturing technology produced a spring that ensures better workability and reliability.



IEC standard (cable diameter)	Push-In Plus terminal block	Screw terminal block
20 N min. (AWG20, 0.5 mm²)	125 N	112 N

✻ Information for Push-In Plus terminal blocks and Screw terminal blocks is based on OMRON's actual measurement value data for the XW2R.

Work with Both Hands

Optimized shape to hold the screwdriver was created by the resin parts and the spring.
Work goes smoothly when connecting stranded wires directly to the terminal because it's easier to aim at the desired terminal.

Products That Support Push-In Plus Terminal Blocks

(As of October 2019)

- Switch Mode Power Supplies
- Noise Filter
- DC Electronic Circuit Protector
- Low Voltage Switching Gears
- Sockets
  For Relays (MY, LY, G2R-S)
  For Relays with Forcibly Guided Contacts (G7SA)
  For Timers (H3Y-□-B and H3YN-B)
  For Liquid Leakage Sensor Amplifiers (K7L-□□B)
- Slim I/O Relays
- Terminal Relay
- I/O Relay Terminal
- Solid State Relays for Heaters
- Solid State Timer
- Measuring and Monitoring Relays
- DIN Track Push-in Terminal Blocks
- Common Terminal Blocks with Visible Indicators
- Power Monitors
- Uninterruptible Power Supply (UPS)
- Pushbutton Switches
- Emergency Stop Pushbutton Switches
- Digital Temperature Controller
- Machine Automation Controllers
- EtherCAT Slave Terminals NX-Series

Refer to the Panel Solution site (www.ia.omron.com/solution/panel/) for details.