YASKAWA
PARTNER SUPPORT
Shared Integration Experience

This document captures ideas, experiences, and informal recommendations from the Yaskawa Partner Support team. It is meant to augment – not supersede manuals or documentation from motoman.com. Please contact the Partner Support team at partnersupport@motoman.com for updates or clarification.

Industrial Networking Options for Motoman Robot Controllers and Using Ethernet/IP

Introduction

As industrial Ethernet now outpaces traditional fieldbus in popularity, what are the latest options for connecting robotic systems to a network? This document will cover the various networking communication protocols available from Yaskawa Motoman, with a strong focus on concepts for implementing Ethernet/IP and Ethernet/IP Safe.

What is an Industrial Network?

An industrial communication network is a special type of data network made to handle **real-time control** and **data integrity** in harsh environments over large installations. It is a way to connect instruments and devices in a manufacturing plant.

An industrial network typically consists of:

- a single cable type that allows for quick connect/disconnect of replacement devices
- simple integration of new devices
- easy configuration and communication between the devices
- delivery of diagnostic data
- and other features to help workers maintain a control system more efficiently
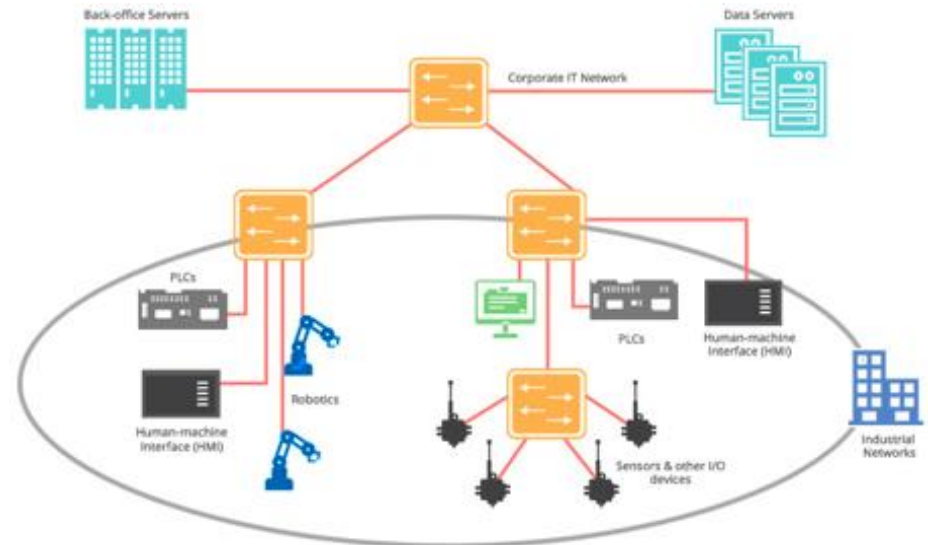
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Industrial Network Options for YRC1000

Yaskawa offers a wide range of industrial networking options (too many to detail here) and they change as market demands and technology evolves. This is just a sample of the options for our YRC1000 controller:

- AS-Interface
- CanOpen
- CC-Link
- CC-Link IE Field
- DeviceNet
- EtherCAT

- Ethernet/IP
- Modbus/TCP
- Powerlink
- Profibus
- Profinet

We also offer several Industrial Safety Network options (defined later).

<u>Safety Networks</u>

- DeviceNet Safety
- Ethernet/IP Safe
- Profisafe

Check with your Yaskawa Motoman sales contact for other controllers, or search https://www.motoman.com. We can probably work with whatever you need.

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Industrial Networks Trends (May 2020)

So, which network type do you choose? Let's look at some market share data and industry trends.

The graphic at the right is from HMS networks. It shows market share, by network protocol for new installations. Some conclusions from their study:

- Industrial Ethernet now makes up 64% of the global market of new installed nodes (compared to 59% last year and 46% in 2017).
- HMS estimates a Fieldbus decline to 30% of new installed nodes (compared to a 35% last year).
- Wireless technologies keep a 6% market share, with WLAN still being the most popular technology, followed by Bluetooth.

Regionally, the US market is dominated by Ethernet/IP.

in Europe and the Middle East Ethernet/IP and PROFINET are leading with PROFIBUS and EtherCAT as runners up. Other popular networks are Modbus (RTU/TCP) and Ethernet POWERLINK.

A fragmented Asian market is led by PROFINET and Ethernet/IP, followed by PROFIBUS, EtherCAT, Modbus (RTU/TCP) and CC-Link/CC-Link IE Field.

Clearly, varieties of Industrial Ethernet and more specifically Ethernet/IP is rapidly becoming the Industrial Network of choice for new installations. The remainder of this document will focus on providing more information on what Ethernet IP is, why to use it, how to use it and capabilities that are added by Industrial Ethernet/IP-SAFE.
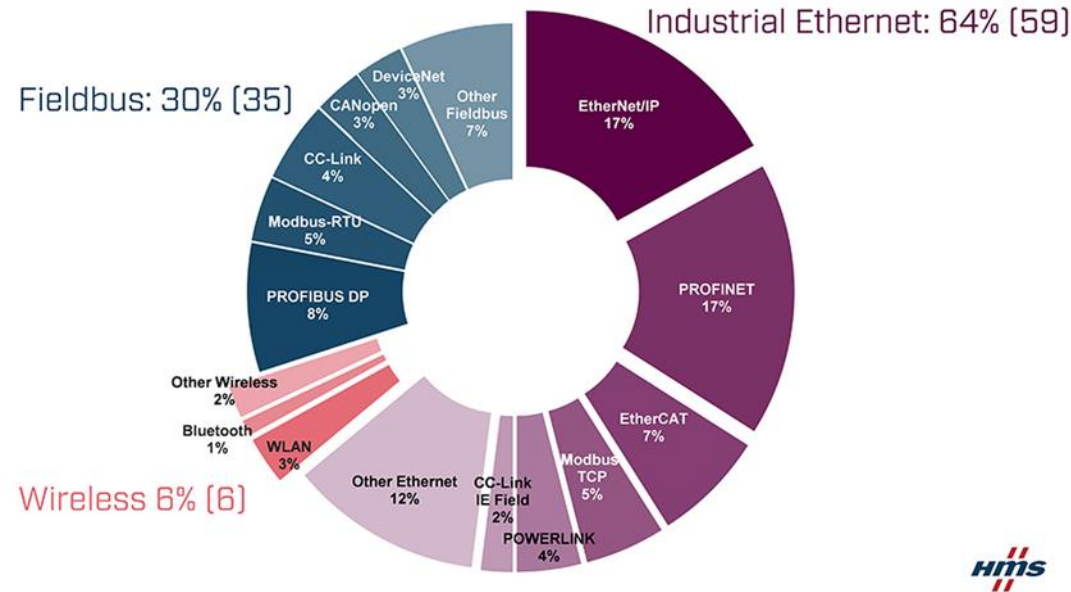
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Ethernet/IP – What is it?

Ethernet/IP (EIP) is an industrial networking protocol (language) built on top of the same Ethernet technology you may already be familiar with. Our home and office networks use the exact same physical connections and lower level protocols (such as TCP/IP) as are used in EIP. The model to the right shows Ethernet physical connections on the bottom, being used with TCP/IP protocol in the middle and the "CIP Stack" of protocols for industrial networks at the top. The difference between an EIP industrial network and a home Ethernet-based network is how the network is being used (software applications) by the devices connected to it. EIP uses the Common Industrial Protocol (CIP) shown at the top of the model here. Our home and office networks use "applications" like HTTP for websites, ping for testing, and others instead of CIP.

Think of the network like a system of roads, with your car being what is used as a transportation application at the top. We can just as easily drive trucks (for our industrial needs) as cars on the same network of roads. This is one of the benefits of EIP: you can simultaneously use TCIP/IP and applications on the same network.

It may be helpful to understand that the "IP" in Ethernet IP stands for "Industrial Protocol". The "IP" in TCP/IP stands for "Internet Protocol".

## Ethernet/IP – Why use it?

Ethernet/IP can use standard Ethernet cabling and hardware, but can also use industrialized / waterproofed connector technologies (circular connectors, etc.)

This makes it easy and inexpensive to setup a network with standard office-based networking equipment and cables. The industrialized components are optional. Many people are already familiar with the basic networking concepts and products used for home or office Ethernet-based networks. Simple PC network skills can assist with troubleshooting. For example, the ping command can be used to verify other devices can be reached on the network.

Ethernet/IP Installation in Robot Controller

DX200 and YRC1000 Ethernet/IP must be installed by Yaskawa. The software option requires "Yaskawa level" user security to enable the option. Once enabled end users can configure the IP addresses and other parameters with the "management" mode password.

Communication functions like MotoCom, WeldCom, FTP, etc. - can all co-exist using the same LAN port with no conflicts.
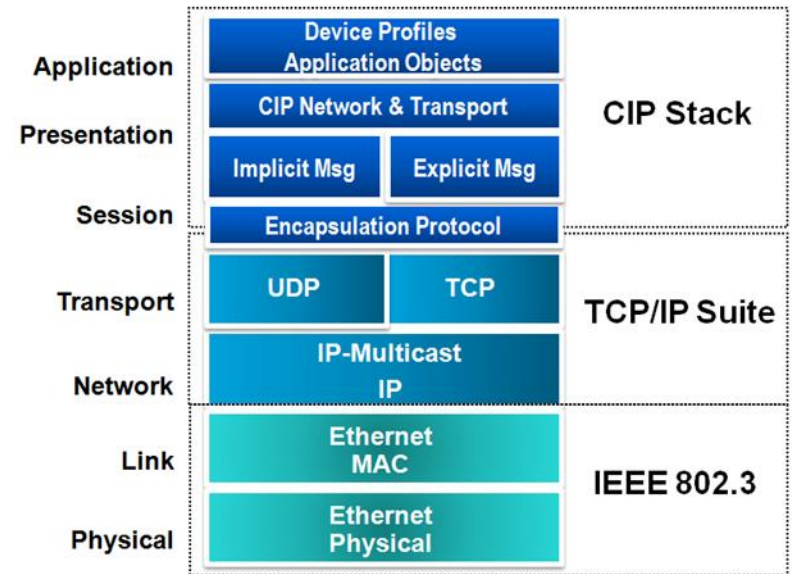
Ethernet/IP – Device Types

There are 2 two types of devices in an Ethernet/IP network: Scanners and Adapters. When you add a new EIP device to your network, you will need to configure them using these terms.

The **Scanner** opens connections and initiates data transfers. It is the "upper level" device on the Ethernet/IP network. Most of the time a scanner is a PLC. In our case, this can also be the robot controller.

The **Adapter** provides data to Scanners. These are typically sensors or actuators. They provide data or wait for instructions

Ethernet/IP – Communication Settings

Continuing with the definition of terms you will need to understand as you build your Ethernet/IP network, there are several communication schemes available:

- Unicast (One-to-One.) Unicast or Point to Point is a connection for the transmission of data to a single device.
- Multicast (One-to-Many) Multicast is the single transmission of an I/O data packet that may be consumed by multiple devices using multicast IP and Ethernet destination addresses.

There are also some "Communication Modes" you should be familiar with:

- Class 1 I/O Connection – "Implicit Messaging". This is the most familiar communication method in use for fieldbus (industrial) communication. It allows reading and writing to bit level I/O.
- Class 3 Messaging – "Explicit Messaging". Explicit messaging is useful when reading or writing to existing multi-byte data structures in the robot controller. For example: **B**yte, **D**ouble, **I**nteger, **R**eal, **S**tring, and ***Position Variables***. The Explicit Message system provides a cleaner way to work with the complex variables, allowing you to directly reference the variable in your PLC logic, versus writing logic to construct and deconstruct these variables bit by bit. One of the most powerful examples is when using Position Variables. Explicit messaging allows you to reference a specific position of the robot in your PLC logic using one variable name. NOTE: *Explicit messaging is not available when Ethernet/IP Safe enabled*.

I/O Assignment Types

The last category of configuration information we will discuss has to do with I/O assignment types. The two types are Exclusive Owner (Unicast) and Input Only (Multicast).

ExclusiveOwner (Unicast)

This is the basic connection method that has been available since the Motoman NX100 implementation. 99% of the configurations use this setting. Start with this for the default selection, unless there is specific advice to do differently.

InputOnly (Multicast)

An Input Only I/O assignment must not have any output information configured (set this to zero). It is extremely rare. A managed switch is a hardware-based solution to these issues.

Entering Communication Parameters in the Controller

Now that we understand the terminology used to create a network based on Ethernet/IP, let us look at how we configure a robot controller to communicate with another device in an EIP network.

You will need to research the communications parameters required for the device you are connecting to. The manufacturer should provide:

- Input Size
- Output Size
- Configuration Size
- Input Instance ID
- Output Instance ID
- Configuration Instance ID

To the right is a screen shot of the DEVICE INFORMATION page on the pendant that is used to define a device the controller will talk to.

To get to this screen, you will need to start the controller in Maintenance Mode and change the security level to MANAGEMENT. Then, select SETUP, OPTION FUNCTION, Ethernet/IP (CPU board). This is the Device Information DETAIL screen.

Navigate through the different communications parameters, setting them according to the manufacturer's data. When finished, press ENTER and confirm these are the settings to be used.

Additional information on setting up devices with Ethernet/IP is available at motoman.com for each controller model.

Where does the I/O go?

Let us take a quick look at the way I/O is mapped for a hypothetical 20 byte "Adapter" configuration for the robot. This is a typical starting configuration when the robot is communicating with a PLC.

Assuming no other communication boards are installed, then the mapping follows this basic approach:

Usage	Size (Bytes)	External IN Starting Address	External IN Ending Address	User I/O Starting	User I/O Ending
Status Byte	1	#20060	#20067	IN 25	IN 32
Reserved	1	#30060	#30067	OUT 25	OUT 32
Inputs	20	#20070	#20267	IN 33	IN 192
Outputs	20	#30070	#30267	OUT 33	OUT 192

The robot controllers do not map the Configuration Data structure. This can be a challenge to use some devices, that NEED access to this data.

• For example – IOLink devices typically have a large chunk of Configuration Data. For that reason, we recommend caution when working with IOLINK. Contact Yaskawa support for questions

Because the robot controller does not use the Configuration Data structure, it seems that invalid Configuration IDs and Sizes can be entered with successful communication resulting.

Troubleshooting

After you have defined all your devices and input the correct parameters, you may find the communications to / from the controller have not been established. Why isn't it communicating? Here are some common issues:

Check your input and output data sizes on all networked components. Note: the robot's data size is in bytes (8 bits). Rockwell's adapter defaults to DINT (32 bits). Be sure to change this setting, if needed. Don't forget: 1 word = 2 bytes.

Check your instance numbers. If the values look correct, try swapping them. Input for one device will be output from the device communicating with it.

Your Scanner and adapter should be on same network subnet! Commonly, a subnet is defined by the first three numbers in an IP address. For example, 192.168.1 Devices are then given a unique number, entered in the last position, .31, .40, etc. There may be exceptions to these rules, but it is a common issue for numbers to be input incorrectly.

Details to Remember

A note about Device Specifications: To re-emphasize the point above,

- The **Input** Instance at a peripheral device would be referred to on the controller as an **Output.**
- The **Output** Instance at a peripheral device would be referred to on the controller as an **Input.**

NOTE: Generally, this is the right approach. If it does not work the first, time try to switch it.

When the controller is setup as a Scanner, it must know the IP Address of each Adapter in the network.

When the controller is setup as an Adapter, other scanners are expecting it at a specific IP address.

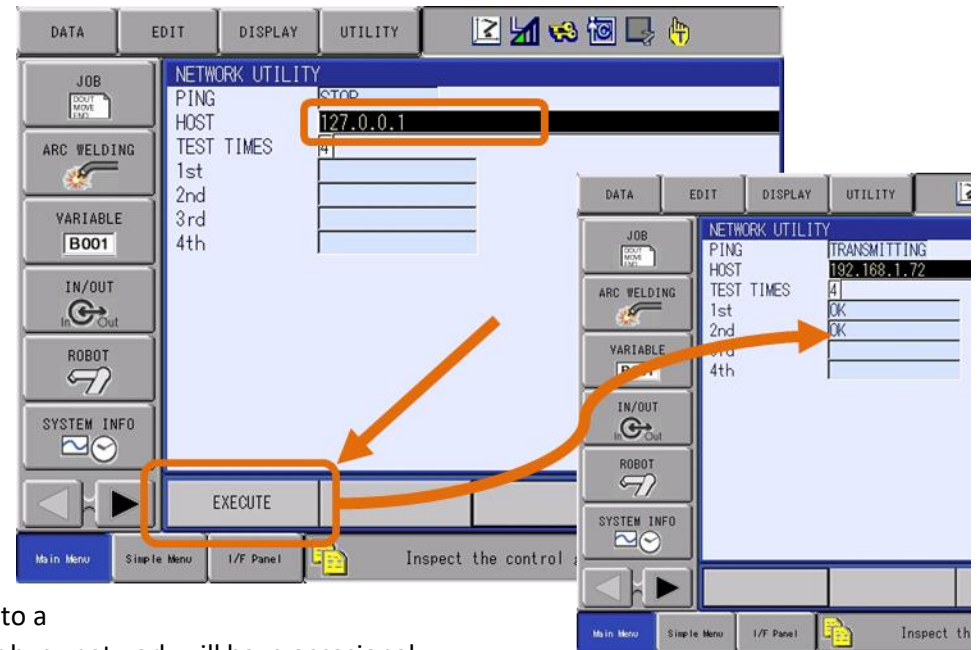Using static IP addressing in all instances is helpful!

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Ping from the Robot Controller

To verify the correct network settings are in place, there is a "ping" function available as part of the TCP/IP applications included on most networked systems. (The name comes from submarine active sonar terminology that sends a pulse of sound and listens for the echo to detect objects under water.) A device can send a "ping" network packet targeting other devices on the network and listen to see if there is a response and how long it takes to return.

A newer feature in DX200 and YRC1000 allows pinging from the robot controller to other devices on the network. The ping function is available from the teach pendant under SYSTEM INFO, NETWORK UTILITY. As shown below, enter the IP address you want to verify is reachable and click the EXECUTE button at the bottom of the screen. If the device can be reached, you will see "OK" as the status for each ping. If it cannot be reached, the status will indicate "TIMEOUT".

To identify intermittent issues, increase the "TEST TIMES" from the default of 4 to a larger value (perhaps 100) and watch the results carefully. A poor connection or busy network will have occasional time outs reported.
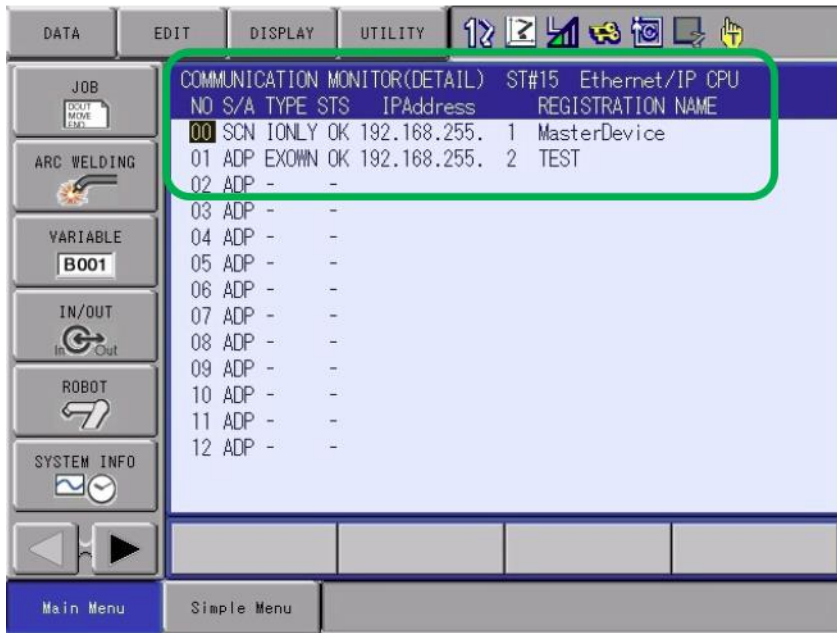
Checking Communication Status from the Pendant

Also, new is the COMMUNICATION MONITOR function, available from the teach pendant under IN/OUT, then COMMUNICATION MONITOR. (See below.)
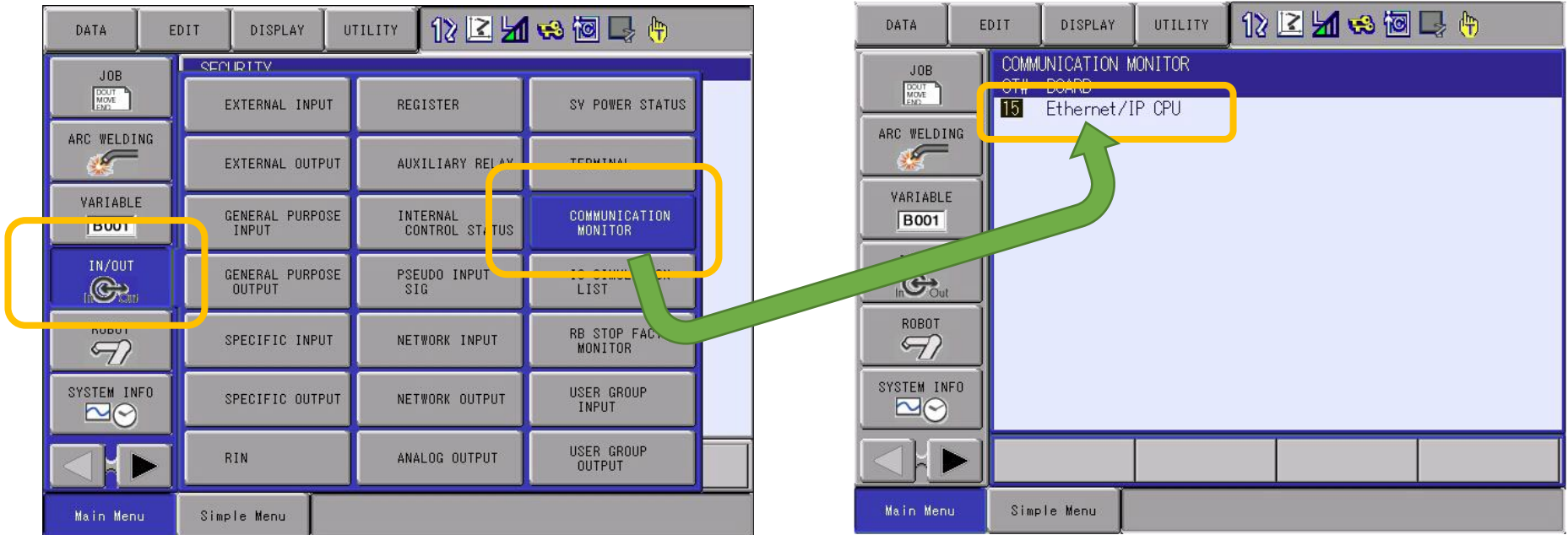
Select Ethernet/IP CPU, to see summarized status for the scanner and adapter entries in your network, as shown below.

Item	Contents
NO	"00": Scanner.
	"01" to "32": Adapter.
	In the line of No.00, the setting information and the I/O communication status of the scanner are shown.
	In the line of No.01 to 32, the setting information and the I/O communication status of the adapter which is registered with each number in *chapter 4.2.5 "Scanner Setting"* are shown.
S/A	The station type of the device is shown in this area.
	"SCN": The communication target is the scanner.
	"ADP": The communication target is the adapter.
TYPE	The communication type is shown in this area.
	"IONLY": The connection type is InputOnly.
	"EXOWN": The connection type is ExclusiveOwner.
	"-": No setting of the device.
STS	The I/O communication status is shown in this area.
	"OK": The communication with the communication target is established.
	"NG": The communication with the communication target is not established.
	"-": No setting of the device.
IPAddress	The IP Address of the device which communicates with the YRC1000 is shown in this area.
	Until the communication with the scanner is established, "0.0.0.0" is shown in the line of No.00's IP Address.
REGISTRATION NAME	The registration name of the device which communicates with the YRC1000 is shown in this area.
	In the line of No.00, "MasterDevice" is shown.
	In the line of No.01 to 32, the registration names of the adapter which is registered with each number in *chapter 4.2.5 "Scanner Setting"* are shown.

You can also select an individual "NO" for detailed status. The status codes and explanations are available in the Ethernet/IP Communication Manual, starting on page 68.

Ethernet/IP-SAFE – What is it?

Ethernet/IP Safe is the implementation of the CIP *safety* protocol on Ethernet/IP networks. This allows the controller to pass safety information, to a "safety PLC". Also, the PLC can instruct the robot to engage specific safety functions such as: E-Stop CAT0/CAT1, Ext Safety Gate, Ext Deadman Switch, Ext E-Stop PB

The robot can send the PLC status of safety signals as single bits, instead of hardwiring: Wired E-Stop status, Servo On, Teach/Play, Deadman, etc.

These inputs can also be used in conjunction with the Functional Safety Unit (FSU) to activate functions, or as status outputs to report back to the Safety PLC. The Safety Field Bus I/O can be used with the robot controller's Safety Logic Circuit to generate basic cell logic.

Note: Cat 4 Pld safety level is _possible_ with this communication interface. But the overall safety level of the controller is limited to Cat 3 due to other equipment limitations.

Ethernet/IP-SAFE – Why use it?

What is gained by Ethernet/IP-Safe? It allows the robot to be an adapter, (Secondary), to a Safety PLC (such as Rockwell's GuardLogix). Putting the robot on the same network as the safety PLC reduces wiring of safety interfaces, resulting in quicker time to project completion.

When using GuardLogix, the standard logic and safety logic is developed within the same program/environment – not duplicated or coordinated amongst multiple platforms. This makes troubleshooting, tag sharing, HMI development, and commissioning easier. Development staff needs to understand only one PLC platform – not multiple platforms.

Some benefits of safety networks include the following: larger numbers of safety devices such as failsafe motor starters and safety drives can be put on the network; more and better diagnostics that provide a direct and positive impact on reducing downtime; a large amount of safety data can be passed over the network in a failsafe way; and better support for wireless safety, including mobile HMI panels with E-stop functionality.

In addition, safety networks safety networks based on Ethernet/IP -safe have the advantages of:

1. Reduced wiring - No need for dual channel wiring and cables from each robot controller to the PLC. Quicker integration time
2. Familiarity - For example, if you already understand Ethernet/IP, you will be able to integrate to Ethernet/IP-Safe very easily.

3. Common network hardware (cabling / switches / software / troubleshooting). - Ethernet/IP and Ethernet/IP-Safe co-exist on same network. (Same as for DeviceNet-Safe and PROFIsafe.)

4. Ideal solution when several robot controllers will interface with an upper level PLC. In this case, the typical cell control PLC can also perform Safety PLC functions with one software package and hardware solution.

   • Rockwell (GuardLogix family)   Ethernet/IP Safe & DeviceNet-Safe

   • Siemens (F-Series)   PROFIsafe

   • Omron (ex. NE1A-SCPU)   DeviceNet-Safe

5. If communication failure occurs, slave devices can be configured to power off or fail into a safe state

Ethernet/IP Add On Profile

Rockwell has an Add on Profile (AOP) available to help define the EIP-SAFE connection. This allows one Ethernet/IP scanner card (ex. 1756-EN2T) in the PLC to connect to the robot controller as two types of adapters: both Ethernet/IP (generic) and Ethernet/IP-Safe

Prior to this AOP, two scanner cards needed to be added to the PLC, or an expensive router would need to be added to the system to translate the hostname to an IP address. Note: a limitation in Rockwell software does not allow same IP address to be listed twice under the same Scanner card "tree"

This is available in Studio5000 v24.00 or above.
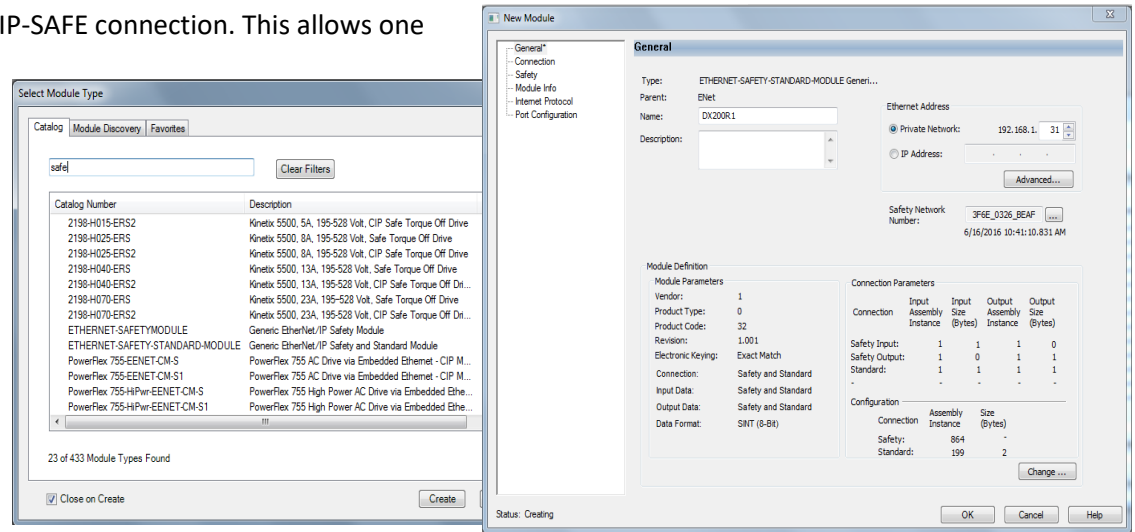
Yaskawa Motoman Industrial Safety Networks: Summary

The following safe industrial network communications are currently available for YRC1000:

- DeviceNet – Slave only
- Ethernet/IP – Slave only
- PROFIsafe – Slave only

The following safe industrial network communications are currently available for DX200:

- DeviceNet – Slave only
- Ethernet/IP – Slave only
- PROFIsafe – Slave only

The FS100 and YRC1000micro do not support any type of industrial safety network.

Additional Resources

For Documentation on our Industrial Networking Products, see https://www.motoman.com/en-us/service-training/product-documentation

For Technical Training, go to: https://www.motoman.com/en-us/service-training/academy/training

For Technical Support, our 24-hour Hotline is 937.847.3200