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# H5U and Easy Series Programmable Logic Controllers

## Programming and Application Guide

Industrial Automation

Intelligent Elevator

New Energy Vehicle

Industrial Robot

Rail Transit

Data code 19012249 A11

# Preface

## Introduction

The H5U series Programmable Logic Controller (PLC), a new generation of small-sized PLC developed by Inovance, supports EtherCAT bus communication and features powerful motion control and distributed I/O control functions. It allows process encapsulation and reuse using the FB/FC function, as well as multi-layer network communication through the RS485, CAN, Ethernet, and EtherCAT interfaces.

Easy series small- and medium-sized PLCs are available in eight models, covering the demands of automation equipment requiring small footprint, multi-axis motion control, accurate temperature control, and easy networking.

This guide describes the basic knowledge, quick start guide, communication, motion control, and high-speed counter of H5U and Easy series PLCs.

## Related Manuals

| Data Code | Doc Name | Description |
|---|---|---|
| 19011419 | H5U Series Programmable Logic Controller User Guide | Describes installation and wiring of H5U series programmable logic controller. |
| PS00006444 | Easy Series Programmable Logic Controller User Guide | Describes installation and wiring of Easy series programmable logic controller. |
| 19012250 | H5U&Easy Series Programmable Logic Controller Instruction Guide | Describes basic instructions and examples of H5U&Easy series programmable logic controller. |

## Revision

| Date | Version | Revision |
|---|---|---|
| May 2023 | A11 | Added the BYTE variable and section 3.3.7 "Defining Specific Unions."<br>Added section 3.11.5 "Encrypting Function Blocks (FB) or Functions (FC)".<br>Added section 3.12 "Folder" for program blocks, function blocks (FBs), and functions (FCs).<br>Added local extension modules GL20-2SCOM and GL20-2S485 (see section 5.2.2.3.7 "Communication Modules").<br>Added section 5.4 "GR10-EC-6SW Branch Module" and section 5.5 "GS20-ECT-8L Module."<br>Added the H5U series PLC PROFINET communication function (see section 11.1 "Overview").<br>Corrected details of the earlier version. |
| January 2023 | A10 | Added local modules.<br>Corrected details of the earlier version. |

| Date | Version | Revision |
|---|---|---|
| November 2022 | A09 | Added the LiteST programming language.<br>Added section 10.3.4 "EtherNet/IP Slave Application Example" and section 10.3.1.4 "Exporting EDS Files".<br>Added section 6.3.2 "Free Protocol Cancellation (SerialSR Instruction)."<br>Added section 6.7 "Modifying Serial Port Parameters."<br>Added models of extension modules supported by Easy series host and running cases of all modules.<br>Added extension modules and use methods of GL20-RTU-ECT coupler.<br>Corrected details of the earlier version. |
| September 2022 | A08 | Added the EIP function.<br>Added use methods of IP variables.<br>Added Easy series functions.<br>Corrected details of the earlier version. |
| August 2021 | A07 | Added the method of setting the FB default.<br>Added graphic block functions of quickly increasing or decreasing label numbers and implementing incremental paste.<br>Added the function of packing and decompressing project archives.<br>Added the function of uploading and downloading Updown files.<br>Added the function of setting axis settings parameters by instructions.<br>Added the function of dragging the motion control axis.<br>Added the function of disabling the EtherCAT slave station by instructions.<br>Corrected details of the earlier version. |
| May 2021 | A06 | Kept the material versions consistent. |
| March 2021 | A03 | Added chapter 16 "Electronic Cam."<br>Added chapter 15 "Bus Encoder Axes."<br>Added chapter 17 "Offline Commissioning."<br>Added chapter 18 "Memory Management."<br>Corrected details of the earlier version. |
| August 2020 | A02 | Optimized the function of binding structure variables to soft elements.<br>Added the function of setting IP addresses using system variables.<br>Added the function of binding array variables to soft elements.<br>Corrected details of the earlier version. |

| Date | Version | Revision |
|---|---|---|
| May 2020 | A01 | Added hard limit processing and the function of automatically starting the EtherCAT slave station, and updated the software UI.<br>Added the interpolation function and axis group configuration.<br>Added the Down file download and login functions.<br>Updated motion control axis fault codes. |
| February 2020 | A00 | First release |

### *Note*

This guide is applicable to AutoShop V4.4.0.0 and PCB software V5.0.0.0 and later version.

## Document Acquisition

This guide is not delivered with the product, but an electronic PDF version is available. To obtain it, visit

- *www.inovance.com*, click Downloads, search for the keyword, and download the guide.
- Scan the QR code on the controller using your mobile phone to obtain a complete set of product manuals.

## Warranty

For faults or damage that occur during normal use within the warranty period, Inovance provides free repair service. (For details about the warranty period of the equipment, see the order list.) When warranty expires, maintenance fee will be charged by Inovance.

Within the warranty period, maintenance fee will be charged by Inovance for the following damage:

- Damage caused by improper operation
- Damage caused by fire, flood, or abnormal voltage
- Damage caused by use beyond the intended scope of application
- Damage caused by use under unintended working conditions
- Secondary damage caused by force majeure events (such as natural disaster, earthquake, and lightning stroke)

The maintenance fee is charged according to the latest Price List of Inovance if not otherwise agreed upon.

For details, see the Product Warranty Card.

# Table of Contents

# 1 Overview

## 1.1 Introduction

### 1.1.1 Product Introduction

The H5U series PLC, a new generation of small-sized PLC developed by Inovance, supports EtherCAT bus communication and features powerful motion control and distributed I/O control functions. It allows process encapsulation and reuse using the FB/FC function, and multi-layer network communication through the RS485, CAN, Ethernet, and EtherCAT interfaces.

Easy series small- and medium-sized PLCs are available in eight models, covering the demands of automation equipment requiring small footprint, multi-axis motion control, accurate temperature control, and easy networking.

### 1.1.2 Software Introduction

AutoShop is programming configuration software provided by Inovance for small-sized PLCs. It provides a friendly programming and commissioning environment and supports various and powerful communication and control functions. AutoShop supports various programming languages, such as the ladder diagram (LD), sequential function chart (SFC), and structured text (LiteST).

AutoShop has the following features:

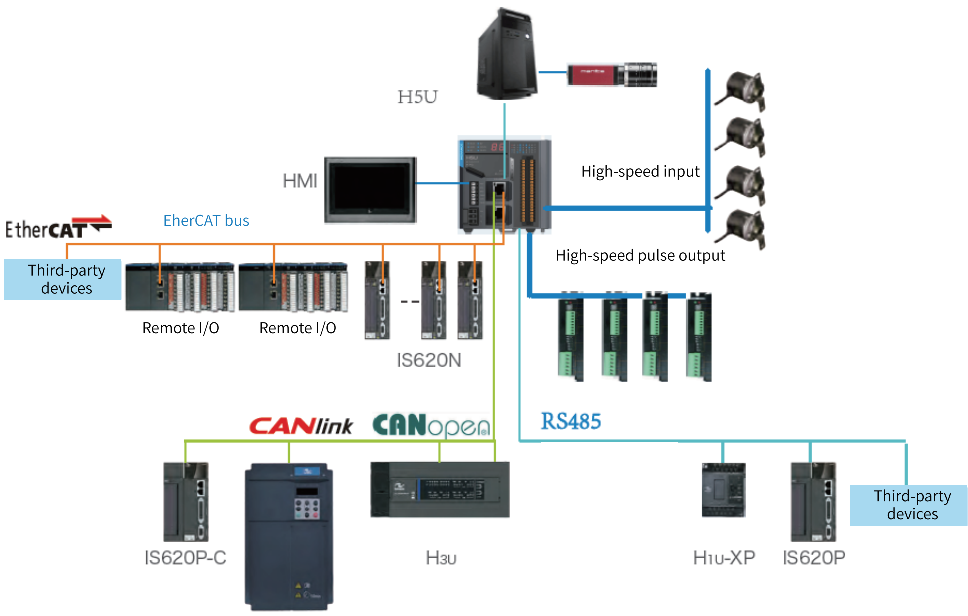
- Flexible communication mode: This feature allows AutoShop to communicate with PLC through COM, USB, and Ethernet. It enables the remote operation and remote collaborative commissioning functions for users, greatly facilitating users.
- Powerful network support: This feature enables the Modbus standard communication function based on configuration and supports CANopen communication configuration and Inovance CANlink communication configuration, greatly reducing difficulties and improving the working efficiency.
- Powerful motion control function: AutoShop has abundant motion control instructions and supports many functions such as the G codes, axis positioning, electronic cam, and flying shear/chasing shear.
- Convenient and diverse commissioning methods: AutoShop supports various functions such as motion profile graphics, monitoring, online modification, oscilloscope, and fault diagnosis, facilitating user commissioning and localization.
- Powerful intellectual property protection function: Functions such as upload password, download password, identifier, and upload forbidding help to effectively protect the intellectual property.

### 1.1.3 Networking Schemes

#### H5U series networking scheme

H5U provides the EtherCAT, CAN, Ethernet, and RS485 interfaces to implement multi-level network communication and meet requirements of multiple scenarios. It is equipped with four high-speed inputs, four medium-speed inputs, and four high-speed outputs, which can realize 4-axis pulse output and 4-axis encoder counting.

The following figure shows a typical application topology.




## Easy series networking scheme

Two Easy series models are used as an example to introduce the typical application topology, as shown in the following figures.

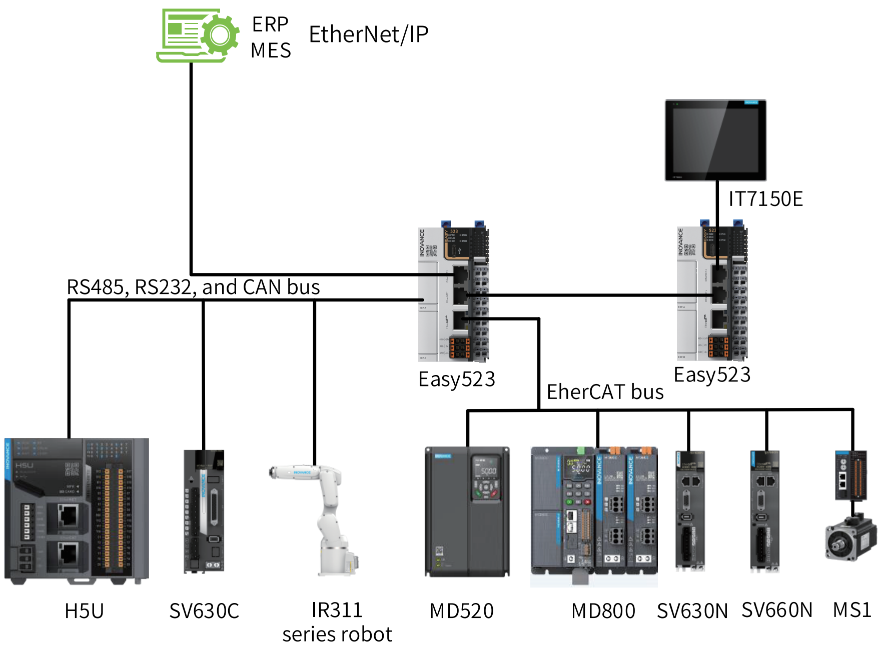



Figure 1-1 Easy523 series application topology

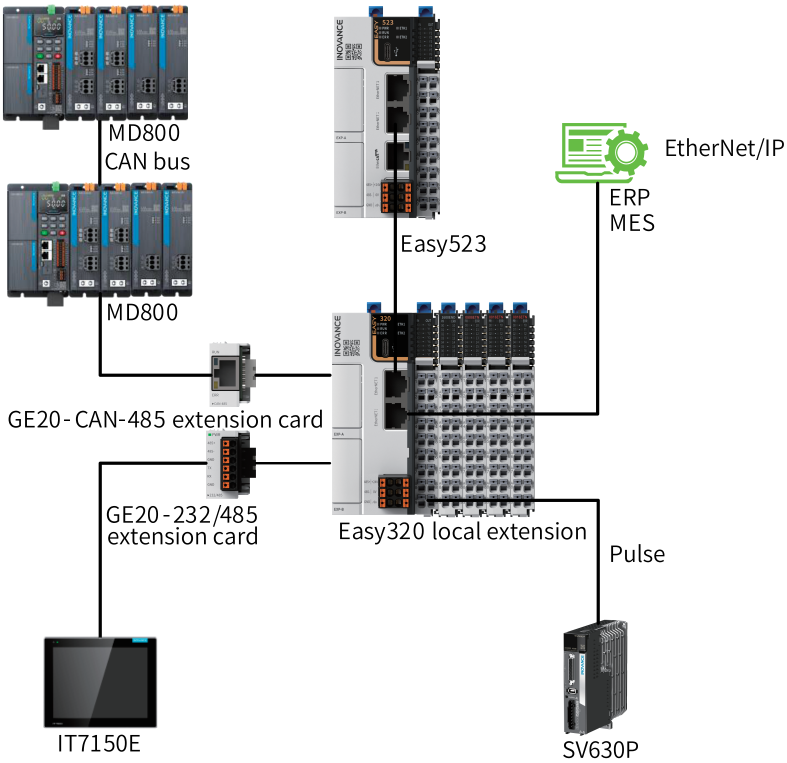



Figure 1-2 Easy320 series application topology

# 1.2 Obtaining and Installing the Software

## 1.2.1 How to Obtain

AutoShop programming software is provided for free. To obtain it, visit [www.inovance.com](http://www.inovance.com), search for the keyword, and download the guide.

### *Note*

As Inovance constantly improves its products and documentation, it is recommended that you update your software versions and consult the latest reference materials when needed to facilitate your application design.

## 1.2.2 Installation Environment Requirements

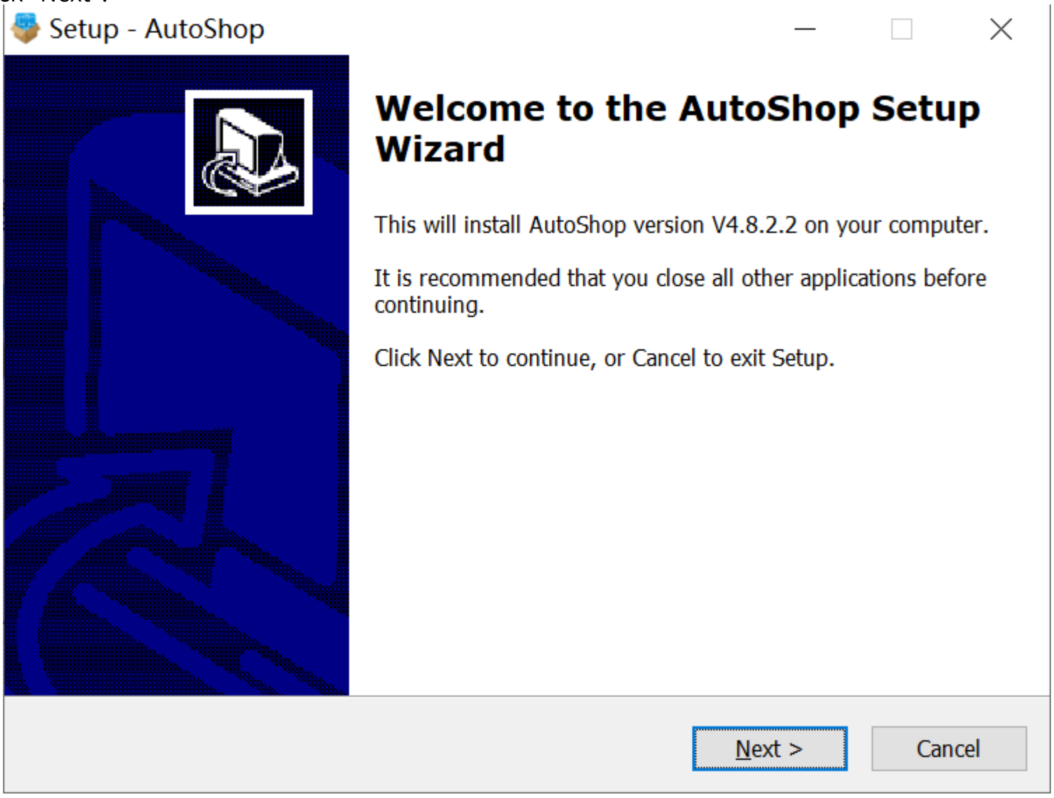
The following table lists the items required for a PC where AutoShop programming software is installed.

| Item | Requirement |
|---|---|
| Operating system | Windows 7 or 10, 64-bit is recommended |
| Primary frequency of CPU | 4 GHz or above |
| Memory | 4 GB or above |
| Hard drive | More than 5 GB |

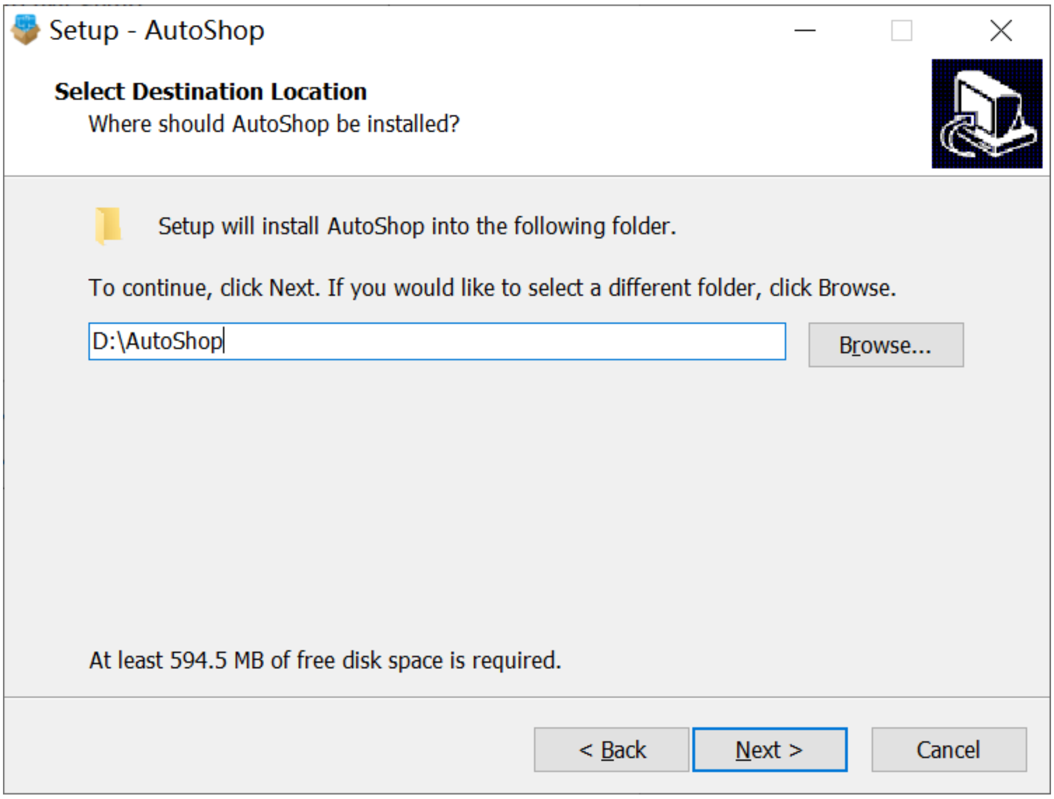
## 1.2.3 Installing the Software

To install AutoShop, you can download the software installation package of the latest version at www.inovance.com, and the installation UI of the latest version shall prevail. AutoShop V4.8.1.0 is installed on Windows 10 as an example.

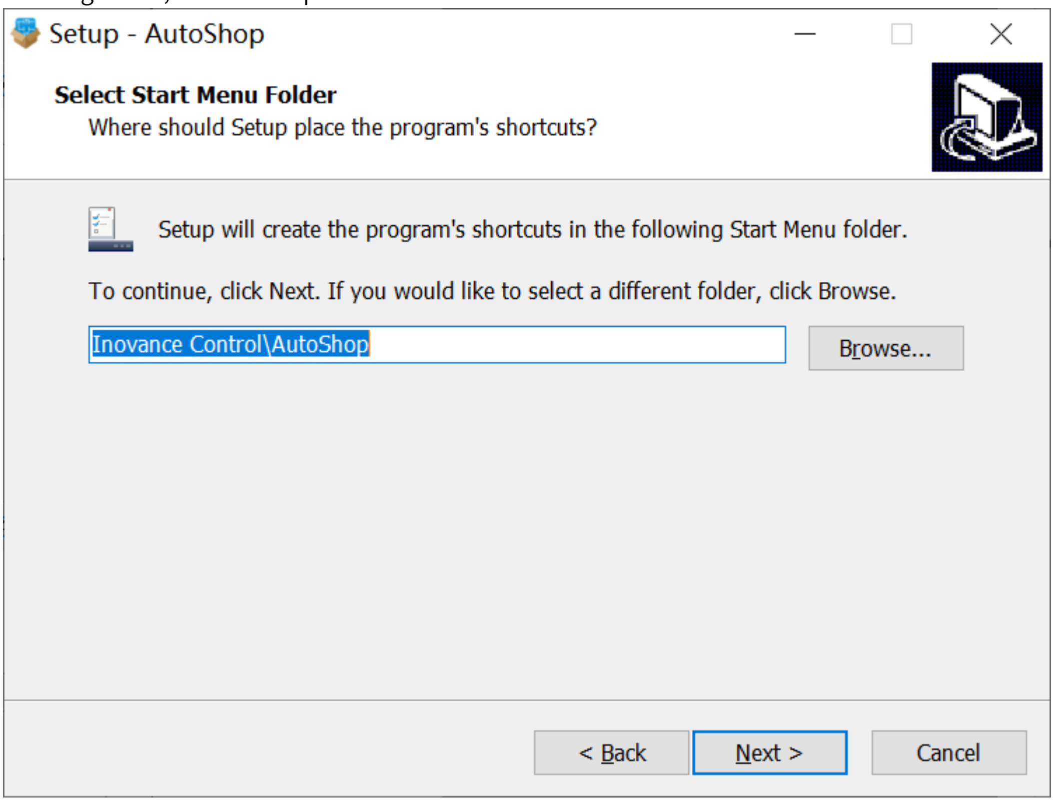
1. Decompress the "AutoShop V4.8.1.0 Setup.zip" package.
2. Double-click "AutoShop V4.8.1.0 Setup.exe." In the "Select language" dialog box, select a language and click "OK".
3. Click "Next".



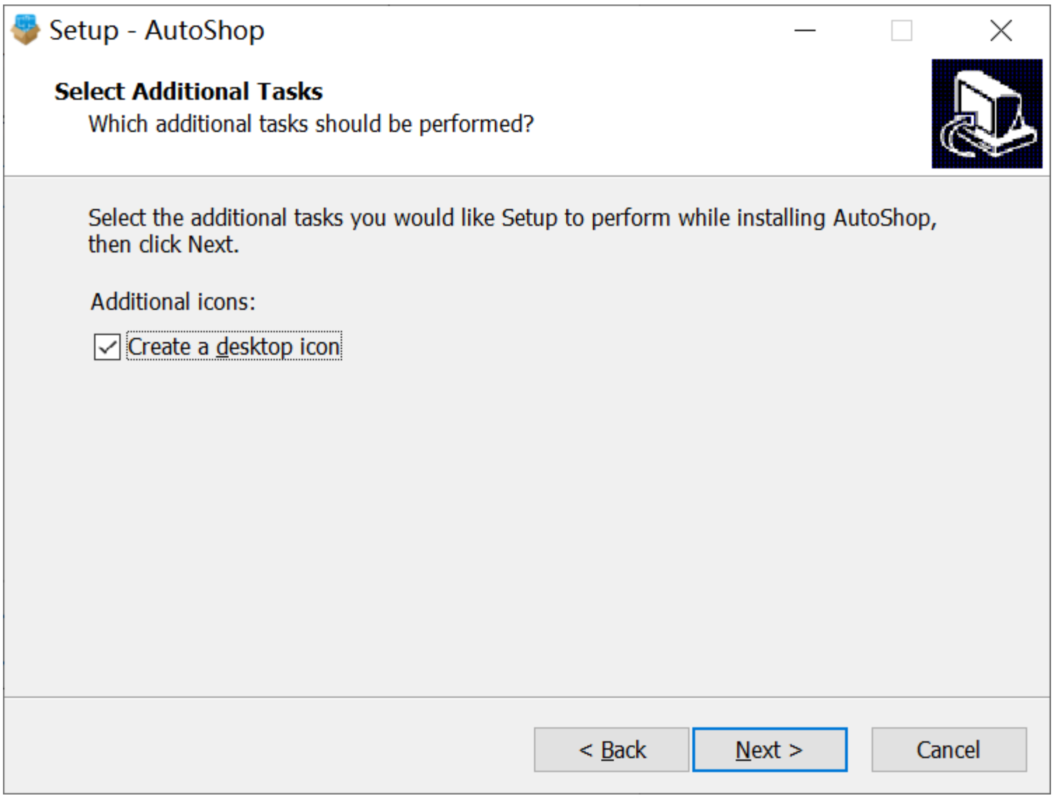

4. Click "Browse". In the dialog box, select an installation path and click "Next". In general, the default path is used.



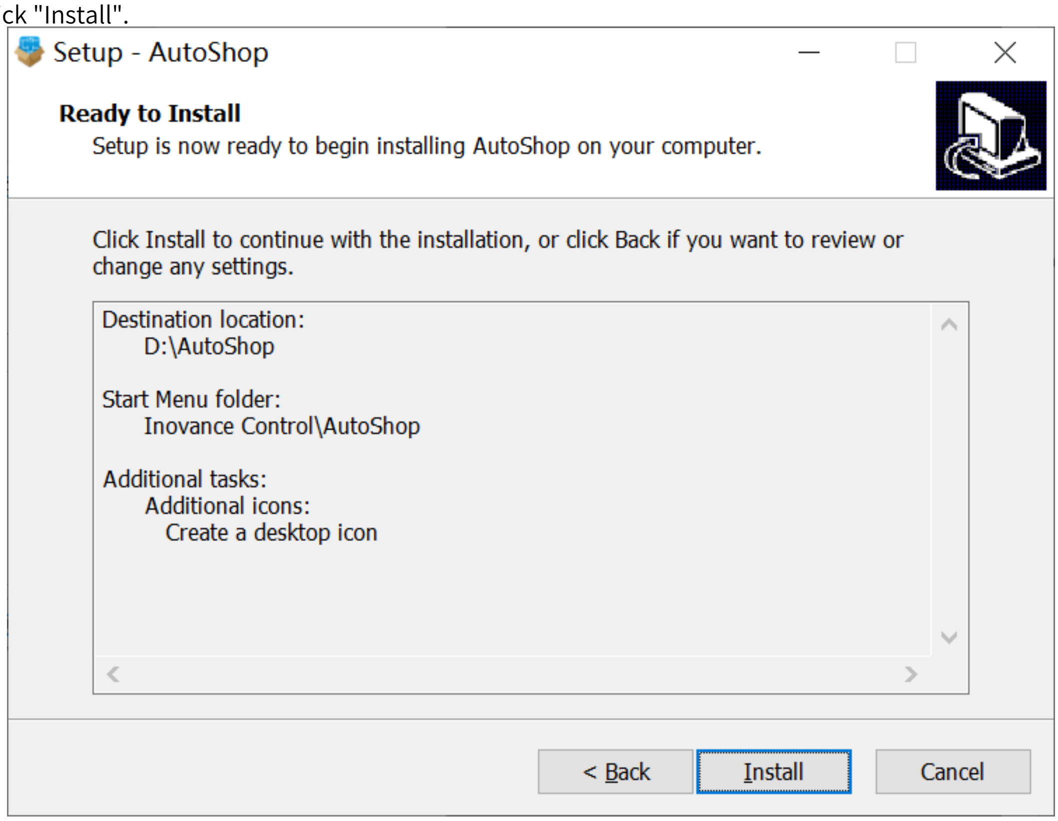

5. Click "Browse". In the dialog box, select an installation path for the program shortcut and click "Next". In general, the default path is used.



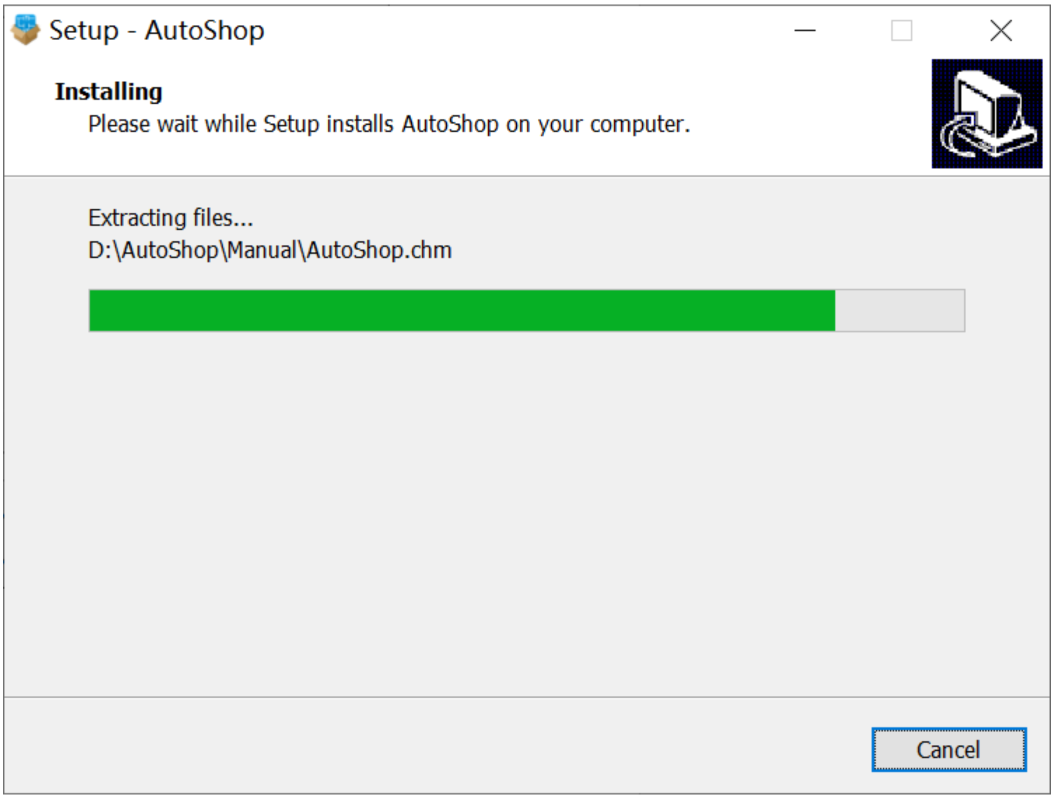

6. Click "Next".




7. Click "Install".




The following figure shows the installation progress.

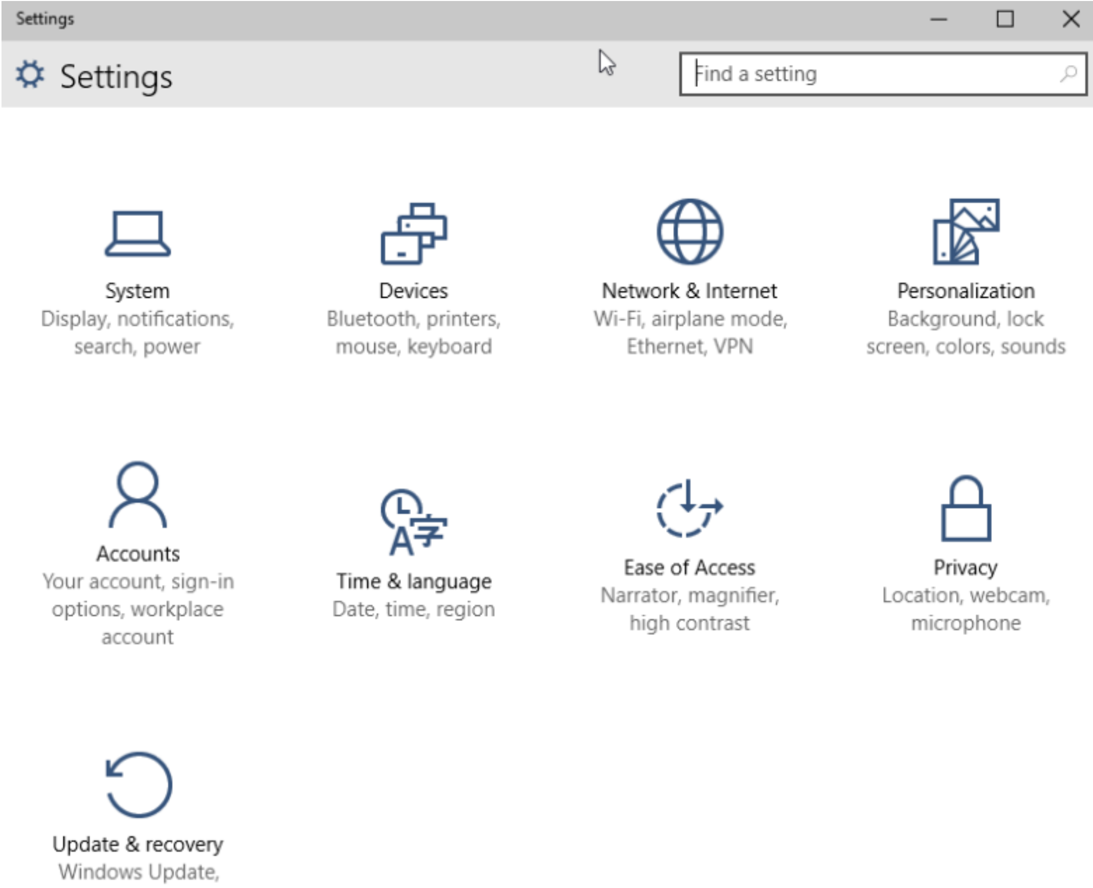



8. Click "Finish."

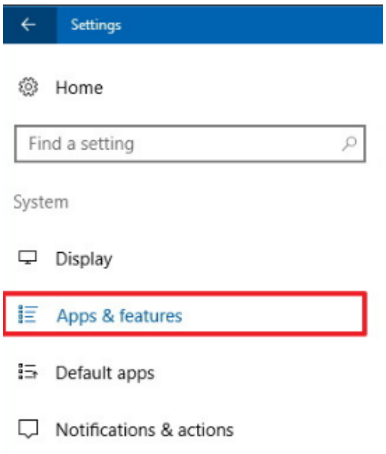

### 1.2.4 Uninstalling the Software

AutoShop V4.6.5.0 is uninstalled on Windows 10 as an example.

1. Click [Windows icon] on the desktop. On the start menu that is displayed, click [settings icon] to access the "Windows setting" page.



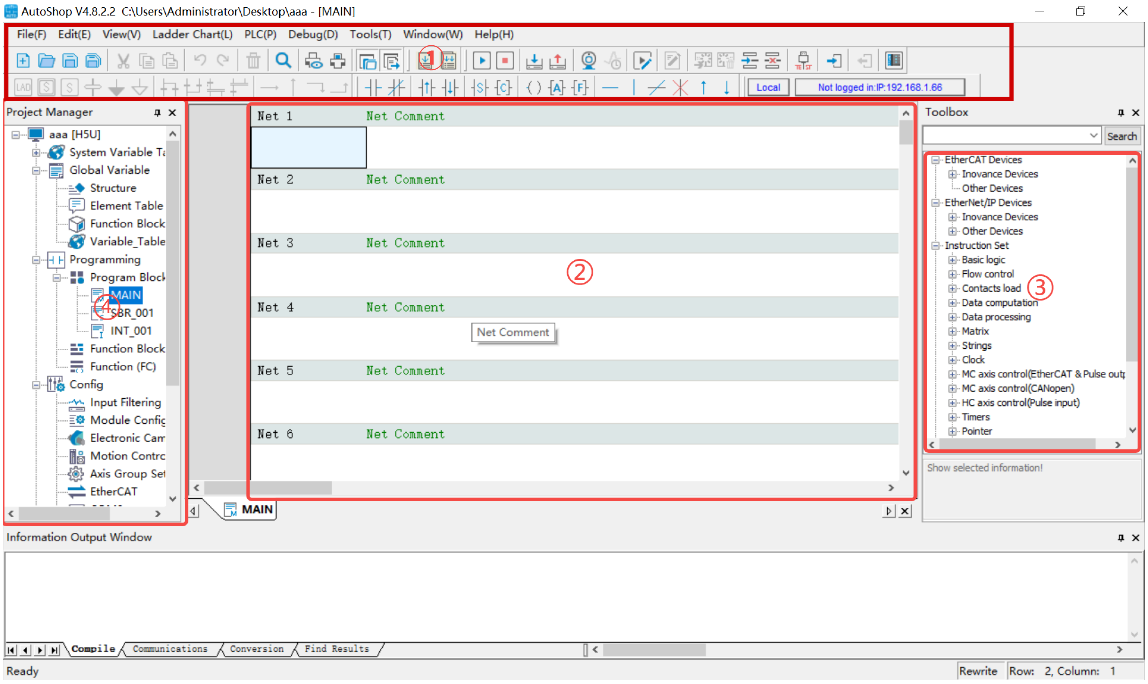

2. Click "Apps & Features" as shown below.




3. On the "Apps & Features" page, click "AutoShop Vx.x.x.x" and then "Uninstall".
4. Click "Uninstall". The "AutoShop uninstall wizard" dialog box is displayed.
5. Click "Yes". After the software is uninstalled, click OK.

## 1.3 Software Interface

The main screen of AutoShop programming software consists of the menu bar, toolbar, engineering management section, program editing section, and toolbox, as shown in the following figure.




| No. | UI | Description |
|---|---|---|
| ① | Menu bar and toolbar | Programming software operation menus, containing settings of programming, commissioning, and communication, and shortcut modes of file management and programming commissioning tools. |
| ② | Program editing section | Compiling application programs for users |
| ③ | Tool kit | Set of instructions supported by the slave station and select PLC in a project. Tool kits are classified into ladder diagram ones and ST ones and can be switched to each other. The two types only differ in instructions supported in the instruction sets. |
| ④ | Engineering management | Including parameter management, variable management, program management, and configuration management of the PLC project. |

# 2 Quick Start

## 2.1 Overview

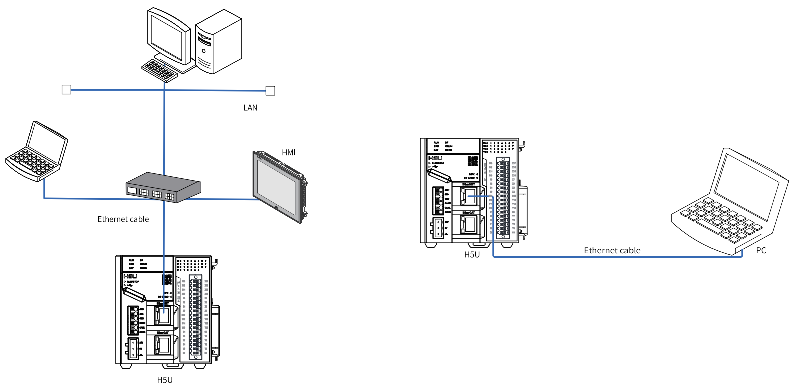
This section provides a simple programming example and general functions used in the programming commissioning process for you to quickly master programming and commissioning. It is quite helpful to beginners.

## 2.2 Communication Connection

### 2.2.1 Overview

An PLC communicates with the PC where AutoShop is located through USB or Ethernet connection to upload, download, monitor, and commission the program.

For example, H5U communicates with the PC through Ethernet, achieving multi-point connection or point-to-point connection in hub-based, switch-based, or direction connection mode, as shown in the following figure.




### 2.2.2 Ethernet Connection

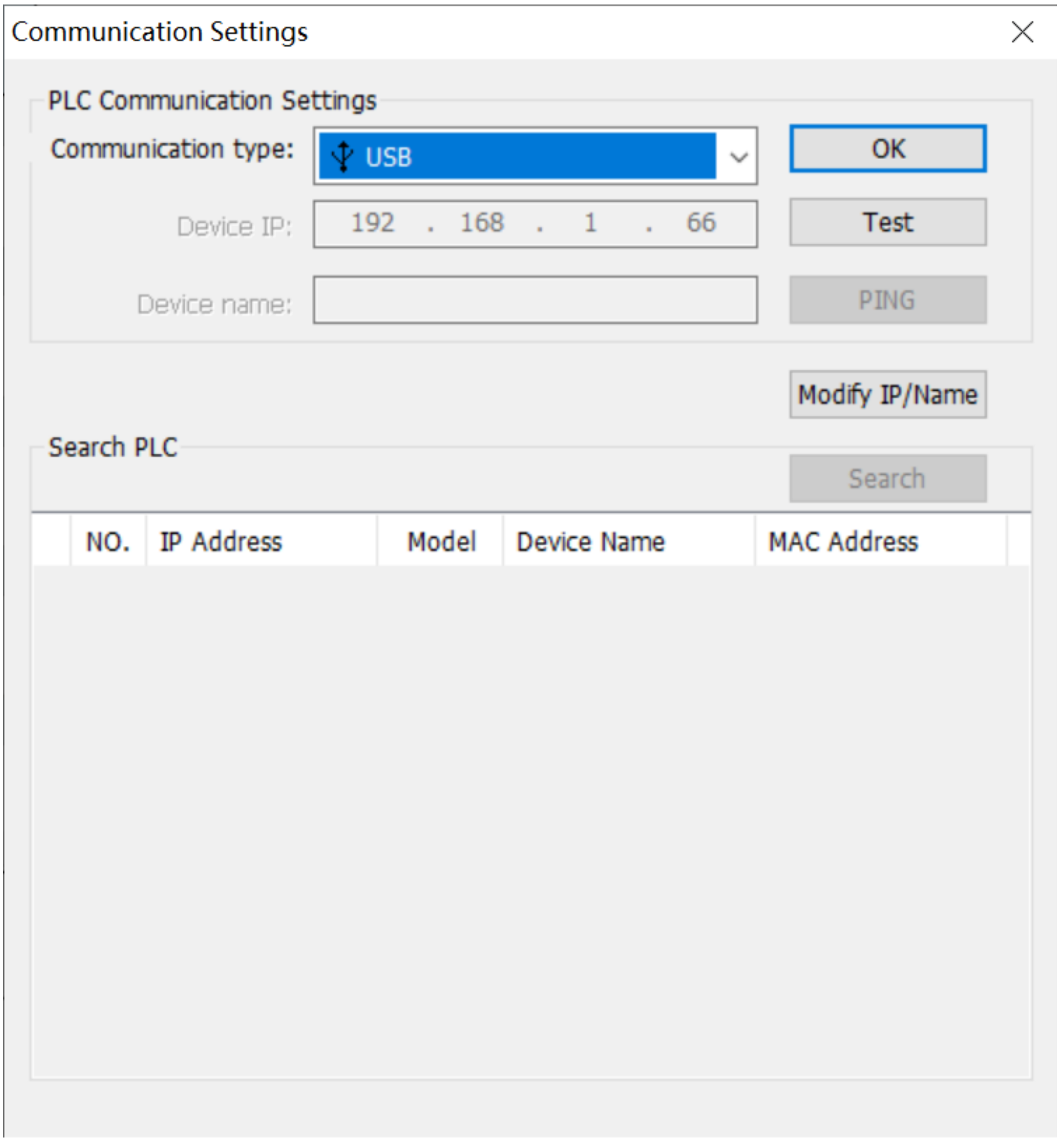
When connecting a PC to an PLC through Ethernet connection, you may need to connect to the target PLC and change the PLC IP address and device name.

**Connecting to the target PLC**

To connect a PC to an PLC through Ethernet connection, you need to select the PLC with the specified IP address.

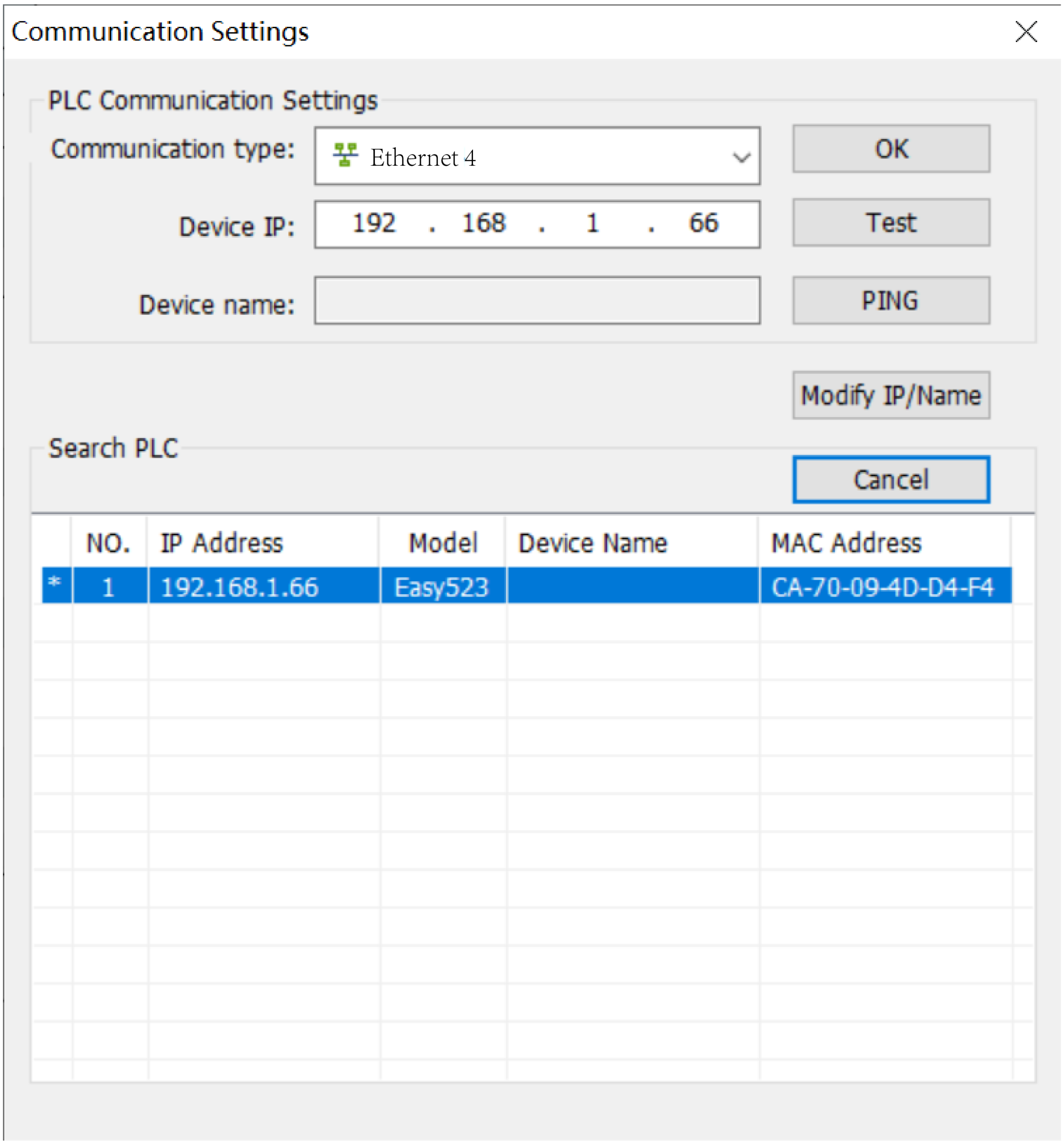
- If the IP address of the PLC is provided, configure the communication type and IP address of the PLC and then connect to the target PLC.

  1. Connect the PC to the PLC using a network cable.
  2. Double-click on the desktop of the PC to start the AutoShop programming software.
  3. Choose "Tools" > "Communication Settings" in the menu bar or click in the toolbar. The "Communication Settings" dialog box is displayed.




4. Set parameters in the "Communication Settings" dialog box.

- Set "Communication type" to "Ethernet".
- Set "Device IP" to the actual IP address of the PLC.




## Note

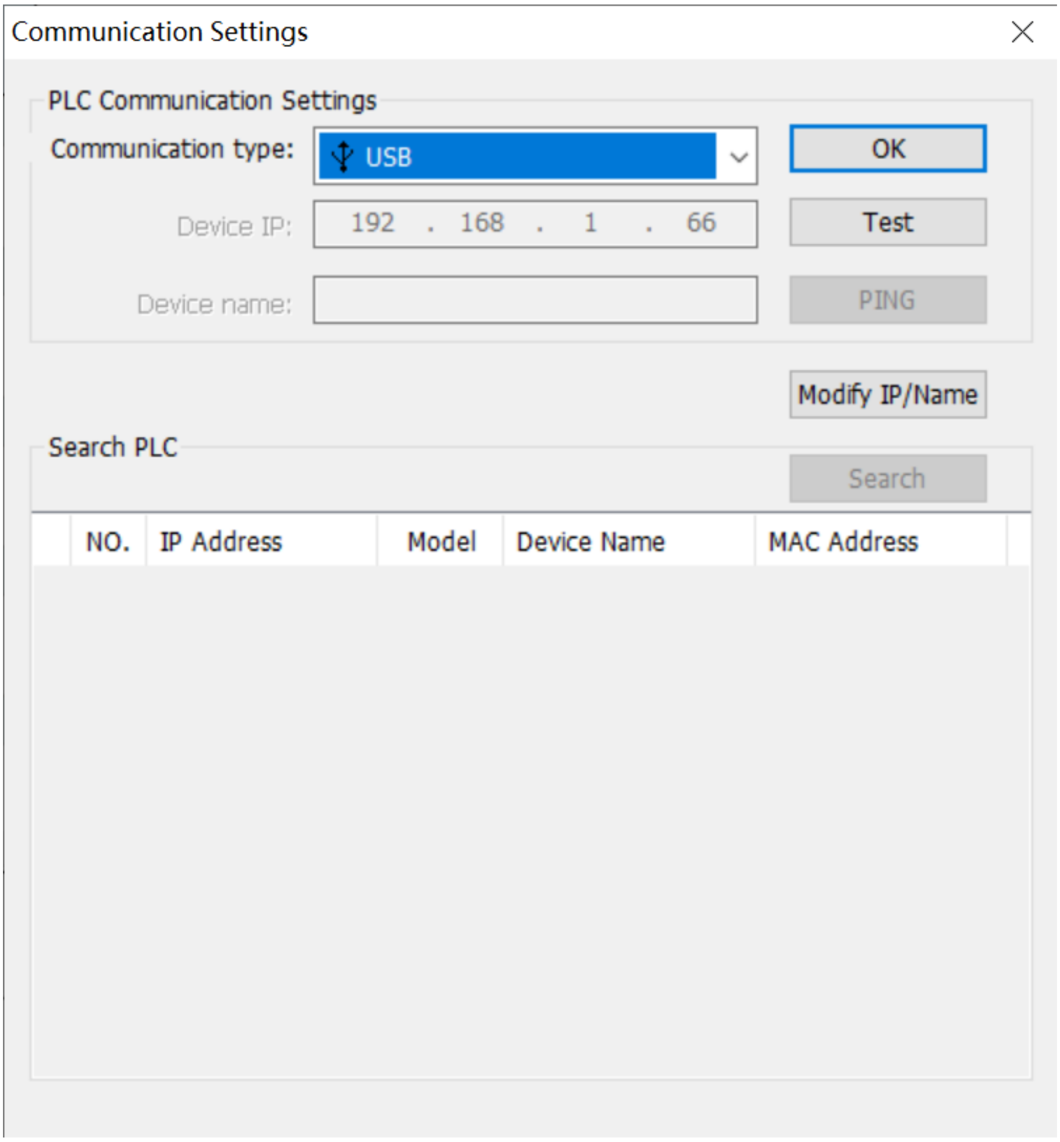
To test the network connection between the PC and the PLC, click "PING".

5. Click "Test" to check whether the target PLC is connected successfully.
   - H5U: When LEDs of the connected H5U display 0 alternatively, the H5U is connected successfully.
   - Easy: When the RUN indicator of the connected Easy flashes, the Easy is connected successfully.
6. Click "OK" to connect to the target PLC.

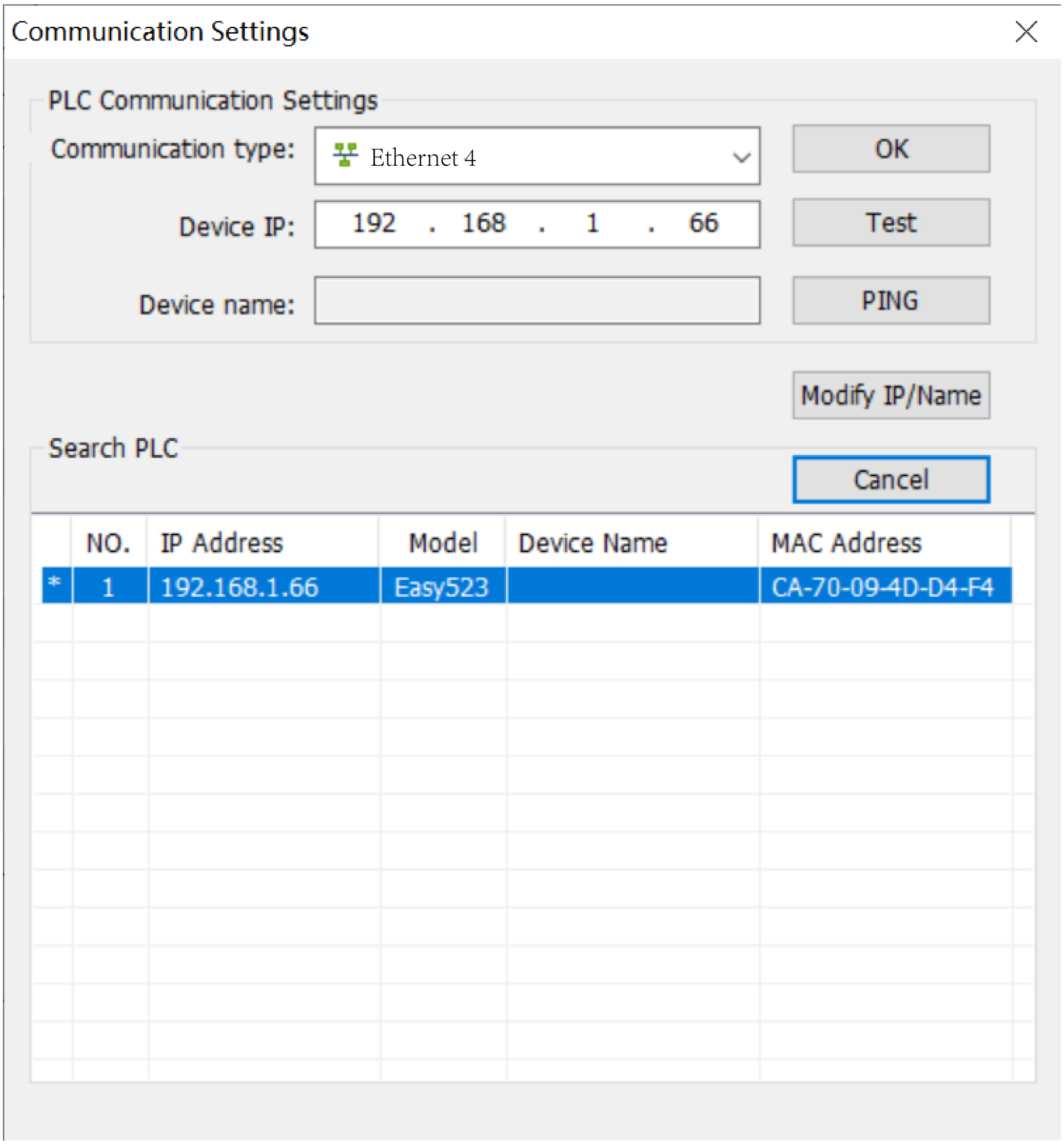
   Then, the IP address of the PLC is displayed in the toolbar and you can download, upload, monitor, or modify the PLC program online.

- If the IP address of the PLC is not provided,
  you can search for the target PLC.

1. Connect the PC to the PLC using a network cable.
2. Double-click on the desktop of the PC to start the AutoShop programming software.
3. Choose "Tools" > "Communication Settings" in the menu bar or click in the toolbar. The "Communication Settings" dialog box is displayed.




4. Set "Communication type" to "Ethernet", and click "Search" to search for the PLC connected in the LAN.
   - In switch-based connection mode, you can only search for the PLC in the same segment of the PC.
   - In direct connection mode, you can search for the PLC in the same segment or a different segment of the PC.




5. Select the IP address row in the search result and click "Test" to check whether the PLC is connected successfully.

- H5U: When LEDs of the connected H5U display 0 alternatively, the H5U is connected successfully.
- Easy: When the RUN indicator of the connected Easy flashes, the Easy is connected successfully.

### *Note*

To test the network connection between the PC and the PLC, click "PING".

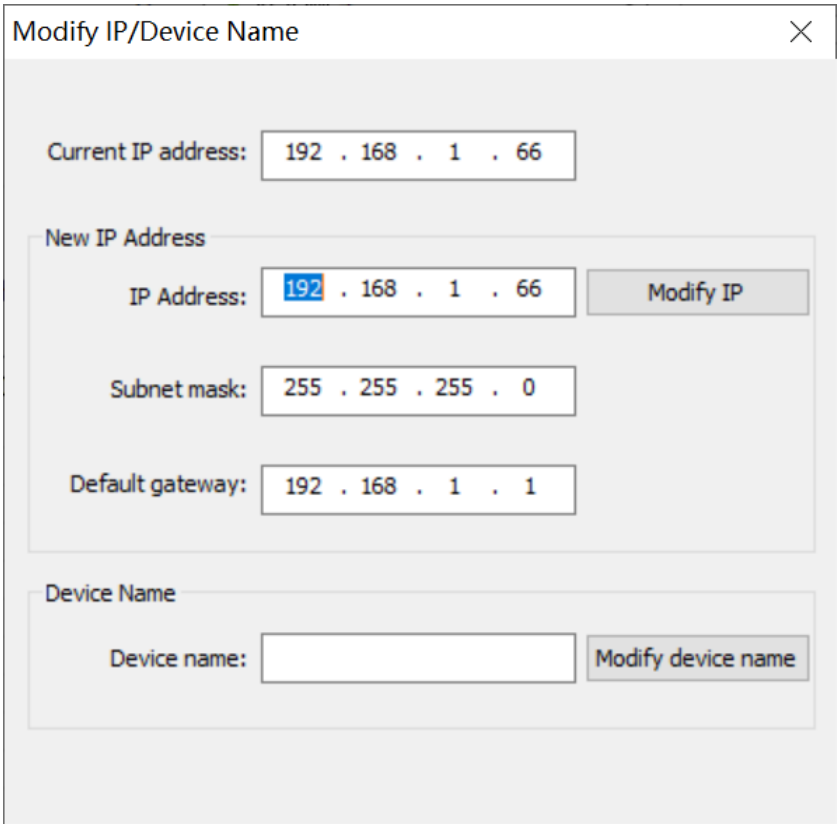
6. Click "OK" to connect to the target PLC.

Then, the IP address of the PLC is displayed in the toolbar and you can download, upload, monitor, or modify the PLC program online.


## Changing the PLC IP address and device name

You can change the IP address or the PLC as needed or change the device name of the PLC for differentiation.

1. After connecting to the target PLC, click "Modify IP/Name" in the "Communication Settings" dialog box. The "Modify IP/Name" dialog box is displayed.




2. Set "IP Address", "Subnet mask", and "Default gateway" in the "New IP Address" section, and click "Modify IP". In the dialog box that is displayed, click "OK". The new IP address takes effect after the PLC is powered on again.

### *Note*

When the new PCB software (V3.0.0.0) is used with an old AutoShop background (V4.0.0.0 or earlier version), the following situation will occur:

When you modify the IP in the communication settings, even if the software prompts success, the IP may not be successfully modified.

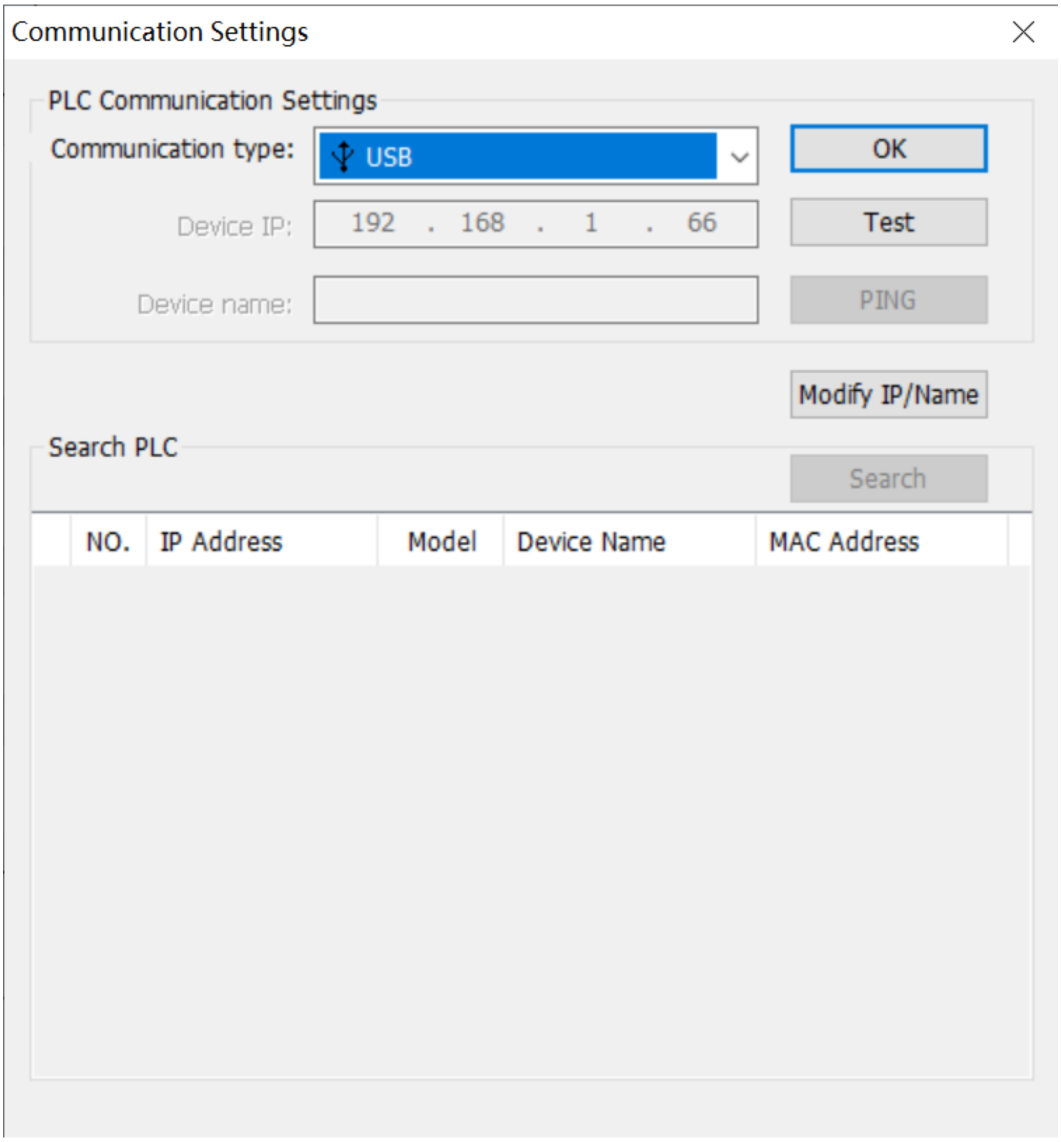
3. In the "Device Name" section, set "Device name" as needed and click "Modify device name". In the dialog box that is displayed, click "OK".

## 2.2.3 USB Connection

When connecting a PC to an PLC through USB connection, you may need to connect to the target PLC and change the PLC IP address and device name.

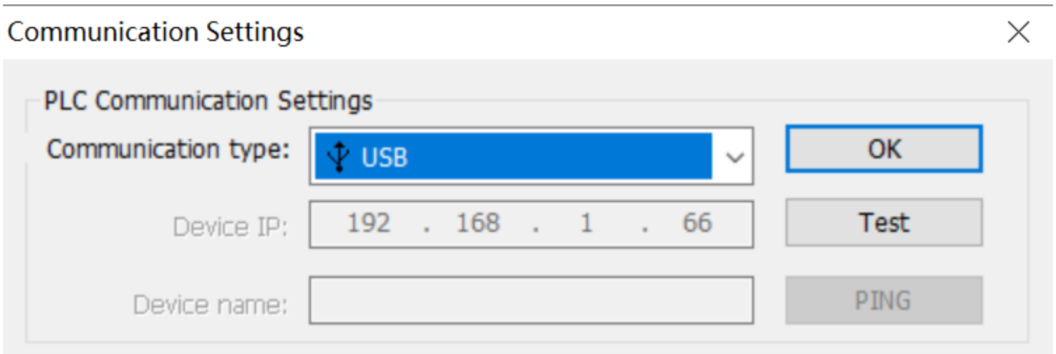
### Connecting to the target PLC

1. Connect the PC to the PLC using a USB cable.
2. Double-click on the desktop of the PC to start the AutoShop programming software.
3. Choose "Tools" > "Communication Settings" in the menu bar or click in the toolbar. The "Communication Settings" dialog box is displayed.




4. Set "Communication type" to "USB" and click "Test" to check whether the target PLC is connected successfully.

- H5U: When LEDs of the connected H5U display 0 alternatively, the H5U is connected successfully.
- Easy: When the RUN indicator of the connected Easy flashes, the Easy is connected successfully.




**Caution**

If AutoShop V4.0.0.0 is used with an old PCB software (V3.0.0.0 or earlier versions), clicking "Test" will not initiate connection to the H5U device. In this case, upgrade the PLC software.

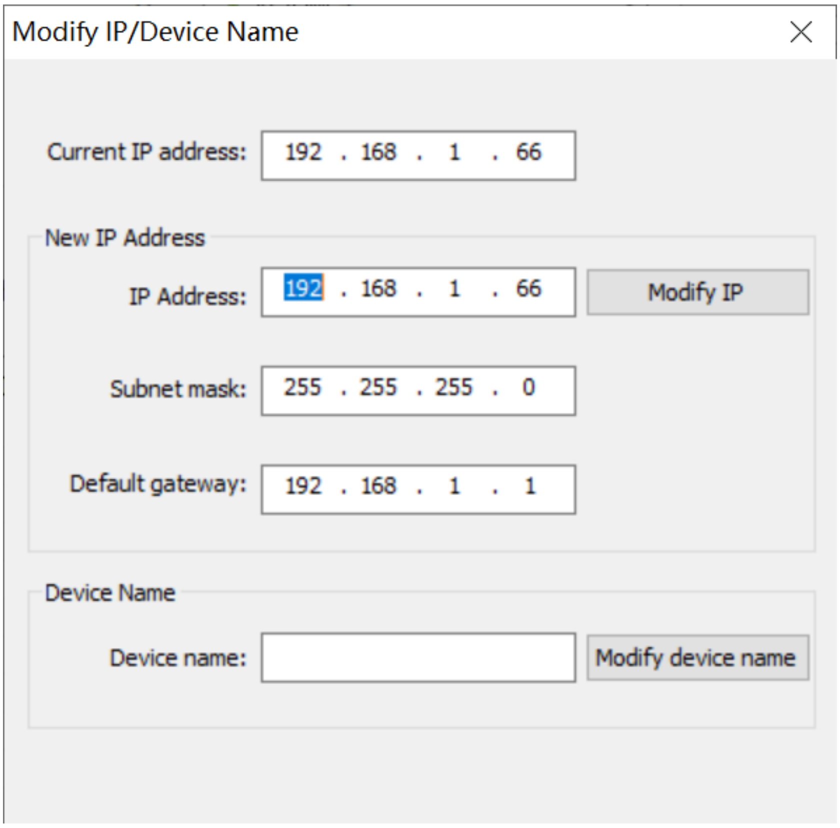
5. Click "OK" to connect to the target PLC.

   Then, you can download, upload, monitor, or modify the PLC program online.

## Changing the PLC IP address and device name

You can change the IP address or the PLC as needed or change the device name of the PLC for differentiation.

1. After connecting to the target PLC, click "Modify IP/Name" in the "Communication Settings" dialog box. The "Modify IP/Name" dialog box is displayed.



2. Set "IP Address", "Subnet mask", and "Default gateway" in the "New IP Address" section, and click "Modify IP". In the dialog box that is displayed, click "OK". The new IP address takes effect after the PLC is powered on again.

---

***Note***

When the new PCB software (V3.0.0.0) is used with an old AutoShop background (V4.0.0.0 or earlier version), the following situation will occur:

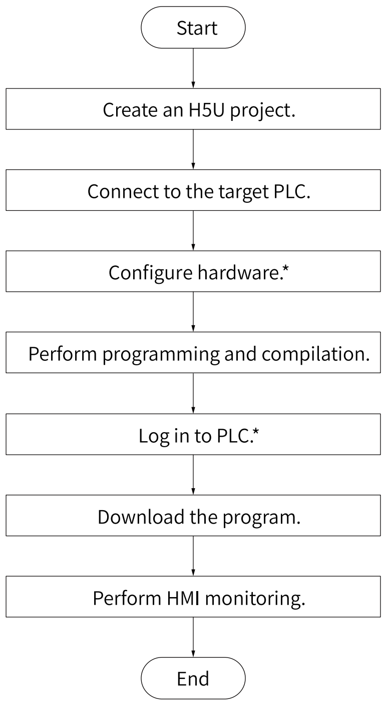
When you modify the IP in the communication settings, even if the software prompts success, the IP may not be successfully modified.

---

3. In the "Device Name" section, set "Device name" as needed and click "Modify device name". In the dialog box that is displayed, click "OK".

## 2.3 Programming Process

A typical user program flowchart of the H5U series PLC is compiled and commissioned as an example, as shown in the following figure.

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***Note***

* If only the H5U host is used, skip the "Hardware configuration" step. If connected to a PLC without a login password, skip the "Login PLC" step.

---

# 2.4 Programming Example

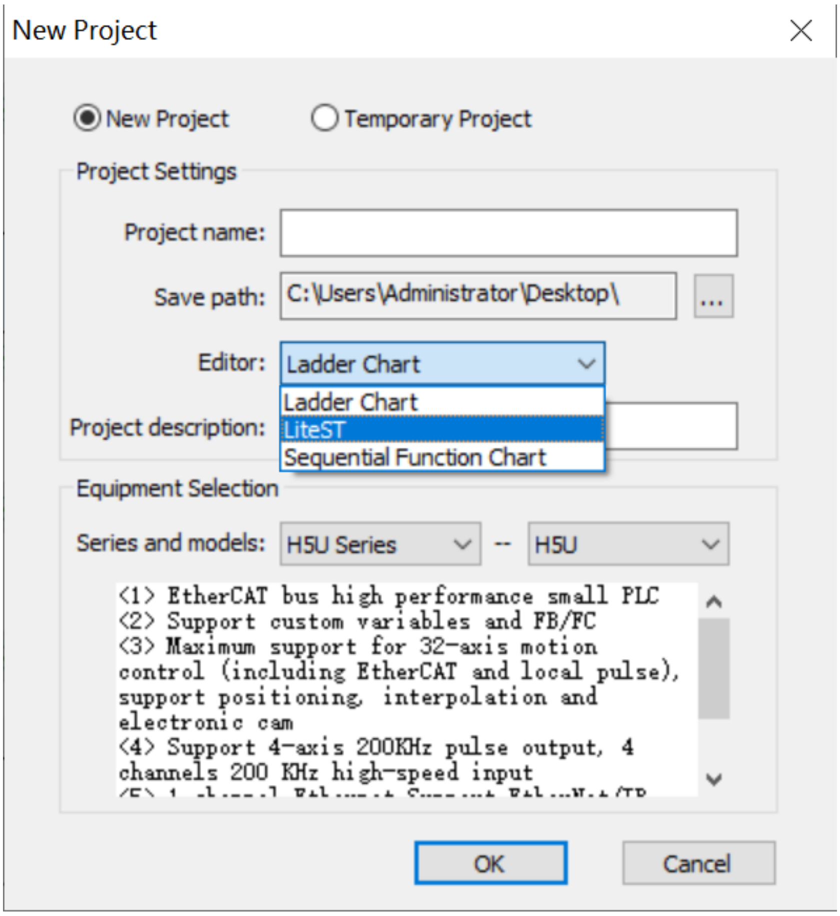
## 2.4.1 Example Requirements

Compile and commission the next marquee program based on the following requirements:

Using a 16-output module, PLC program shifts one bit rightwards from Y20 every 1s. When the output reaches Y27, the PLC program returns the output to Y20 for a new cycle, which is monitored through HMI.

## 2.4.2 Creating a Project

1. Double-click the AutoShop shortcut icon on the desktop.
2. Choose "File" > "New Project" in the menu bar or click in the toolbar. In the dialog box that is displayed, choose an editor type from the "Editor" drop-down list, and set "Series and models" to "H5U".




3. Set "Project name" and "Save path", and click "OK" to create a project. Then, the main screen of the project is displayed.

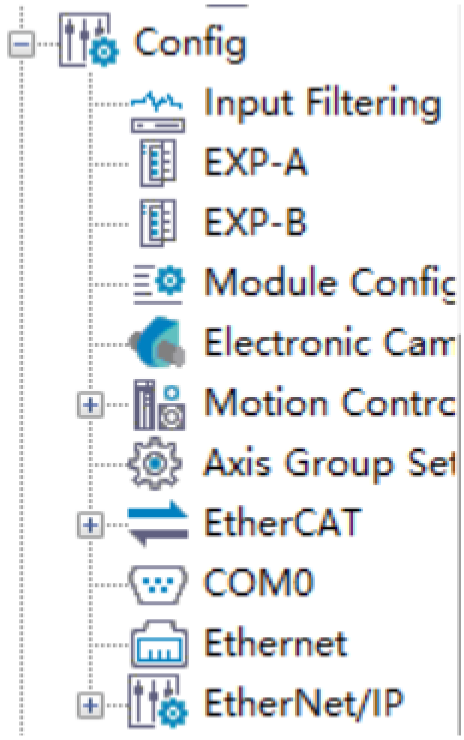
### 2.4.3 Connecting to Target PLC

This section takes the Ethernet connection between the PC and PLC as an example. For details about how to connect to the target PLC, see "Connecting to the target PLC" in *"2.2.2 Ethernet Connection" on page 29*.

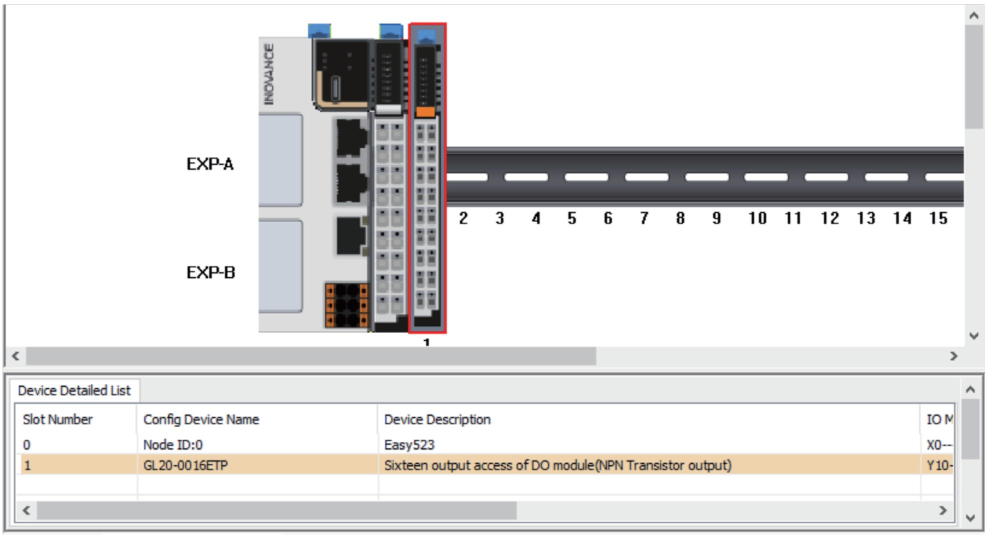
### 2.4.4 (Optional) Configuring Hardware

If the local extension module is installed for the H5U host, perform the steps in this section. Otherwise, skip this section.

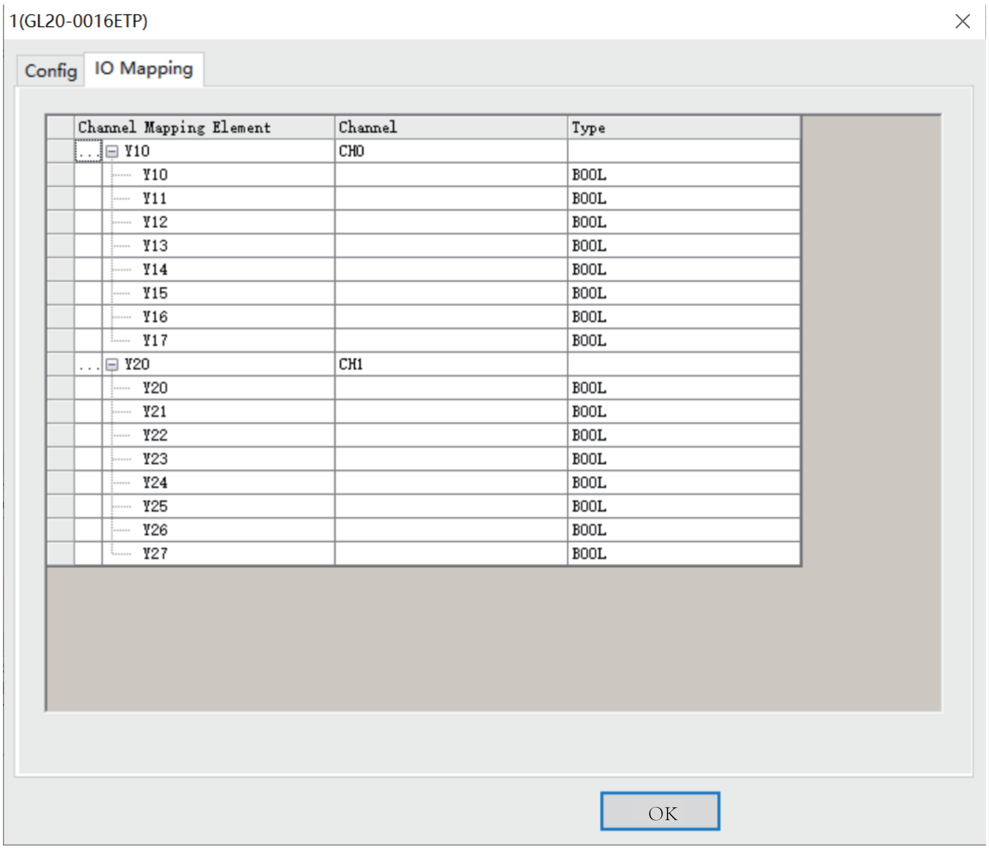
1. In the "Project Manager" tree, unfold "Config" and double-click "Module Config". The "Module Config" page is displayed.




2. Double-click the modules under "Module" on the right of the page based on the installation sequence to add the corresponding modules.



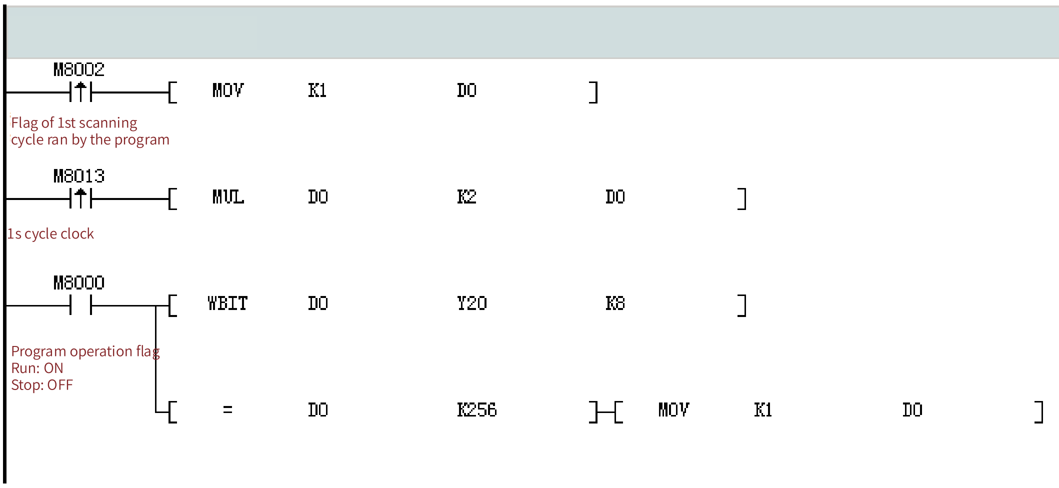

3. Double-click an added module and configure the channel mapping element corresponding to the module channel.




4. Click "OK".

## 2.4.5 Programming and Compiling

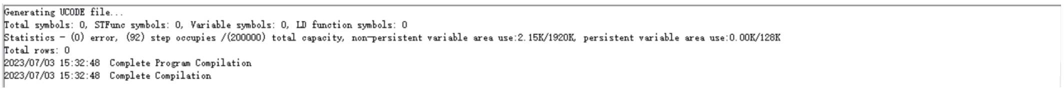
1. In the "Project Manager" tree, unfold "Programming" and double-click "MAIN" to compile the marquee program.




2. In the toolbar, click or for compiling.

- : Compile the opened program.
- : Compile the overall project.

After compiling is completed, the compilation information is displayed at the bottom of the main screen.

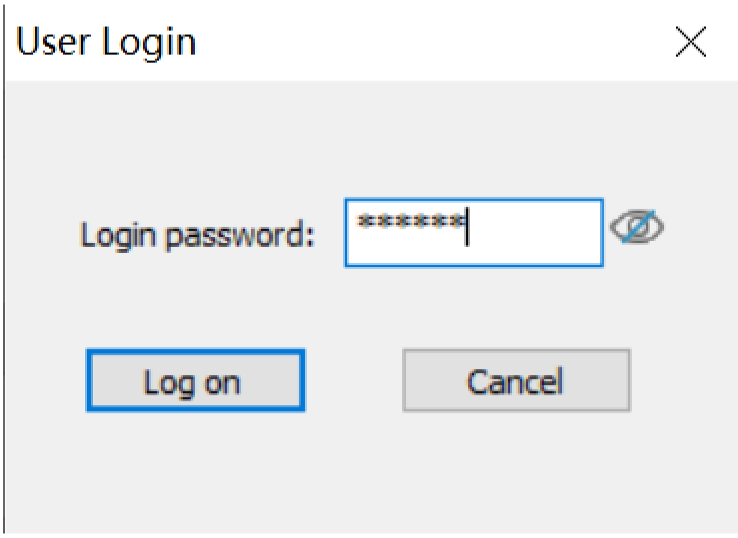


```
Generating UCODE file...
Total symbols: 0, STFunc symbols: 0, Variable symbols: 0, LD function symbols: 0
Statistics - (0) error, (92) step occupies /(200000) total capacity, non-persistent variable area use:2.15K/1920K, persistent variable area use:0.00K/128K
Total rows: 0
2023/07/03 15:32:48  Complete Program Compilation
2023/07/03 15:32:48  Complete Compilation
```

## 2.4.6 (Optional) Logging In to PLC

In case of Ethernet connection between a PC and a PLC with the login password set, to modify, upload, download, or verify the program online, perform the steps in this section. Otherwise, skip this section.

1. In the toolbar, click . The "User Login" page is displayed.




2. Enter the PLC login password in the "Login password" text box and click "Log on".

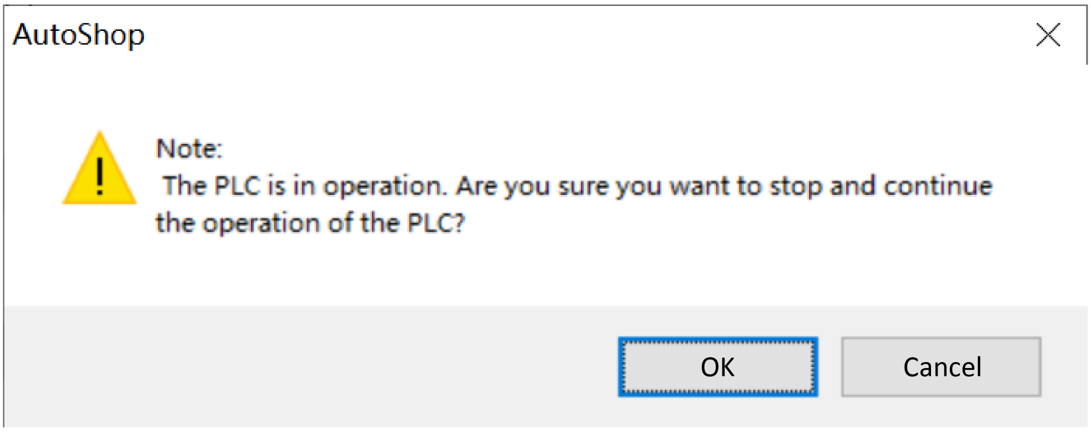
***Note***

For more details about logging in to the PLC, see section "2.10 Logging in to PLC".

## 2.4.7 Downloading Program

1. Choose "PLC" > "Download" in the menu bar or click in the toolbar to download the program.

- If the PLC is in the running state, perform operations to access the prompt dialog box and click "OK", as shown in the following figure: Proceed to Step 2.




- If the PLC is in the stopped state: Proceed to Step 3.

2. Upon download completion, click "OK" in the dialog box to switch the PLC to the running state.

3. Upon download completion, click in the toolbar to switch the PLC to the running state.

***Note***

When the new PCB software (V3.0.0.0) is used with an old AutoShop background (V4.0.0.0 or earlier version), the following situation will occur:

If the PLC is not configured with a login password, projects downloaded through the new background cannot be uploaded through the old background.

## 2.4.8 HMI Monitoring

You can monitor the execution of the marquee program through the HMI.

1. Create a project, connection, or variable and view the configuration screen on the HMI side. For details, see *XX Series HMI Quick Start*.
2. When running the PLC program, you can monitor the marquee status change on the HMI configuration screen.


## 2.5 Switching PLC Working Modes

An PLC can work in RUN or STOP mode.

- RUN: The PLC detects input at the X point, scans and calculates the user program, refreshes elements, and enables output and communication at the Y point.
- STOP: The PLC stops scanning of the program and output at the Y point, and disables the communication function.

PLC working modes can be switched in either of the following two ways:

- Toggle the "RUN/STOP" switch on the PLC.
- In the toolbar, click  to run the PLC or click  to stop the PLC.

## 2.6 Modifying Program Online

After the mode is enabled, online editing of the program does not affect the running PLC. Therefore, the program can be edited without the need of stopping the PLC, facilitating program commissioning.

**Caution**

- Program modification does not support:
  - Adding or deleting program files
  - Renaming program files
  - Modifying program file properties
  - Encrypting or decrypting subprograms
- Modifying configuration is not supported.
- Global variables:
  - Adding or deleting variables is supported.
  - Modifying names or comments of variables is supported, but modifying other features is not supported.
- FB/FC local variables:
  - Adding, modifying, or deleting IN/INOUT/OUT type variables is not supported.
  - Adding or deleting Var type variables is supported.
  - Var variables added before the current online modification cycle: Modifying names or comments of Var type variables is supported, but modifying other features is not supported.
  - Var variables added during the current online modification cycle: Modifying any features of Var variables is supported.
- Do not power off the system within 5s to 10s after successful online modification and download of the program. Otherwise, program errors may occur.

1. Choose "PLC" > "Online Edit Mode" in the menu bar or click in the toolbar to enable the online modification mode. At the same time, the software enters the monitoring mode.
   In online modification mode, if the running program is different from the program in the PLC, the "Failed to enter online modification mode!" prompt dialog box is displayed. In this case, you need to check whether the program is started correctly.
2. Click to compile the program online as required.
3. Click to download the modified program to the running PLC. The PLC does not stop running during the operation.
   Information shown in the following figure is displayed in the lower part of the main screen. Then, the PLC runs with the modified program.

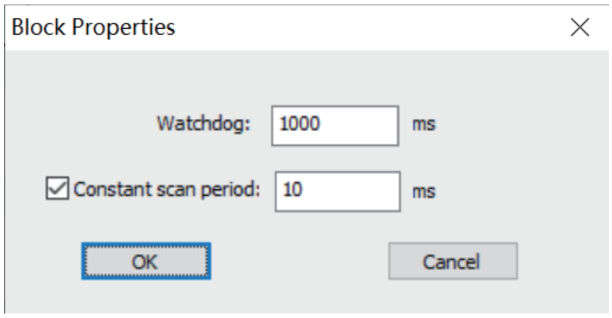
```
Information(2023-07-03 15:45:42)  Downloadmodbus.foid Success
Information(2023-07-03 15:45:42)  Downloadcanlink.foid Success
Information(2023-07-03 15:45:42)  Downloadmodcfg.foid Success
Information(2023-07-03 15:45:42)  Downloadstprog.o Success
Information(2023-07-03 15:45:42)  DownloadEcam.foid Success
Information(2023-07-03 15:45:42)  Download successful!
```

## 2.7 Setting Program Scan Cycles

You can select the constant scan cycle or the non-constant scan cycle.

- When the constant scan cycle is selected, the program runs by the specified scan cycle. If the actual running time is less than or equal to the set scan cycle, the PLC scans the program based on the set value. If the actual running time is greater than the set scan cycle, the PLC scans the program based on the actual running time.
- When the non-constant scan cycle is selected, the PLC automatically adjusts the scan cycle based on the running time of the program.

1. In the "Project Manager" tree, right-click "Function block" and select "Block Properties". The "Block Properties" dialog box is displayed.




2. Set "Watchdog" and "Constant scan period".

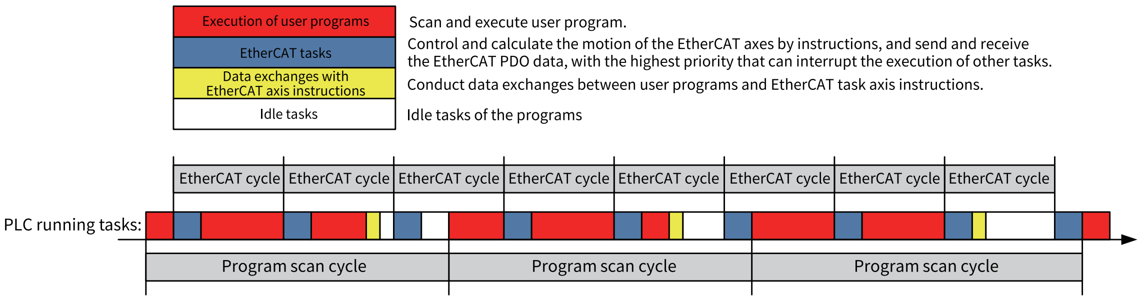
- ① Watchdog: indicates the maximum scan cycle of the program. When the running time of the program is greater than the value, the PLC reports an error and stops running.
- ② Constant scan period: When the check box is selected, the constant scan cycle mode is selected and the scan cycle equals to the value. Otherwise, the scan cycle equals to the actual running time.

3. Click "OK" and download the program to the PLC. The settings take effect immediately.

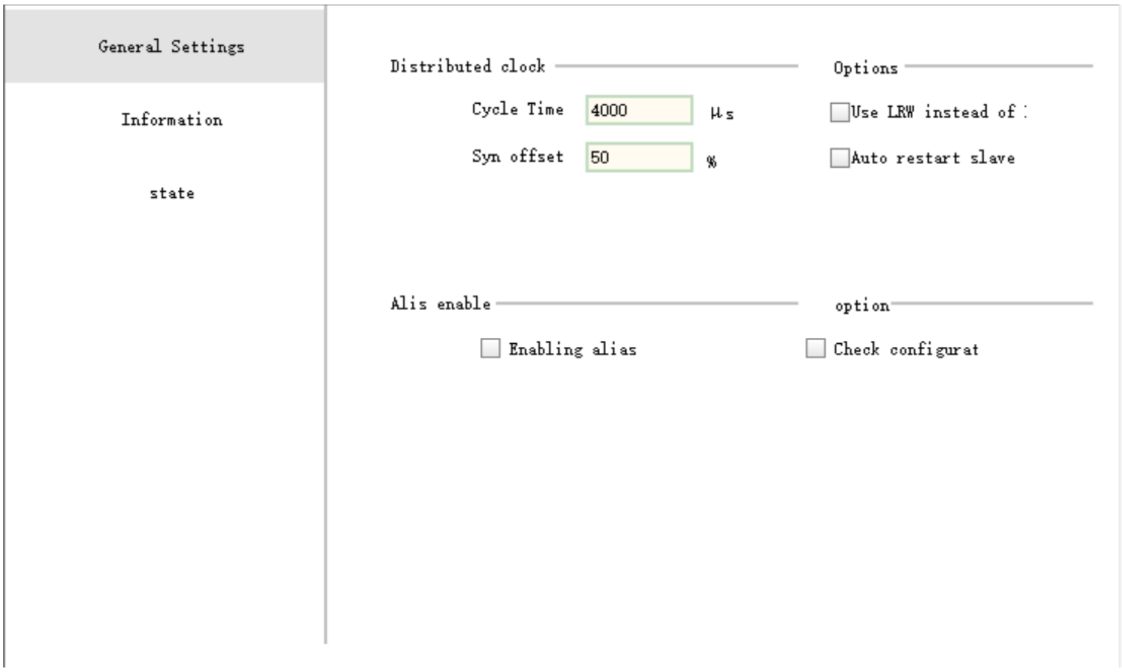
## 2.8 Setting EtherCAT Task Cycles

You can set EtherCAT task cycles as needed.
One program scan cycle contains the program execution, EtherCAT task, and EtherCAT axis instruction data exchange. When program scanning is idle, the scan cycle also contains the idle task. The priority of the EtherCAT task is the highest so that the EtherCAT task can interrupt execution of other tasks.

The following figure shows the relationship between the EtherCAT task cycle and the program scan cycle.




1. In the "Project Manager" tree, unfold "Config" and double-click "EtherCAT". The "General Settings" page is displayed.



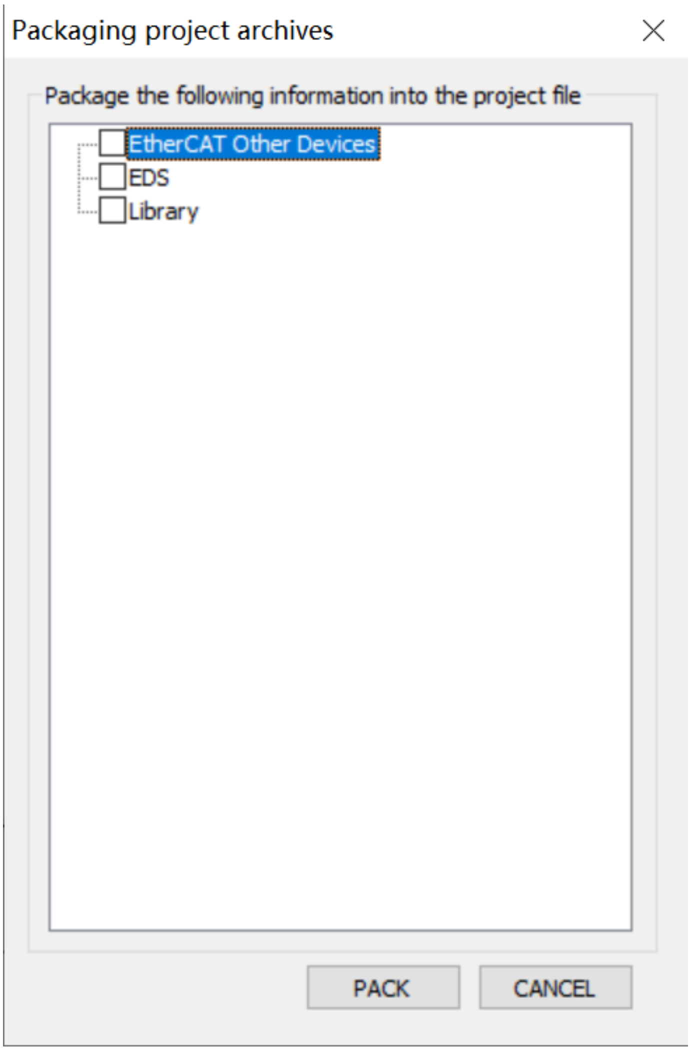

2. Set the cycle time of the EtherCAT task to a value ranging from 1000 µs to 9000 µs.
3. (Optional) In monitoring mode, click the "Status" tab. On the "EtherCAT task monitoring" page that is displayed, obtain communication information.
4. Click "OK" and download the program to the PLC. The settings take effect immediately.

## 2.9 Packing and Decompressing Project Archives

A project archive is an .hclib file consisting of the current project, EDS file, library file, and third-party EtherCAT device XML file. The current project cannot be a temporary project, and the library file used in the program is packed by default. To provide your project for other users, you only need to pack the project archive into an .hclib file and send it to the target user. The user then decompresses the file and directly compiles and downloads the project archive, without the need of sending the EDS file, library file, or third-party XML file.

### Packing a project archive

1. In the menu bar, choose "File" > "Pack Project Archives". The "Packaging project archives" dialog box is displayed.

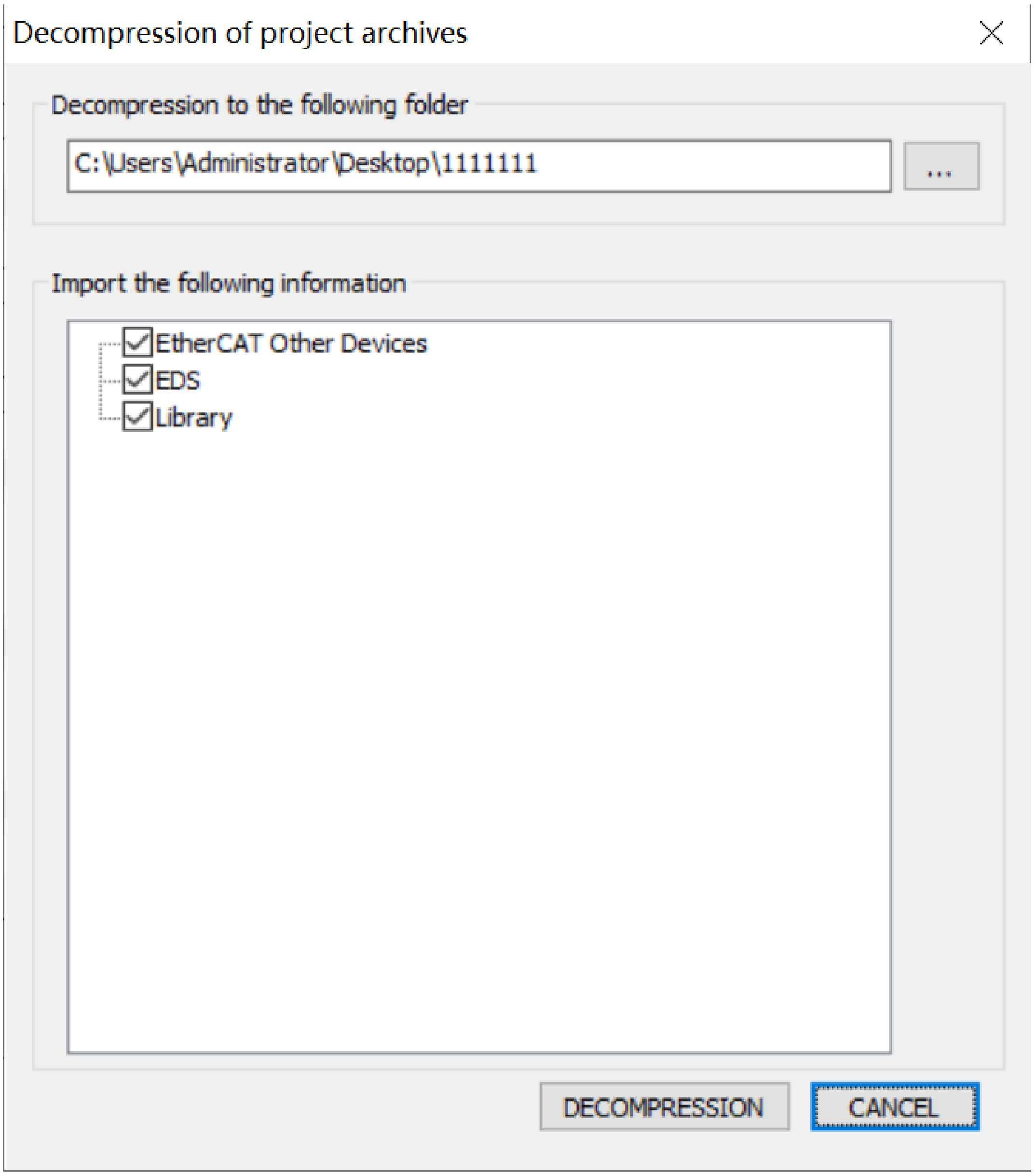



2. Select the files to be packed (library files used in the program are automatically selected), and click "PACK" to save the .hclib file.

## Decompressing a project archive

**Prerequisites:** An .hclib file is prepared.

1. In the menu bar, choose "File" > "Decompress Project Archives". The "Open" dialog box is displayed.
2. Select and open the .hclib file to be decompressed. The "Decompression of project archives" dialog box is displayed.




3. Set "Decompression to the following folder".
   By default, the project archive is decompressed into the folder with the project archive name in the folder where the .hclib file is located. If the storage folder does not exist, it is automatically created. You can also click "..." to select a target folder for decompression.

4. Select required files (all selected y default), click "DECOMPRESSION", and import the third-party EtherCAT device XML file, EDS file, and library file.

# 2.10 Logging in to PLC

## 2.10.1 Overview

Caution

Only PLCs with a login password set need to use this function.

The login function protects the intellectual property of customers and prevents the PLC program from unauthorized modification.

The following table lists the number of login users, login password, and login permissions.

| Item | | Description |
| --- | --- | --- |
| Number of login users | | Only one user can log in to the PLC at a time. Other users can log in only after the user logs out. Otherwise, a login failure is prompted. |
| Login password | | A login password contains up to eight characters in ANSI C mode. |
| Login permissions | Upload and download[1] | A permission password is required. |
| | Modifying the program online | A permission password is required. |
| | RTC | A permission password is required. |
| | Changing the IP address | A permission password is required. |
| | Clearing the PLC program storage space | A permission password is required. |
| | Verifying the program | A permission password is required. |

***Note***

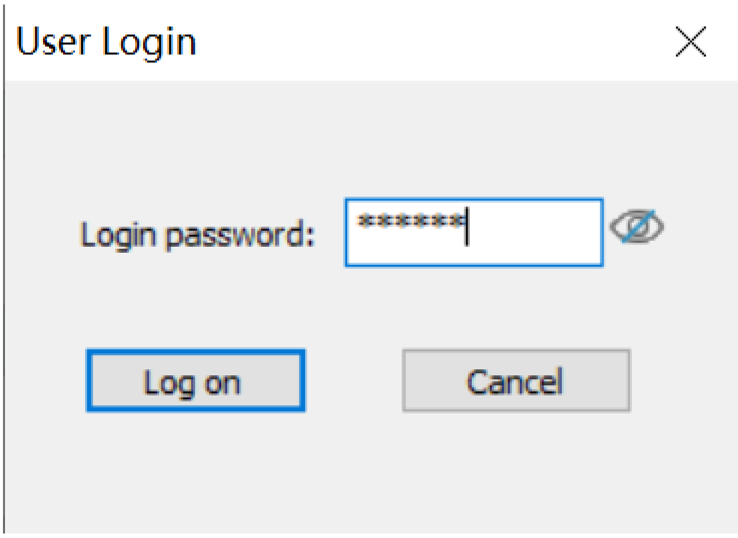
[1]: Upload and download refer to the upload and download of user programs and configuration data through the AutoShop programming software.

## 2.10.2 Logging In to and Logging Out of PLC

### Logging in to PLC

**Prerequisites:** The PC is properly connected to the PLC, and the PLC is online.

1. In the toolbar, click . The "User Login" page is displayed.




2. Enter the PLC login password in the "Login password" text box and click "Log on" to log in to the PLC.
   After successful login, the login button turns gray and the logout button turns red.


### *Note*

After a user logs in to the PLC, other users attempting to log in to the PLC will receive a pop-up prompt saying that the PLC is being used and rejects the login request. Only after the current user logs out can other users log in to the PLC.

### Logging out of PLC

**Prerequisites:** The PC is properly connected to the PLC, and the PLC runs properly.

In the toolbar, click to log out of the PLC.

After successful logout, the login button turns blue and the logout button turns gray.

## 2.10.3 Managing Login Password

The password used to log in to the PLC can be set, changed, or deleted.

### *Note*

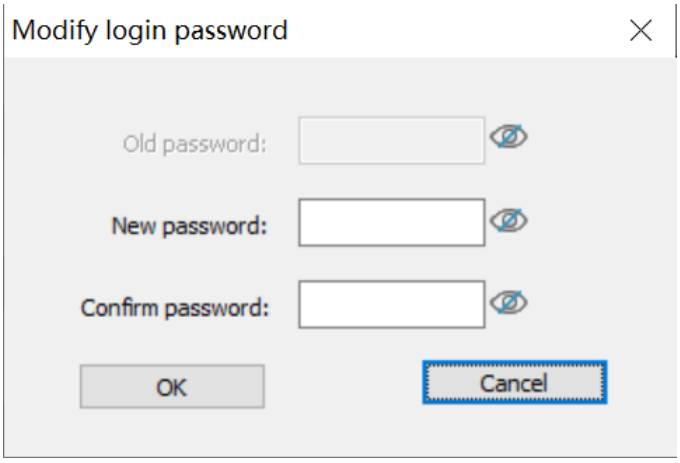
1. The password is saved in memory. When you re-open the project and re-connect to the PLC, you need to log in again.
2. When generating a Down file, you can opt for the login password. If no password is set, you do not need to enter a password.
3. A password can only contain some characters in the ANSI character set, including uppercase and lowercase letters, numbers, and some special characters such as parenthesis (()), comma (,), exclamatory mark (!), and atmark (@).
4. When you opt for the login password, some functions, such as IP address modification, PLC scan, and login password modification, will exit the login status. After opting for the login password, you need to log in again.

## Setting PLC login password

When no login password is set for the PLC, you can set a PLC login password.

**Prerequisites:** The PC is properly connected to the PLC, and the PLC is online.

1. In the menu bar, choose "PLC" > "Set/Modify Login PLC Password". The "Modify login password" dialog box is displayed.



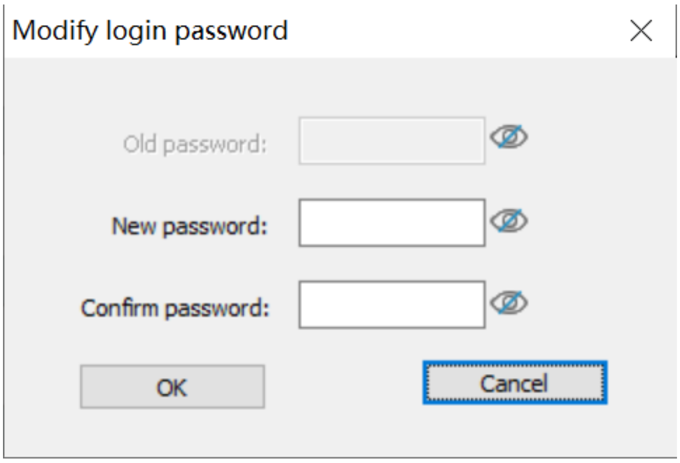

2. Enter the new password in the "New password" and "Confirm password" text boxes, and click "OK" to set the PLC login password.

## Changing PLC login password

When a login password is set for the PLC, you can change the PLC login password.

**Prerequisites:** The PC is properly connected to the PLC, and the PLC is online.

1. In the menu bar, choose "PLC" > "Set/Modify Login PLC Password". The "Modify login password" dialog box is displayed.



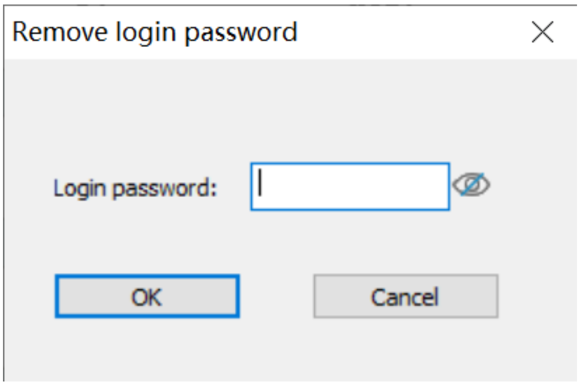

2. Enter the old password in the "Old password" text box and the new password in the "New password" and "Confirm password" text boxes, and click "OK" to change the PLC login password.

## Deleting PLC login password

When a login password is set for the PLC, you can delete the PLC login password.

**Prerequisites:** The PC is properly connected to the PLC, and the PLC is online.

1. In the menu bar, choose "PLC" > "Delete Login PLC Password". The "Remove login password" dialog box is displayed.




2. Enter the PLC login password in the "Login password" text box and click "OK" to delete the PLC login password.

# 2.11 Trace Monitor Variables

## 2.11.1 Overview

Like a digital sampling oscilloscope, the Trace function can record historical values of variables. When the Trace function is enabled, AutoShop starts to save the data records containing time, and you can continuously monitor variable changes on the Trace page to facilitate program commissioning.

## 2.11.2 Adding Trace Monitor Variables

This section introduces how to add Trace monitor variables by capturing changes of the D100, D200, and TEST variables.

**Procedure**

1. In the "Project Manager" tree, right-click "Trace" and select "New" to create a Trace monitor view.

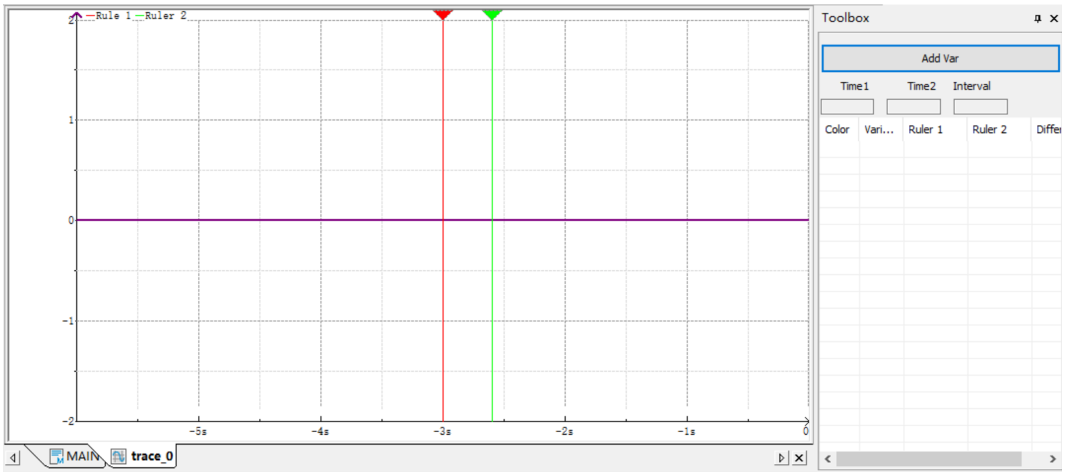
---

***Note***

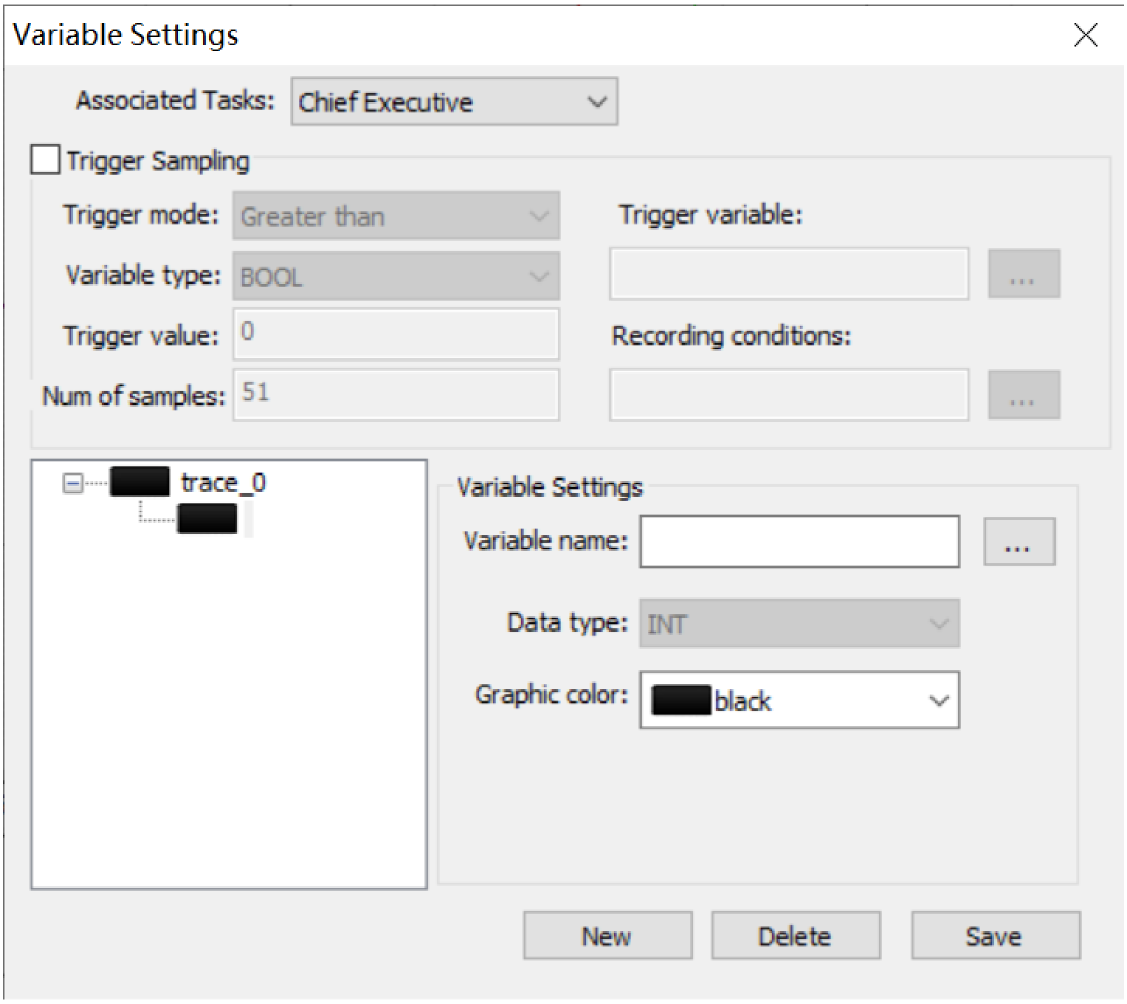
Right-click the newly created monitor chart and select "Delete" to delete the monitor chart, or select "Rename" to rename the monitor chart.

---

2. Double-click the new Trace monitor view to access the Trace page.



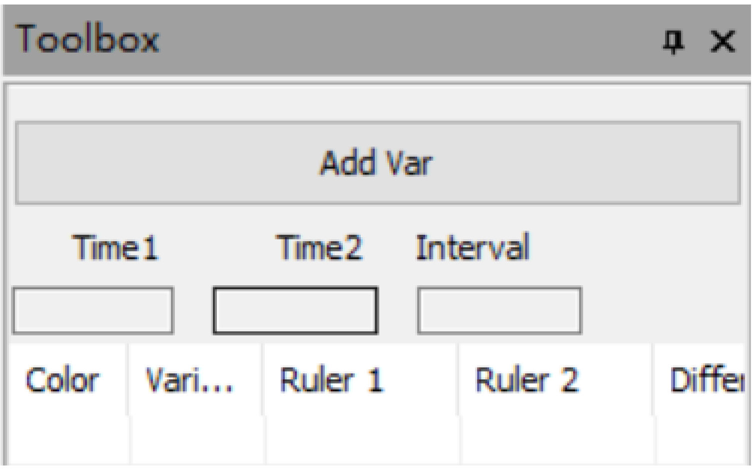

3. Click "Add Var". The "Add Var" dialog box is displayed.




| Parameter Name | Description |
|---|---|
| Associated Tasks | Indicates a variable used to select a monitor for sampling in main tasks or EtherCAT tasks.<br>Select "Chief Executive" or "Ethercat Task" from the drop-down list. |
| Trigger Sampling Enables | Indicates the function switch to trigger sampling enabling, which is valid upon checked. |

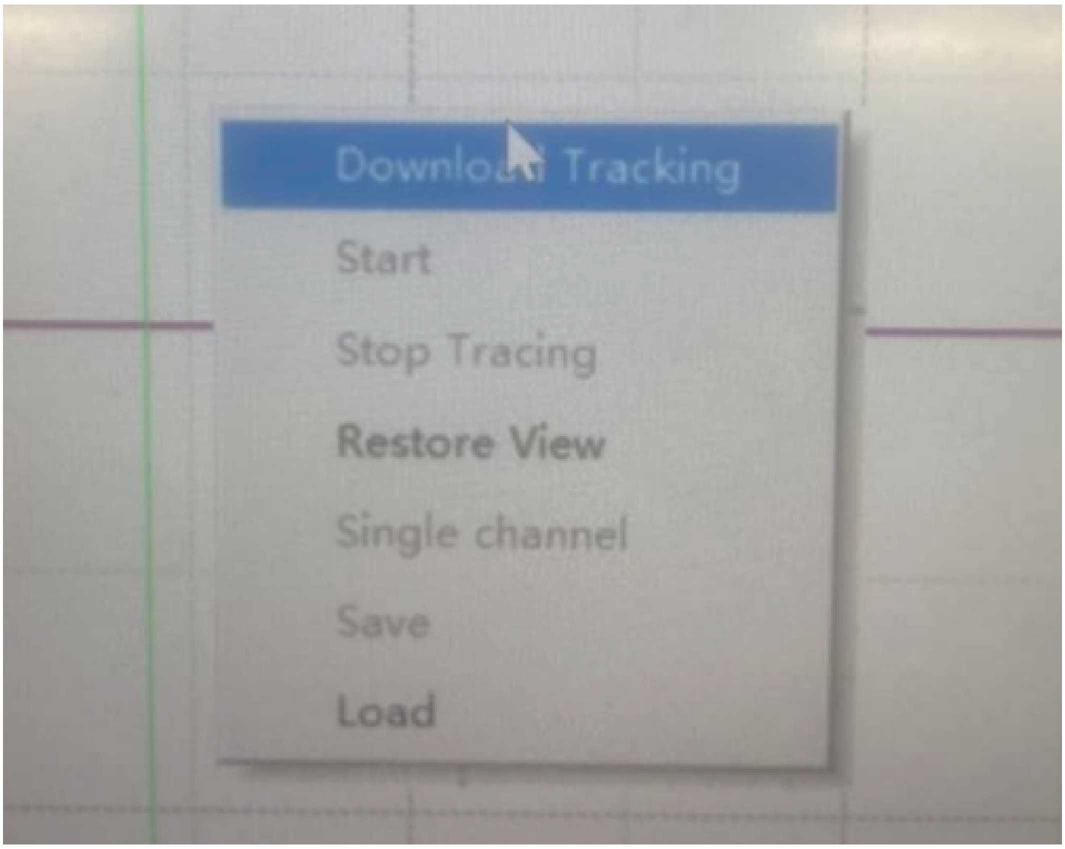
| Parameter Name | Description |
|---|---|
| Trigger mode | Indicates the mode to trigger sampling.<br>Select "Greater than", "Less than", "Not equal to", "Equal to", "Greater than or equal to", or "Less than or equal to" from the drop-down list. |
| Trigger value | Indicates that triggering stops when the trigger variable meets the trigger mode and trigger value conditions. |
| Variable type | Indicates the data type of a trigger variable.<br>Select "BOOL", "INT", "DINT", or "REAL" from the drop-down list. |
| Number of samples | Indicates the number of sampling points before trigger stops when trigger conditions are met. |
| Trigger variable | Indicates a trigger object. |
| Recording conditions | Indicates a BOOL variable of recording conditions to start tracking. This parameter can be left empty. |
| Variable Settings | Indicates the variable name of the monitor, corresponding variable data type, and graphic color on the Trace monitor view.<br>**Note:** Up to six variables are supported. |

4. Set "Associated Tasks" to "Chief Executive" and set the D100, D200, and TEST variables to be captured as an example. Set other parameters according to the preceding table, and click "Save" to save the variable settings.
   View variable information in the toolbox on the right.




| Parameter Name | Description |
|---|---|
| Color | Indicates the legend color of a variable on the Trace view. |
| Variable Name | Indicates the name of a variable. |
| Time1 | Indicates the value and time of the point corresponding to ruler 1. |
| Time2 | Indicates the value and time of the point corresponding to ruler 2. |
| Difference | Indicates the value and time difference between the points corresponding to the two rulers. |

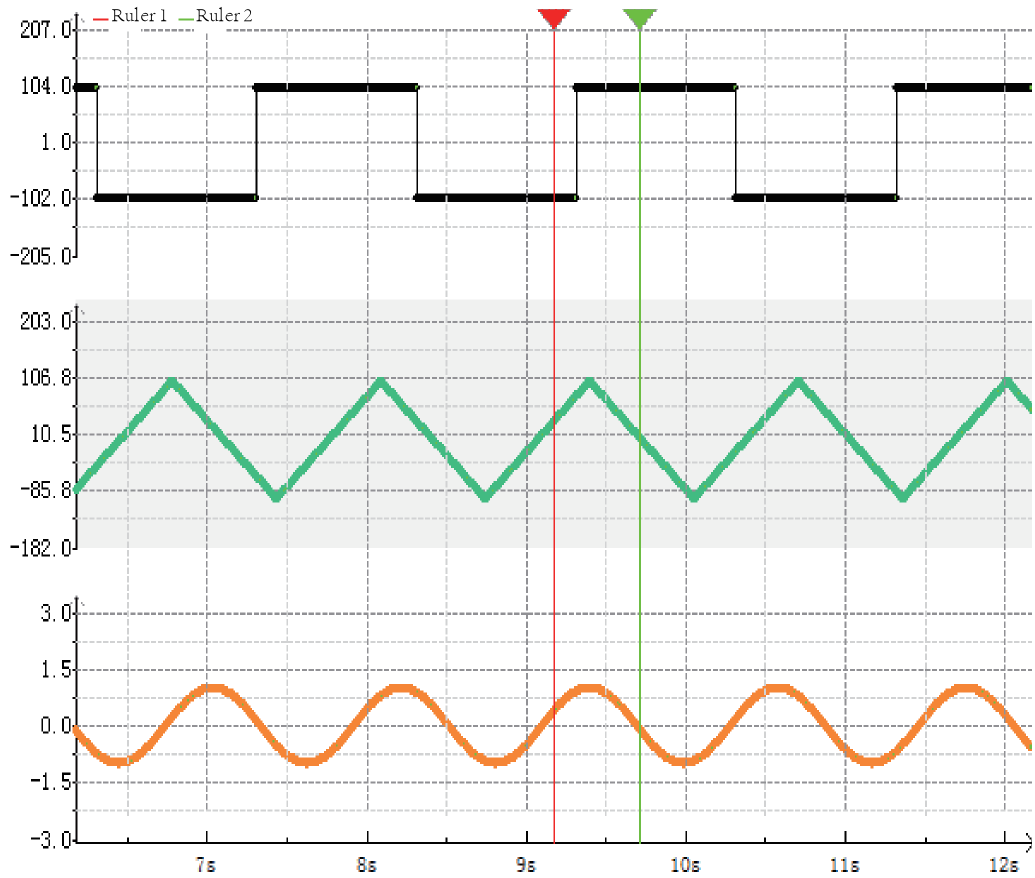
5. After configuring the variables, right-click on the Trace view and select "Download Tracking".




The following table lists the shortcut menus.

| Parameter Name | Description |
|---|---|
| Download Tracking | Indicates to download the set tracking variables and start tracking. |
| Start | Indicates to start the original variables to continue to track data acquisition after tracking variables are stopped. |
| Stop Tracing | Indicates to stop data acquisition after tracking starts. |
| Restore View | Indicates to restore the initial acquisition speed and data interval after you use the mouse roller to zoom in or out and translate the view. |
| Single channel/ Multichannel | Indicates variable collection for a single coordinate system or multiple coordinate systems. |
| Save | Indicates to save all collected data in the tracking stopped state. |
| Load | Indicates to load the saved file of collected data. |

After tracking is downloaded, you can start to monitor variables.




### Note

- In Trace mode, the horizontal and vertical coordinates of the chart automatically adapt to variable values. You can adjust the coordinates by scrolling the mouse wheel. Specifically, directly scroll the mouse wheel to zoom in or out the horizontal coordinate, and scroll the mouse wheel while holding down the Ctrl key to zoom in or out the vertical coordinate.
- In Monitor mode, you can drag the rulers to view the data of specific points, or drag the curve back and forth to view the data of key points. During this process, the Trace monitor chart stops scrolling, but data is still being collected. To restore to automatic scrolling mode, right-click the Trace monitor chart and select "Restore View".
- For other operations to the Trace monitor chart, see the preceding table of shortcut menus.

### Trace monitor example

When M0 is set to TRUE, Trace sampling starts. When D0 is greater than value 2 of "Trigger value", sampling stops after 51 data entries are sampled. D0 and D1 are tracking variables.

## 2.11.3 Importing or Exporting Trace Data

### Exporting Trace data

**Prerequisite:** Data acquisition is stopped, that is, tracking is stopped.

Right-click on the Trace monitor view and select "Save" to save data to the corresponding folder.

## Importing Trace data

**Prerequisite:**

- A Trace data file is prepared.
- Data acquisition is stopped, that is, tracking is stopped.

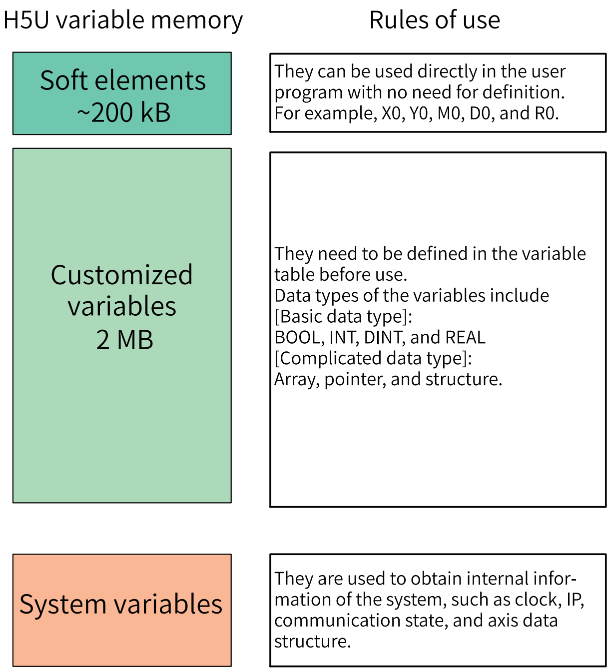
Right-click on the Trace monitor view and select "Load". In the dialog box that is displayed, select a Trace data file to load data to the Trace monitor view.

# 3 Programming Basics

## 3.1 Overview

The variable memory structure for programming contains soft elements, customized variables, and system variables.

The following figure shows the corresponding rules of use.




## 3.2 Elements

### 3.2.1 Bit Elements

The PLC supports bit elements. The following table describes the specific type, range, number of points, and description of bit elements.

| Type | Range | Number of Points | Data Type | Description |
|---|---|---|---|---|
| X | X0 to X1777 | 1024 points, octal | BOOL | Input |
| Y | Y0 to Y1777 | 1024 points, octal | BOOL | Output |
| M | M0 to M7999 | 8000 points | BOOL | M0 to M999 not retained upon power failure, M1000 to M7999 retained upon power failure |

| Type | Range | Number of Points | Data Type | Description |
|---|---|---|---|---|
| S | S0 to S4095 | 4096 points | BOOL | S0 to S999 not retained upon power failure, S1000 to S4095 retained upon power failure |
| B | B0 to B32767 | 32768 points | BOOL | B0 to B999 not retained upon power failure, B1000 to B32767 retained upon power failure |

## 3.2.2 Word Elements

The PLC supports word elements. The following table describes the specific type, range, number of points, and description of word elements.

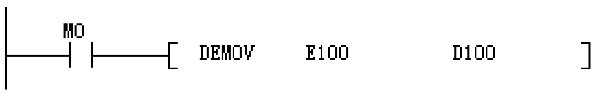
| Type | Range | Number of Points | Data Type | Description |
|---|---|---|---|---|
| D | D0 to D7999 | 8000 points | BOOL/INT/DINT/REAL | D0 to D999 not retained upon power failure, D1000 to D7999 retained upon power failure |
| R | R0 to R32767 | 32768 points | BOOL/INT/DINT/REAL | R0 to R999 not retained upon power failure, R1000 to R32767 retained upon power failure |
| W | W0 to W32767 | 32768 points | BOOL/INT/DINT/REAL | W0 to W999 not retained upon power failure, W1000 to W32767 retained upon power failure |

### Example

1. Word element used as a 16-bit integer
   Use the 16-bit assignment instruction to assign the value 100 to the word element D100, which occupies D100.


2. Word element used as a 32-bit integer
   Use the 32-bit assignment instruction to assign the value 100 to the word element D100, which occupies occupy D100 (low-order) and D101 (high-order).


3. Word element used as a floating-point number
   Use the floating-point instruction to assign the value 100 to the word element D100, which occupies D100 and D101.

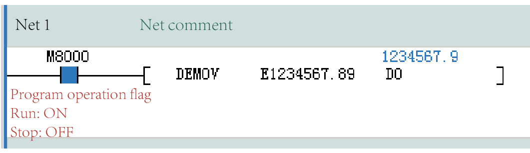


### 3.2.3 Special Elements

The PLC supports special elements. The following table describes the specific type, range, and description of special elements.

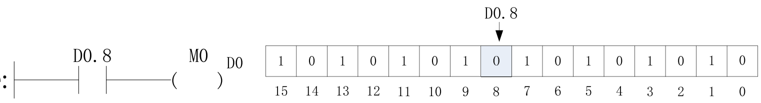
| Type | Function | Range | Number of Points | Description |
|---|---|---|---|---|
| SBR | Subprogram label | SBR0 to SBR1023 | 1024 | Used by the CALL instruction. Subprograms can be set as common subprograms or encrypted subprograms, which share the capacity of the system program area. |
| L | Jump label | L0 to L1023 | 1024 points | Used in combination with the CJ and LBL instructions |
| I | External interrupt | - | 4 | Interrupt label, X port rising edge, falling edge, rising and falling edge |
| | Timer interrupt | - | 4 | Timing duration (ms) |
| | Compare interrupt | - | 16 | Limited by the number of internal encoder axes (high-speed counters) |
| K | Decimal | K-32,768 to K32,767 (16-bit), K-2,147,483,648 to K2,147,483,647 (32-bit) | - | - |
| H | Hexadecimal | H0000 to HFFFF (16-bit), H00000000 to HFFFFFFFF (32-bit) | - | - |
| E | Floating-point number, real number | $-3.402823e^{+38}$ to $-1.175495e^{-38}$, 0, $+1.175495e^{-38}$ to $+3.402823e^{+38}$ | - | Up to 7 decimal significant digits for a single-precision floating-point number (the excess will be automatically rounded off) |
| Character | Character, string | - | - | Used as instruction parameters |

A single-precision floating-point number has a maximum of 7 significant decimal digits. If the 9-bit binary floating-point number 1234567.89 is transferred to the destination location D0, the actual value of D0 is 1234567.9. The precision is reduced.




### 3.2.4 Bit-based Operation on Word Elements

Bit-based operations on word elements can be implemented by using a dot (.). For example, writing D0.8 during programming indicates an operation on the 8th bit of the D0 word element.

Example: 


The bits of the word element are counted from the 0th bit. When the 8th bit of D0 is 0, the output M0 is OFF; when the 8th bit of D0 is 1, the output M0 is ON.

# 3.3 Variables

## 3.3.1 Custom Variables

In a PLC programming system, in addition to using direct addresses, such as the X, Y, M, D, R and other elements, for programming, you can also use variables without specific storage addresses for programming to implement the required control logic, or the complete control process of the application object, so as to facilitate code compiling and improve the readability of the code.

Table 3–1 Supported custom variables

<table>
<tr><th>Type</th><th>Capacity</th><th>Data Type</th><th>Description</th></tr>
<tr><td>Pointer</td><td>4096 points (32-bit)</td><td>BOOL/INT/DINT/REAL</td><td>Pointer Variable<br>Not retained upon power failure</td></tr>
<tr><td>BOOL</td><td rowspan="7">2 MB (8-bit)</td><td rowspan="7">BOOL/INT/DINT/REAL/IP/STRING/ BYTE variable<br>BOOL/INT/DINT/REAL/IP/STRING/ BYTE array<br>BOOL/INT/DINT/REAL/IP/STRING/ BYTE compound structure</td><td rowspan="7">256 KB data retained upon power failure<br>Other data not retained power failure</td></tr>
<tr><td>INT</td></tr>
<tr><td>DINT</td></tr>
<tr><td>REAL</td></tr>
<tr><td>IP</td></tr>
<tr><td>STRING</td></tr>
<tr><td>BYTE</td></tr>
</table>

## 3.3.2 Defining Variables

The PLC supports custom variables. You can define a global variable and directly use the variable name during programming. Abide by the following rules when naming a global variable:

- It contains only letters, digits, Chinese characters, and underscores (_) and does not start with a digit or underscore (_).
- It is not the same as the name of an element, constant, standard data type, instruction, subprogram, or interrupt subprogram.
- It cannot be keywords such as ARRAY, TRUE, FALSE, ON, OFF, and NULL.

### Variable Data Types

Structures and arrays are supported. The following table lists the supported data types.

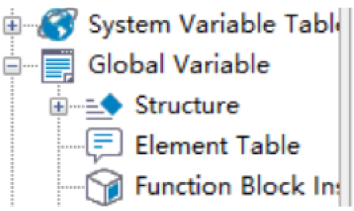
Table 3–2 Variable data types

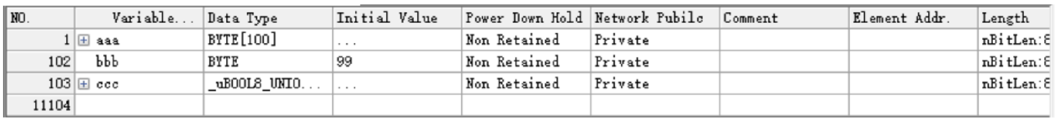
| Data Type | Description |
|---|---|
| BOOL | Boolean |
| INT | Single-word integer |

| Data Type | Description |
|---|---|
| DINT | Double word integer |
| REAL | Real number |
| STRING | String type |
| IP | IP |
| BYTE | Byte |

## Defining Global Variables

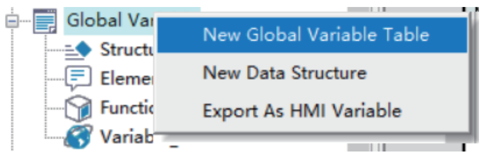
"Global Variable" in the project management window is used for variable management, allowing you to add, delete, and edit variables.



| NO. | Variable... | Data Type | Initial Value | Power Down Hold | Network Pubilc | Comment | Element Addr. | Length |
|---|---|---|---|---|---|---|---|---|
| 1 | aaa | BYTE[100] | ... | Non Retained | Private | | | nBitLen:8 |
| 102 | bbb | BYTE | 99 | Non Retained | Private | | | nBitLen:8 |
| 103 | ccc | _uBOOL8_UNIO... | ... | Non Retained | Private | | | nBitLen:8 |
| 11104 | | | | | | | | |

1. Add a variable table and variables. Right-click "Global Variable" and choose "New Global Variable Table" to create a global variable table.




2. Double-click the variable table to go to the variable editing interface.

- Edit a variable: Double-click the text box to edit or click the drop-down box to select.
- Add a variable: Right-click and choose "Insert Row(&I)".
- Delete a variable: Right-click the row to be deleted and choose "Delete Row(&L)".

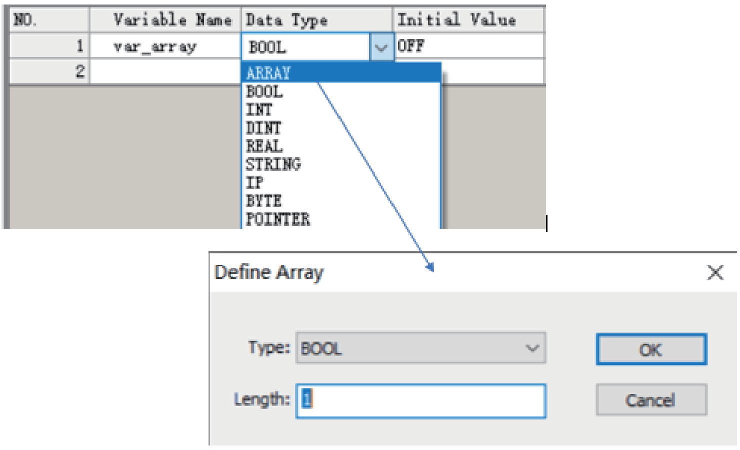
| Parameter Name | Description |
|---|---|
| Variable Name | Custom variable name. You can directly use the variable name for programming. |
| Type | The data types include BOOL, INT, DINT, REAL, IP, STRING, and BYTE variables, BOOL, INT, DINT, REAL, IP, STRING, and BYTE arrays, and BOOL, INT, DINT, REAL, IP, STRING, and BYTE structures.<br>If the data type is an array, you can set the type and length of the array variable in the displayed dialog box. If the data type is a pre-defined structure, you can define a structure variable. |
| Initial Value | You can assign an initial value to a variable. For arrays and structures, the initial value of each element can be specified individually. |

| Parameter Name | Description |
| --- | --- |
| Power Down Hold | "Power Down Hold" can be set to "Non Retained" or "Retained". The specified initial value is valid only when this parameter is set to "Non Retained". |
| Network Public | This parameter can be set to "Private", "Public", or "In/Out". For structure, specific union, structure array, and specific union array variables, this parameter must be set to "Private".<br>When this parameter is set to "Public", a label configuration file named "LabelConfig.xml" will be generated in the "InteractiveFile" folder under the project directory after project compiling. Importing this configuration file into third-party software enables label communication. |

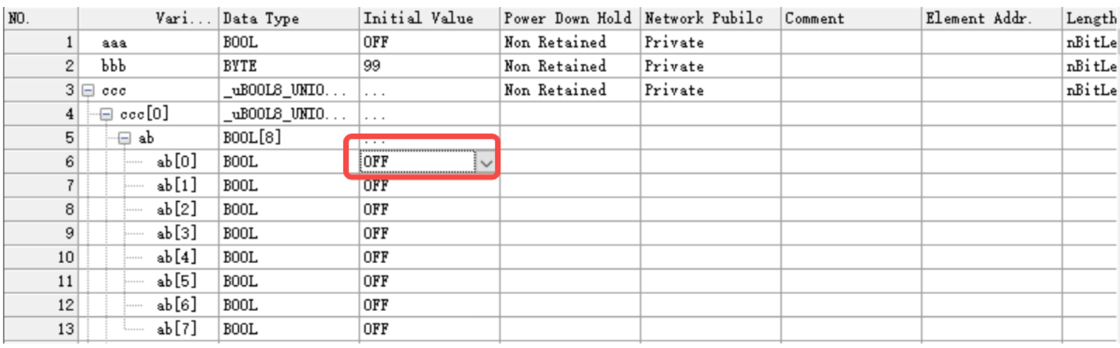
## 3.3.3 Defining Arrays

During user programming, if the data type is set to "ARRAY", an array can be defined.

1. Select the type and length of the array variable in the displayed dialog box and click "OK" to define an array.




2. Click "+" next to the array variable to edit the initial values and comments of member variables.

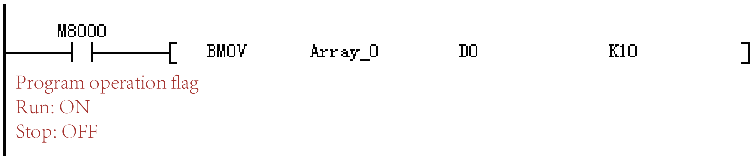


| NO. | Vari... | Data Type | Initial Value | Power Down Hold | Network Pubilc | Comment | Element Addr. | Length |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | aaa | BOOL | OFF | Non Retained | Private | | | nBitLe |
| 2 | bbb | BYTE | 99 | Non Retained | Private | | | nBitLe |
| 3 | ccc | _uBOOL8_UNIO... | ... | Non Retained | Private | | | nBitLe |
| 4 | ccc[0] | _uBOOL8_UNIO... | ... | | | | | |
| 5 | ab | BOOL[8] | ... | | | | | |
| 6 | ab[0] | BOOL | OFF | | | | | |
| 7 | ab[1] | BOOL | OFF | | | | | |
| 8 | ab[2] | BOOL | OFF | | | | | |
| 9 | ab[3] | BOOL | OFF | | | | | |
| 10 | ab[4] | BOOL | OFF | | | | | |
| 11 | ab[5] | BOOL | OFF | | | | | |
| 12 | ab[6] | BOOL | OFF | | | | | |
| 13 | ab[7] | BOOL | OFF | | | | | |

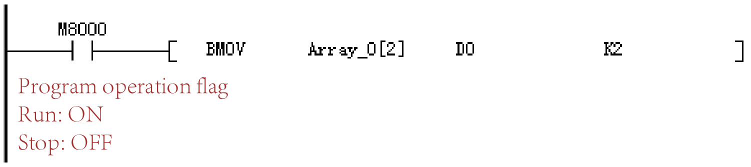
When an array is used in an instruction, if the array subscript is not specified, the access starts from the first element of the array. If the array subscript is specified, the access starts from the element specified by the subscript.

The following are two examples.

- Assign Array_0[0]–Array_0[9] to D0–D9.

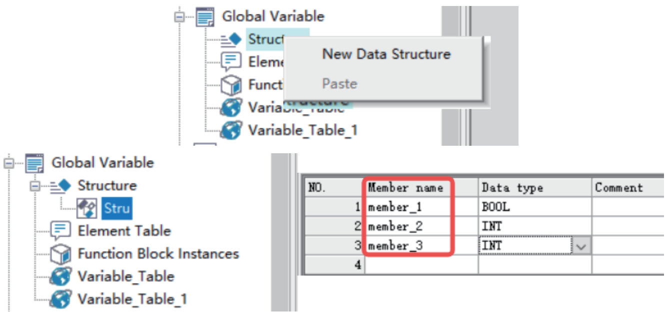



- Assign Array_0[2]–Array_0[3] to D0–D1.

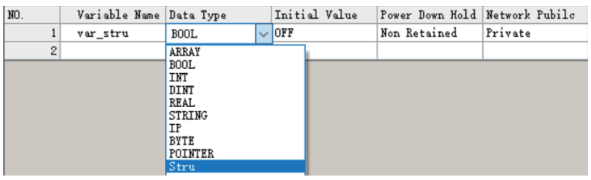



## 3.3.4 Defining Structures

To define a structure variable, you need to define the data structure of the structure in advance. Right-click "Structure" under "Global Variable", choose "New Data Structure", and enter a structure name. The structure is defined. When defining a variable in the variable table, you can select this structure as the data type of the variable to define the variable as a structure variable.




After the structure and member variables are created, you can select "Stru" in the "Data Type" column to define a structure variable.

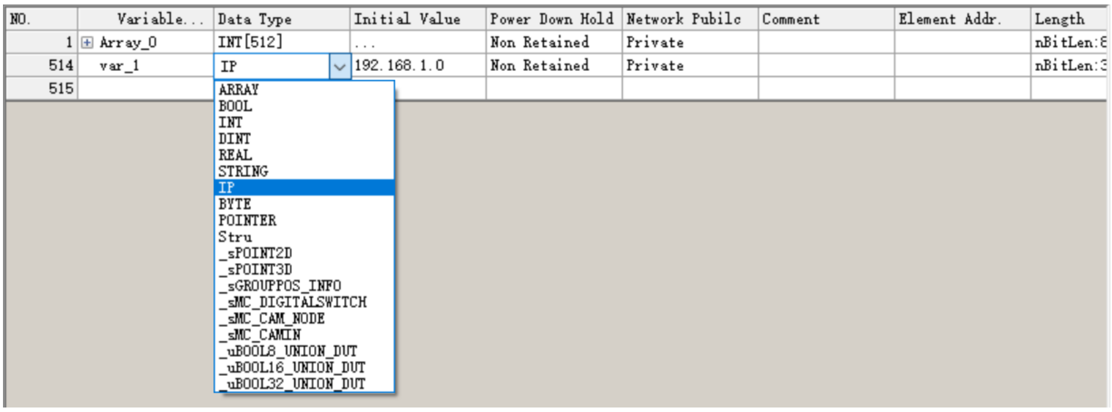



Click the "Initial Value" column of the structure variable to set the initial values of structure variable members.

## 3.3.5 Defining IP Variables

You can define IP variables in the variable table or program. An IP variable occupies 32 bits, and the default value is "192.168.1.0".

- Select "IP" from the "Type" drop-down list.



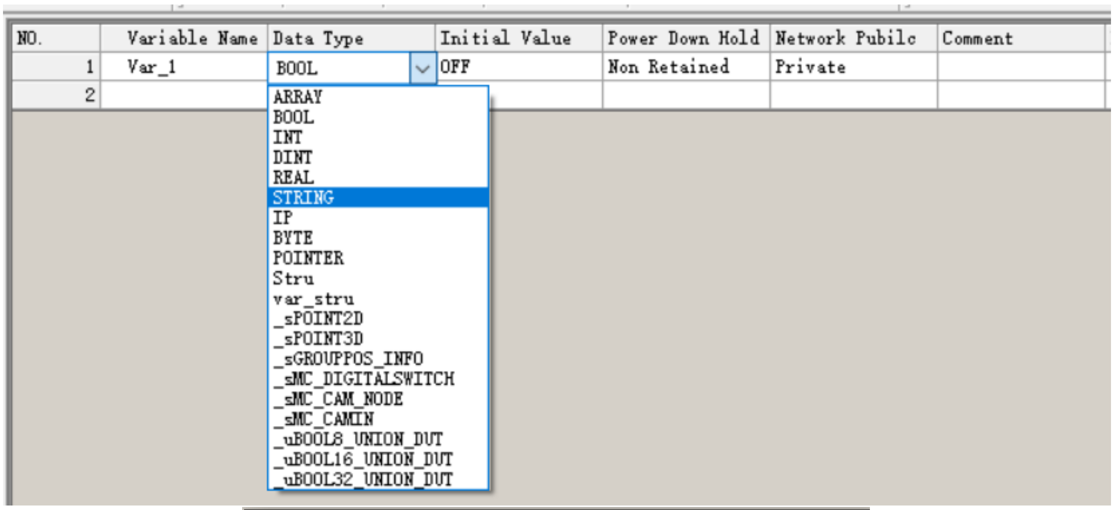

- Use an IP variable in the ST program, and assign a value to the IP variable by using single quotation marks.

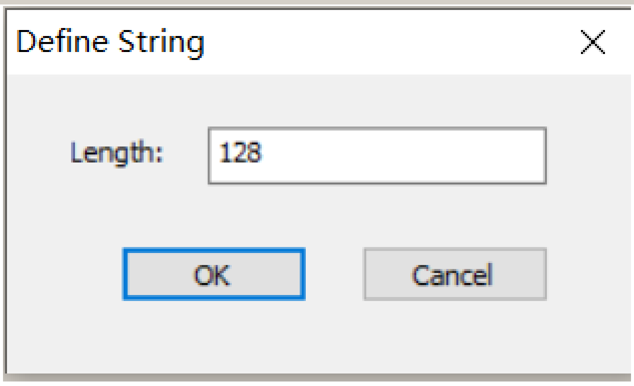
```
10  var_1:='10.45.121.90';
```

### 3.3.6 Defining Strings

You can define string variables in the variable table or program.

- Select "STRING" from the "Type" drop-down list of the variable table, and set the length of the string in the displayed dialog box.
  The default length is 128 bytes and the maximum length is 256 bytes. The last byte is the terminator by default.



- Use a string variable in the ST program, and assign a value to the string variable by using single quotation marks.

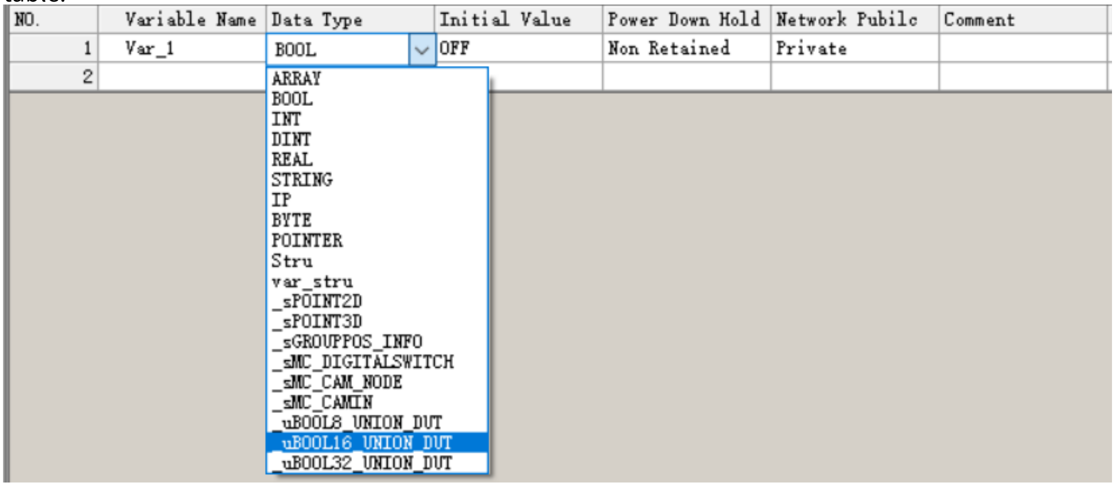
```
1 var_1:='abc';
```

### 3.3.7 Defining Specific Unions

A specific union is similar to a structure in that they both are collections of different types of elements. The difference lies in the fact that each member of a structure has its own independent storage space, while the members of a specific union share the same memory space (which is why a specific union is called a union). This will inevitably cause the members to overwrite each other, resulting in data loss. Therefore, the ideal application scenario for a specific union is when its members are not used simultaneously, but rather one after another.

You can define specific union variables in the variable table or program. There are three types of specific union variables: _uBOOL8_UNION_DUT, _uBOOL16_UNION_DUT, and _uBOOL32_UNION_DUT, corresponding to lengths of 1 byte, 2 bytes, and 4 bytes, respectively.

- Select the required specific union variable type from the "Type" drop-down list of the variable table.




Take _uBOOL32_UNION_DUT as an example. Create a variable in the variable table, and select "_uBOOL32_UNION_DUT" from the "Type" drop-down list.

| NO. | Variab... | Data Type | Initial Value | Power Down Hold | Network Pubilc | Comment | Element Addr. | Length |
|---|---|---|---|---|---|---|---|---|
| 1 | var_1 | _uBOOL32_UNI... | ... | Non Retained | Private | | D0 | nBitLen:3 |
| 2 | ab | BOOL[32] | ... | | | | | |
| 35 | ai | INT[2] | ... | | | | | |
| 36 | ai[0] | INT | 0 | | | | D0 | |
| 37 | ai[1] | INT | 0 | | | | D1 | |
| 38 | abyte | BYTE[4] | ... | | | | | |
| 39 | abyte[0] | BYTE | 0 | | | | D0 | |
| 40 | abyte[1] | BYTE | 0 | | | | D0.8 | |
| 41 | abyte[2] | BYTE | 0 | | | | D1 | |
| 42 | abyte[3] | BYTE | 0 | | | | D1.8 | |
| 43 | byte0 | BYTE | 0 | | | | D0 | |
| 44 | byte1 | BYTE | 0 | | | | D0.8 | |
| 45 | byte2 | BYTE | 0 | | | | D1 | |
| 46 | byte3 | BYTE | 0 | | | | D1.8 | |
| 47 | i0 | INT | 0 | | | | D0 | |
| 48 | i1 | INT | 0 | | | | D1 | |
| 49 | f0 | REAL | 0.000000 | | | | D0 | |
| 50 | di0 | DINT | 0 | | | | D0 | |
| 51 | | | | | | | | |

- In a program, you can access different members of a specific union variable by using the dot operator ("."). This allows you to parse variables in different scenarios.

### 3.3.8 Using Variables

After a variable is defined, you can directly use the variable name for programming without assigning elements.

- When a common variable is used, directly use the variable name during programming.
- When an array variable is used, use "[Number]" to indicate an array element during programming. The number starts from 0.
- When a structure variable is used, use "Structure variable name.Member variable" to indicate a structure member during ST programming.
- When an IP or string variable is used, use a value enclosed in a pair of single quotation marks ('Value') to indicate the value of the variable.

```
1 var_1:='10.45.121.90';
```

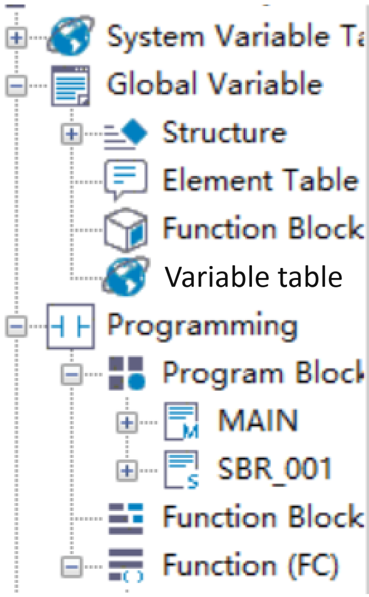
```
1 var_1:='abc';
```

For BYTE, INT, and DINT variables and arrays, you can perform bit operations using the syntax "variable_name.bit_number" in programming. For details, see *"3.2.4 Bit-based Operation on Word Elements" on page 60*.

## 3.4 Binding Variables to Addresses

### 3.4.1 Overview

Customized variables can be bound to soft element addresses so that customized variable addresses are associated with soft element addresses.
You only need to enter the target address in the address column in the variable table and compile the project. Then the software will automatically generate an address for the customized variable.




| NO. | Variable... | Data Type | Initial Value | Power Down Hold | Network Pubilc | Comment | Element Addr. | Length |
|---|---|---|---|---|---|---|---|---|
| 1 | Test_1 | BOOL | OFF | Non Retained | Private | | | nBitLen:1 |
| 2 | Test_2 | INT | 0 | Non Retained | Private | | | nBitLen:1 |
| 3 | Test_3 | BOOL | OFF | Non Retained | Private | | | nBitLen:1 |
| 4 | ⊞ stru_0 | Stru | ... | Non Retained | Private | | | nBitLen:4 |
| 12 | | | | | | | | |

### 3.4.2 Variable Property

A customized variable turns retentive or non-retentive at power failure according to the bound soft element.

As shown in the following figure, M1 is in the area of retention at power failure, so Test_1 is retentive at power failure after being bound to it; D100 is in the area of non-retention at power failure, so Test_2 is non-retentive at power failure after being bound to it.

The variable automatically turns retentive or non-retentive at power failure after being bound to an element.

### 3.4.3 Binding Basic Variables to Soft Elements

- A BOOL variable consists of one bit and can be bound only to a bit element. An INT variable consists of 16 bits and can be bound to one word element. A DINT or REAL variable consists of 32 bits and can be bound to two consecutive word elements.
- A BYTE variable consists of eight bits, and a word element consists of 16 bits. Therefore, a BYTE variable occupies only the low-order 8 bits of a word element upon binding.
- An IP variable consists of 32 bits, occupying two consecutive word elements.
- A STRING variable consists of a customized number of bytes, such as two bytes. For example, if the variable consists of five bytes, it occupies six bytes. After it is bound to soft element D0, it occupies D0, D1, and D2.

### 3.4.4 Binding Array Variables to Soft Elements

To bind an array variable to a soft element, enter the address to be mapped in the address column in the variable table.

- A word variable occupies a specified number of word elements based on the variable type. One INT variable occupies one 16-bit element, while a REAL or DINT variable or an IP variable occupies two 16-bit elements.
- Each member of a BYTE array variable occupies half a word element. For example, when a BYTE[5] variable is bound to D0, the first member is bound to the low-order 8 bits of D0 and the second member is bound to the high-order 8 bits of D0. Other elements are bound like this in sequence.
- Each member of a STRING array variable contains two bytes and occupies word elements in sequence.
- A BOOL variable occupies a specified number of bit elements.
- An array variable can be only bound to soft elements of corresponding types. That is, word variables can be only bound to word elements and bit variables can be only bound to bit elements.

For example, if a BOOL array variable is defined as Array_0 to be bound to the M0 element and the length is 10, the variable occupies elements M0 to M9. If an INT array variable is defined as Array_1 to be bound to the D0 element and the length is 10, the variable occupies elements D0 to D9.

### 3.4.5 Binding Structure Variables to Soft Elements

AutoShop earlier than V4.0.0.0 does not allow to bind the structure to soft elements. This section describes how to bind a project customized by AutoShop earlier than V4.0.0.0 to a variable after AutoShop is upgraded to V4.0.0.0, and how to bind a project customized by AutoShop 4.0.0.0 or later to a soft element.

When binding a structure variable to a soft element, enter a word element address to be mapped in the address column in the variable table, and click "Compile". AutoShop will automatically generate the address of the structure member. The address assignment rules are as follows:

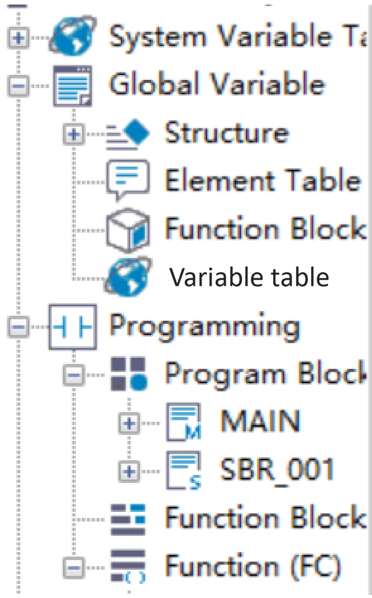
1. An INT variable occupies one 16-bit element, while a REAL or DINT variable occupies two 16-bit elements.
2. Multiple consecutive BOOL variables are considered to occupy one 16-bit element as a whole, and are assigned with an address in sequence from bit 0 of the 16-bit element. Multiple non-consecutive BOOL variables are considered to occupy one 16-bit element separately.
3. Arrays and structure variables occupy one 16-bit element as a whole.

For example, the Stru_0 variable of the Stru type is defined and the D1000 element is bound.

| No. | Member Variable Name | Data Type |
|---|---|---|
| 1 | member_1 | BOOL |
| 2 | member_2 | INT[2] |
| 3 | member_3 | BOOL[2] |
| 4 | member_4 | DINT |
| 5 | member_5 | REAL |
| 6 | member_6 | INT |
| 7 | member_7 | BOOL |

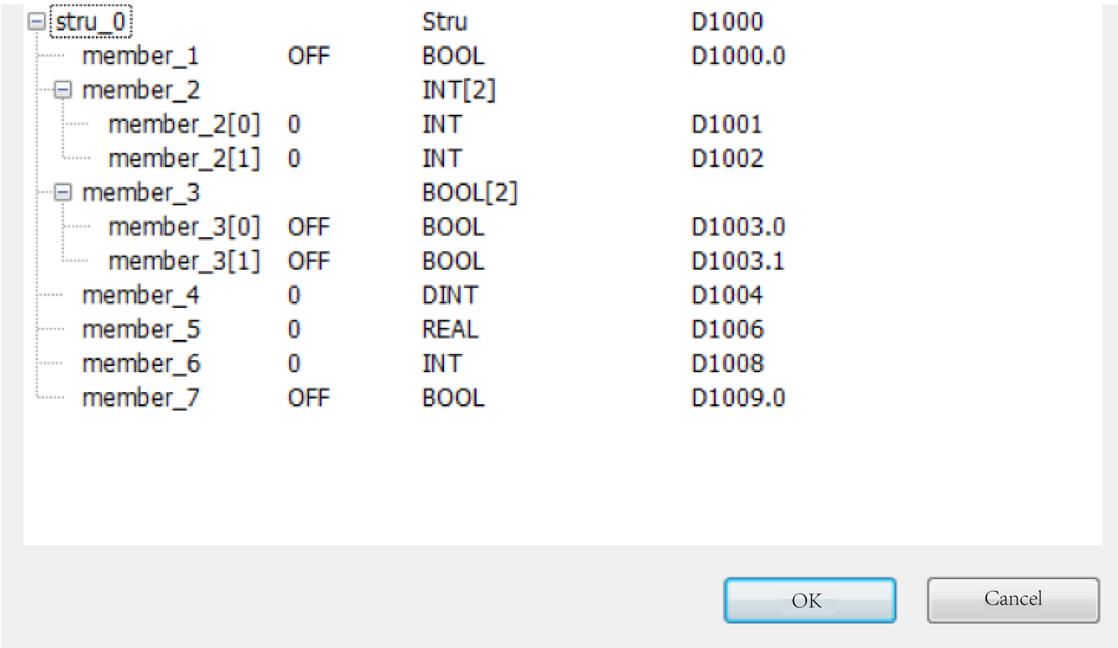
- Stru_0.member_1//The type is BOOL, so D1000.0 is bound.
- Stru_0.member_2//The type is INT array, so D1001 and D1002 are bound.
- Stru_0.member_3//The type is BOOL array, so D1003.0 and D1003.1 are bound.
- Stru_0.member_4//The type is DINT, so D1004 is bound.
- Stru_0.member_5//The type is REAL, so D1006 is bound.
- Stru_0.member_6//The type is INT, so D1008 is bound.
- Stru_0.member_7//The type is BOOL, so D1009.0 is bound.

1. To bind a project customized by AutoShop 4.0.0.0 and later, enter the address to be mapped in the address column in the variable table.




| NO. | Variable... | Data Type | Initial Value | Power Down Hold | Network Pubilc | Comment | Element Addr. | Length |
|---|---|---|---|---|---|---|---|---|
| 1 | Test_1 | BOOL | OFF | Non Retained | Private | | | nBitLen:1 |
| 2 | Test_2 | INT | 0 | Non Retained | Private | | | nBitLen:1 |
| 3 | Test_3 | BOOL | OFF | Non Retained | Private | | | nBitLen:1 |
| 4 | ⊞ stru_0 | Stru | ... | Non Retained | Private | | | nBitLen:4 |
| 12 | | | | | | | | |

Compile the project. An address will be automatically generated. Then, double-click the initial value of the corresponding structure variable in the variable table to view the mapping address of each member in the structure and set the variable input value.




2. The address assignment policy for projects customized by AutoShop earlier than V4.0.0.0 is different. To bind a structure variable for such a project, upgrade the address assignment policy.

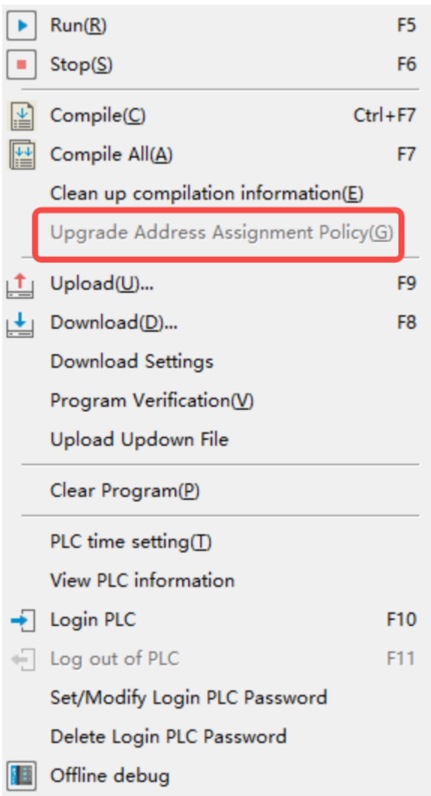
   The procedure is as follows: Open the project, switch to the variable table page, click "PLC" in the menu bar, and select "Upgrade Address Assignment Policy".

---

## *Note*

The upgrade can result in change to the original addresses that are automatically assigned. If the monitoring variable table is used for communication with the HMI, the information of the monitoring variable table needs to be updated to the HMI. If the element binding method is used, the addresses will not be affected.

---



After the upgrade, the method of binding a structure variable to a soft element is the same as that later than AutoShop 4.0.0.0. For details, see the preceding procedure.

### 3.4.6 Binding Specific Union Variables to Soft Elements

Specific union variables are classified into three types, and specific union members obtain addresses at a fixed offset.

- A uBOOL8_UNION_DUT variable consists of eight bits and occupies the low-order 8 bits of a word element. Members of the variable are bound to soft elements in sequence based on the offset.
- A uBOOL16_UNION_DUT variable consists of 16 bits and occupies one word element. Members of the variable are bound to soft elements in sequence based on the offset.

| NO. | Variab... | Data Type | Initial Value | Power Down Hold | Network Pubilc | Comment | Element Addr. | Length |
|---|---|---|---|---|---|---|---|---|
| 1 | var_1 | _uBOOL8_U... | ... | Non Retained | Private | | | nBitLen:8 |
| 2 | ab | BOOL[8] | ... | | | | | |
| 3 | ab[0] | BOOL | OFF | | | | | |
| 4 | ab[1] | BOOL | OFF | | | | | |
| 5 | ab[2] | BOOL | OFF | | | | | |
| 6 | ab[3] | BOOL | OFF | | | | | |
| 7 | ab[4] | BOOL | OFF | | | | | |
| 8 | ab[5] | BOOL | OFF | | | | | |
| 9 | ab[6] | BOOL | OFF | | | | | |
| 10 | ab[7] | BOOL | OFF | | | | | |
| 11 | byte0 | BYTE | 0 | | | | | |
| 12 | | | | | | | | |

| NO. | Variab... | Data Type | Initial Value | Power Down Hold | Network Pubilc | Comment | Element Addr. | Length |
|---|---|---|---|---|---|---|---|---|
| 1 | var_1 | _uBOOL16_... | ... | Non Retained | Private | | | nBitLe |
| 2 | ab | BOOL[16] | ... | | | | | |
| 3 | ab[0] | BOOL | OFF | | | | | |
| 4 | ab[1] | BOOL | OFF | | | | | |
| 5 | ab[2] | BOOL | OFF | | | | | |
| 6 | ab[3] | BOOL | OFF | | | | | |
| 7 | ab[4] | BOOL | OFF | | | | | |
| 8 | ab[5] | BOOL | OFF | | | | | |
| 9 | ab[6] | BOOL | OFF | | | | | |
| 10 | ab[7] | BOOL | OFF | | | | | |
| 11 | ab[8] | BOOL | OFF | | | | | |
| 12 | ab[9] | BOOL | OFF | | | | | |
| 13 | ab[10] | BOOL | OFF | | | | | |
| 14 | ab[11] | BOOL | OFF | | | | | |
| 15 | ab[12] | BOOL | OFF | | | | | |
| 16 | ab[13] | BOOL | OFF | | | | | |
| 17 | ab[14] | BOOL | OFF | | | | | |
| 18 | ab[15] | BOOL | OFF | | | | | |
| 19 | abyte | BYTE[2] | ... | | | | | |
| 20 | abyte[0] | BYTE | 0 | | | | | |
| 21 | abyte[1] | BYTE | 0 | | | | | |
| 22 | i0 | INT | 0 | | | | | |
| 23 | byte0 | BYTE | 0 | | | | | |
| 24 | byte1 | BYTE | 0 | | | | | |

- A uBOOL32_UNION_DUT variable consists of 32 bits and occupies two consecutive word elements. Members of the variable are bound to soft elements in sequence based on the offset. For example, the member var_1 is bound to soft element D0. The address offset of other BOOL array members is 0, so the initial address ab[0] is bound to D0.0, ab[15] to D0.15, and ab[31] to D1.15. The address offset of INT array members is 0, so the initial address ai[0] is bound to D0 and ai[1] to D1. The address offset of BYTE array members is 0, so the initial address abyte[0] is bound to D0, abyte[1] to D0.8, and so on.

  The offset is 0 for byte0, 8 bits for byte1, 16 bites for byte2, and 24 bits for byte 3. Therefore, the members are bound to D0, D0.8, D1, and D1.8 in sequence.

  The offset is 0 for i0 and 16 bits for i1. Therefore, the members are bound to D0 and D1 in sequence.

The offset is 0 for the floating-point number variable f0. Therefore, the variable is bound to the D0 and D1 elements. The offset is 0 for the DINT variable. Therefore, the variable is bound to the D0 and D1 elements.

| NO. | Variab... | Data Type | Initial Value | Power Down Hold | Network Pubilc | Comment | Element Addr. | Length |
|---|---|---|---|---|---|---|---|---|
| 1 | var_1 | _uBOOL32_UNI... | ... | Non Retained | Private | | D0 | nBitLen:3 |
| 2 | ab | BOOL[32] | ... | | | | | |
| 35 | ai | INT[2] | ... | | | | | |
| 36 | ai[0] | INT | 0 | | | | D0 | |
| 37 | ai[1] | INT | 0 | | | | D1 | |
| 38 | abyte | BYTE[4] | ... | | | | | |
| 39 | abyte[0] | BYTE | 0 | | | | D0 | |
| 40 | abyte[1] | BYTE | 0 | | | | D0.8 | |
| 41 | abyte[2] | BYTE | 0 | | | | D1 | |
| 42 | abyte[3] | BYTE | 0 | | | | D1.8 | |
| 43 | byte0 | BYTE | 0 | | | | D0 | |
| 44 | byte1 | BYTE | 0 | | | | D0.8 | |
| 45 | byte2 | BYTE | 0 | | | | D1 | |
| 46 | byte3 | BYTE | 0 | | | | D1.8 | |
| 47 | i0 | INT | 0 | | | | D0 | |
| 48 | i1 | INT | 0 | | | | D1 | |
| 49 | f0 | REAL | 0.000000 | | | | D0 | |
| 50 | di0 | DINT | 0 | | | | D0 | |
| 51 | | | | | | | | |

# 3.5 Using Variables as Array Subscripts

## 3.5.1 Rules of Use

Only one variable can be used as the subscript in the variable group.

The format is defined as array[index] or stru[index].var. In the format, array indicates an array or a structure array, index, var, and i are variables, and stru indicates the structure.

### Basic combination types

- Array variables only support bit variable arrays, word variable arrays, doubleword variable arrays, and float point variable arrays, but not pointer variables.
- Index variables, as array subscript variables, support single-word INT variable (16-bit) and doubleword DINT variable (32-bit), but not soft elements or other variables such as bit variables, float point variables, or pointer variables. A specified element of an array or a specified member of the structure can be used as an index variable, such as array[index[5]] and array[stru.index]. An array element with a variable sub-index or an array member of the structure cannot be used as index variables, such as array[index[i]] and array[stru[i].index].

### Complex combination types

- Array elements can be used as operands of instructions, with the index variable at the end, such as array[index], stru. Array[index], stru1[3].stru2. Array[index], and stru1.stru2.stru3. array[index].
- Members of structure arrays can be used as operands of instructions, with the index variable in the middle, such as stru[index].var, stru1[index].stru2.var, and stru1.stru2[5].stru3[index].array[3].
- Structure arrays containing two or more variables are not supported, such as stru[index1].array [index2].
- Two-dimension or multi-dimension arrays are not supported, such as array[index1][index2].

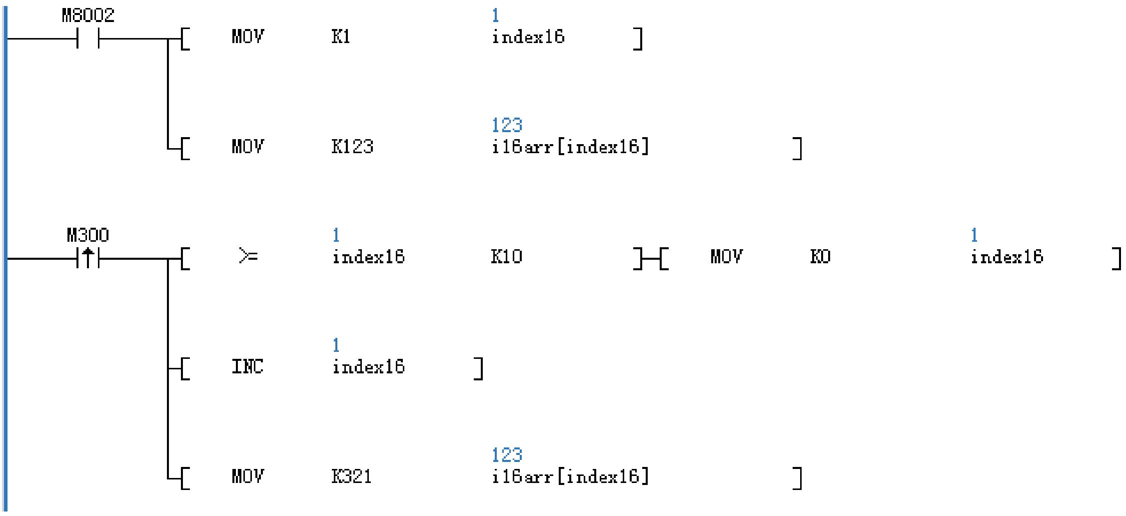
## *Note*

- Operands of the ZSET/ZRST instructions do not support arrays that use variables as subscripts.
- Operands of the PTxxx instructions do not support arrays that use variables as subscripts.
- Operands of the SFC instructions do not support arrays that use variables as subscripts.
- For operands (array type operands) of instructions (such as the BMOV instruction for batch assignment) that use multiple consecutive variables, variables in the arr[index] format can be used, but elements of a structure array in the stru[index].var format must not be used (because they are not consecutive). If jump assignment is required, a loop instruction must be used to achieve batch jump assignment.
- This function is mainly used in operands of single-cycle instructions and is not recommended for operands of multi-cycle instructions. If it is necessary to use this function in operands of multi-cycle instructions, logic and timing must be strictly controlled. In case of poor timing control, abnormal execution or conflict may occur upon value switchover (such as the pulse output instruction axis).

## 3.5.2 Programming Example

### Example 1

The program for assigning a value for an element in an array is shown in the following figure.




After startup, value 123 is assigned for i16arr[1]. Then, M300 assigns value 321 for the next array element upon each trigger. The following figure shows the result upon startup.

| | | | |
|---|---|---|---|
| i16arr | INT[10] | | |
| i16arr[0] | INT | Dec | 0 |
| i16arr[1] | INT | Dec | 123 |
| i16arr[2] | INT | Dec | 0 |
| i16arr[3] | INT | Dec | 0 |
| i16arr[4] | INT | Dec | 0 |
| i16arr[5] | INT | Dec | 0 |
| i16arr[6] | INT | Dec | 0 |
| i16arr[7] | INT | Dec | 0 |
| i16arr[8] | INT | Dec | 0 |
| i16arr[9] | INT | Dec | 0 |

Result upon the first trigger by M300

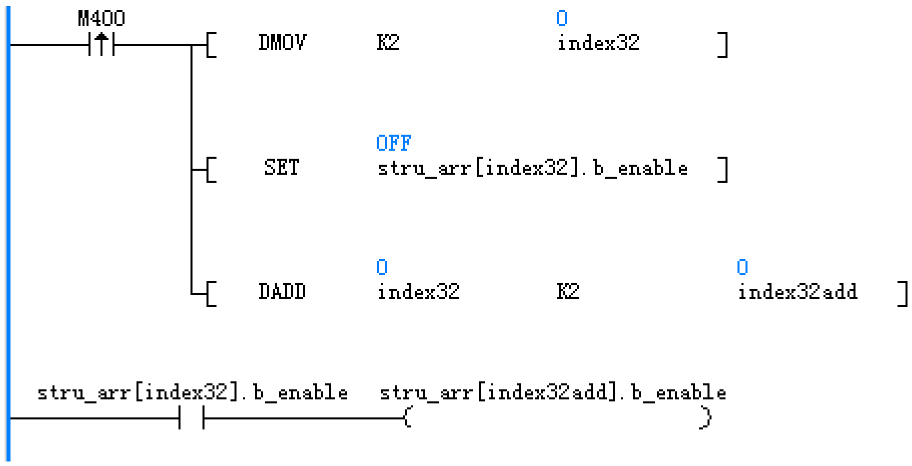
| | | | |
|---|---|---|---|
| i16arr | INT[10] | | |
| i16arr[0] | INT | Dec | 0 |
| i16arr[1] | INT | Dec | 123 |
| i16arr[2] | INT | Dec | 321 |
| i16arr[3] | INT | Dec | 0 |
| i16arr[4] | INT | Dec | 0 |
| i16arr[5] | INT | Dec | 0 |
| i16arr[6] | INT | Dec | 0 |
| i16arr[7] | INT | Dec | 0 |
| i16arr[8] | INT | Dec | 0 |
| i16arr[9] | INT | Dec | 0 |

Result after multiple triggers by M300

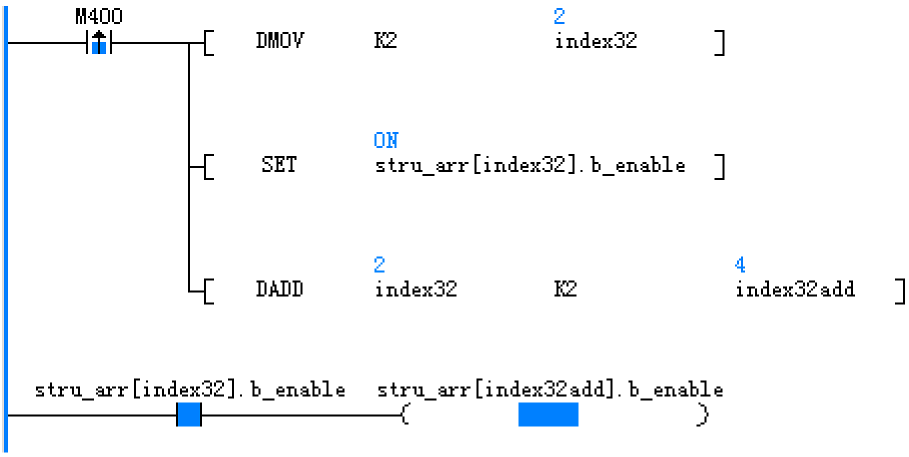
| | | | |
|---|---|---|---|
| i16arr | INT[10] | | |
| i16arr[0] | INT | Dec | 0 |
| i16arr[1] | INT | Dec | 123 |
| i16arr[2] | INT | Dec | 321 |
| i16arr[3] | INT | Dec | 321 |
| i16arr[4] | INT | Dec | 321 |
| i16arr[5] | INT | Dec | 321 |
| i16arr[6] | INT | Dec | 0 |
| i16arr[7] | INT | Dec | 0 |
| i16arr[8] | INT | Dec | 0 |
| i16arr[9] | INT | Dec | 0 |

## Example 2

The program for operating a member variable of a structure array is shown in the following figure.




After a trigger by M400, stru_arr[2].b_enable is set and stru_arr[4].b_enable is controlled based on the status of stru_arr[2].b_enable.



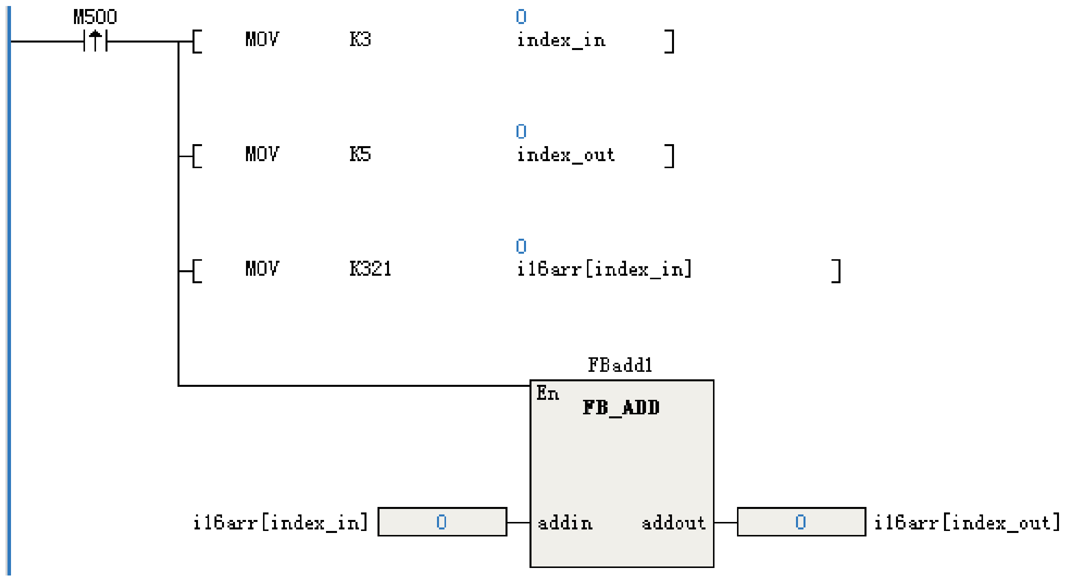

| | | | |
|---|---|---|---|
| stru_arr | Stru1[5] | | |
| stru_arr[0] | Stru1 | | |
| b_enable | BOOL | Bin | OFF |
| i16_a | INT | Dec | 0 |
| i32_b | DINT | Dec | 0 |
| stru_arr[1] | Stru1 | | |
| b_enable | BOOL | Bin | OFF |
| i16_a | INT | Dec | 0 |
| i32_b | DINT | Dec | 0 |
| stru_arr[2] | Stru1 | | |
| b_enable | BOOL | Bin | ON |
| i16_a | INT | Dec | 0 |
| i32_b | DINT | Dec | 0 |
| stru_arr[3] | Stru1 | | |
| b_enable | BOOL | Bin | OFF |
| i16_a | INT | Dec | 0 |
| i32_b | DINT | Dec | 0 |
| stru_arr[4] | Stru1 | | |
| b_enable | BOOL | Bin | ON |
| i16_a | INT | Dec | 0 |
| i32_b | DINT | Dec | 0 |

The following figure defines the structure.

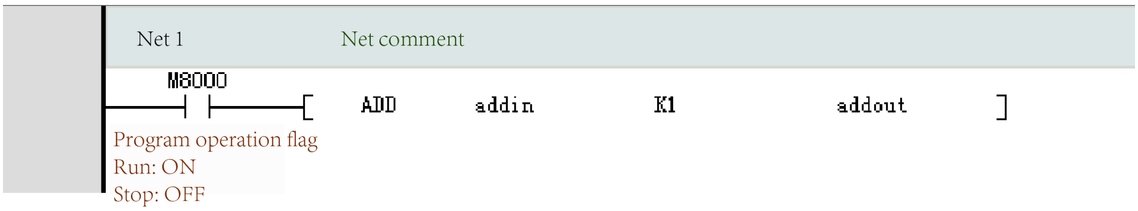
| | | | |
|---|---|---|---|
| 1 | b_enable | BOOL | |
| 2 | i16_a | INT | |
| 3 | i32_b | DINT | |

## Example 3

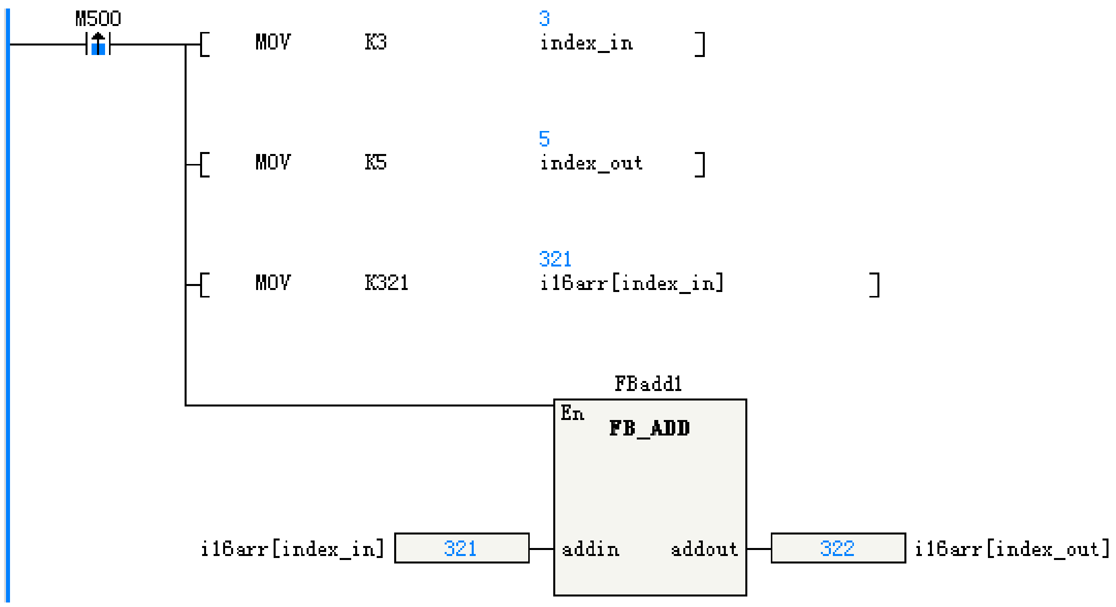
The program for using a variable as the array subscript for FB parameters is shown in the following figure.




FB program




After a trigger by M500, value 321 is assigned for i16arr[3] and then for i16arr[5] after FB calculation. The FB program adds 1 to the input parameter value and then assigns the new value for the output.



| | | | |
|---|---|---|---|
| ⊟ i16arr | INT[10] | Dec | |
| i16arr[0] | INT | Dec | 0 |
| i16arr[1] | INT | Dec | 0 |
| i16arr[2] | INT | Dec | 0 |
| i16arr[3] | INT | Dec | 321 |
| i16arr[4] | INT | Dec | 0 |
| i16arr[5] | INT | Dec | 322 |
| i16arr[6] | INT | Dec | 0 |
| i16arr[7] | INT | Dec | 0 |
| i16arr[8] | INT | Dec | 0 |
| i16arr[9] | INT | Dec | 0 |

# 3.6 Pointer Type Variables

## 3.6.1 Definition of Pointer Type Variables

Pointer type variables can be used as addresses of pointer storage soft elements or array variables. During programming, pointer type variables can be used for indirect addressing or indexed addressing. H5U and Easy series PLCs do not support the V and Z soft element functions.
In the variable table, after the variable name is defined and POINTER is selected as the data type, a pointer type variable is defined. The initial value of the pointer variable is NULL, indicating a null pointer, and the pointer variable is non-retentive upon a power failure.

Pointer type variables allow address operations and indirect addressing operations. Instruction of pointer address operations specify the address operations of pointers. The following table lists the instruction of pointer address operations. These instructions can be run to obtain addresses, realize offsets for pointer addresses, and compare pointer addresses.

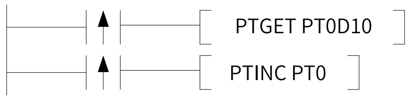
Table 3–3 Instructions of pointer address operations

| Instruction | Description |
|---|---|
| PTGET | Obtaining pointer addresses |
| PTINC | Pointer variable address incremented by 1 |
| PTDEC | Pointer variable address decremented by 1 |
| PTADD | Adding offsets for pointer variable addresses |
| PTSUB | Deducting offsets for pointer variable addresses |
| PT>, PT>=, PT<, PT<=, PT=, and PT<> | PT variable contact comparison |
| PTMOV | Pointer variable mutual assignment |

For other instructions, when pointer type variables are used, indirect addressing operations are performed on pointer type variables, indicating the operations on the values of soft elements or array variables directed by the pointer type variables. Indirect addressing operations on pointer type variables are indicated by "*Pointer type variable" during programming.

### Example

- Address operations on pointer type variables




The PTO points to the D10 address.

The PTO points to the next address.

- Indirect addressing operations on pointer type variables


Add the soft element pointed to by the PTO address to the D100.

---

***Note***

In programming, in addition to the instructions for pointer address operations in the preceding table, if other instructions use a pointer type variable, the programming software automatically adds an asterisk (*) before the variable. Alternatively, users can enter asterisk (*) manually.

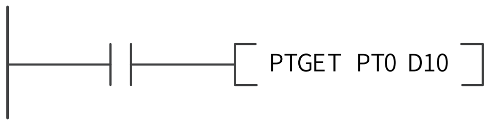
---

## 3.6.2 Obtaining Directing Addresses of Pointer Type Variables

Directing addresses of pointer type variables can be obtained by the pointer variable assignment instruction (PTGET).

**Example**

When the instruction energy flow is effective, the pointer type variable PT0 directs to D10. That is, PT0 obtains the address of the D10 soft element.



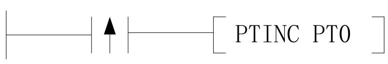

Point the PTO's address to D10

Pointer type variables can direct to bit elements (X, Y, M, S, and B), word elements (D, R, and W), and customized array variables.

## 3.6.3 Operations on PT Pointer Addresses

After pointer addresses of pointer type variables are obtained, they can be added or deducted to specify the element offset of pointer type variables.

**Example 1**




When the instruction energy flow is effective, one soft element offset is added for the PT0 pointer address of the pointer type variable. For example, PT0 originally directed to D10 and then directs to D11 after the PTINC instruction is executed. After PTINC execution, the system automatically adds one offset based on the element or array variable type directed by the pointer type variable.

| Current PT0 Pointer | PT0 Pointer After PTINC Execution |
|---|---|
| D10 | D11 |
| M200 | M201 |
| diVal[3] | diVal[4] |

## Example 2

```
|----| ↑ |----[ PTDEC PT0 ]
```

When the instruction energy flow is effective, one soft element offset is deducted for the PT0 pointer address of the pointer type variable. For example, PT0 originally directed to D10 and then directs to D9 after the PTDEC instruction is executed. After PTDEC execution, the system automatically deducts one offset based on the element or array variable type directed by the pointer type variable.

| Current PT0 Pointer | PT0 Pointer After PTDEC Execution |
|---|---|
| D10 | D9 |
| M200 | M199 |
| diVal[3] | diVal[2] |

## Example 3

```
|----| ↑ |----[ PTADD PT0 K5 PT10 ]   (1)
|----| ↑ |----[ PTADD PT0 K5 PT0 ]    (2)
```

When the energy flow of instruction (1) is effective, five soft element offsets are added for the PT0 pointer address of the pointer type variable and assigned to PT10. For example, PT0 originally directed to D10 and then PT10 directs to D15 after execution of instruction (1). When the energy flow of instruction (2) is effective, five soft element offsets are added for the PT0 pointer address and assigned to PT0. For example, PT0 originally directed to D10 and then directs to D15 after execution of instruction (2).

| Current PT0 Pointer | Pointer After Execution of Instruction (1) | | PT0 Pointer After Execution of Instruction (2) |
|---|---|---|---|
| | PT10 Pointer | PT0 Pointer | |
| D10 | D15 | D10 | D15 |
| M200 | M205 | M200 | M205 |
| diVal[3] | diVal[8] | diVal[3] | diVal[8] |

## Example 4

```
|----| ↑ |----[ PTSUB PT0 K2 PT10 ]   (1)
|----| ↑ |----[ PTSUB PT0 K2 PT0 ]    (2)
```

When the energy flow of instruction (1) is effective, two soft element offsets are deducted for the PT0 pointer address of the pointer type variable and assigned to PT10. For example, PT0 originally directed to D10 and then PT10 directs to D8 after execution of instruction (1). When the energy flow of instruction (2) is effective, two soft element offsets are deducted for the PT0 pointer address and assigned to PT0. For example, PT0 originally directed to D10 and then directs to D8 after execution of instruction (2).

| Current PT0 Pointer | Pointer After Execution of Instruction (1) | | PT0 Pointer After Execution of Instruction (2) |
|---|---|---|---|
| | PT10 Pointer | PT0 Pointer | |
| D10 | D8 | D10 | D8 |
| M200 | M198 | M200 | M198 |
| diVal[3] | diVal[1] | diVal[3] | diVal[1] |

***Note***

In all the preceding examples of pointer address operations, the PTGET instruction must be used to obtain the pointer address first. When PT points to an array variable, pay attention to boundary checking when executing address operation instructions.

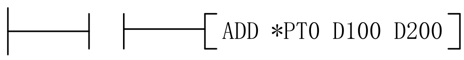
**Example 5**


The PT> instruction determines whether the PT0 pointer address of the pointer type variable is greater than D20. If the PT0 pointer directs to D21, the output M0 is ON. Similar inspections such as PT>=, PT<, PT<=, PT=, and PT<> can determine the directions of PT pointers.

### 3.6.4 Indirect Addressing Operations on Pointer Type Variables

After you obtain an address for a pointer type variable by running address operation instructions, the address can be used in instructions, indicating the indirect addressing operation on the soft element or array variable directed by the pointer variable.

**Example**



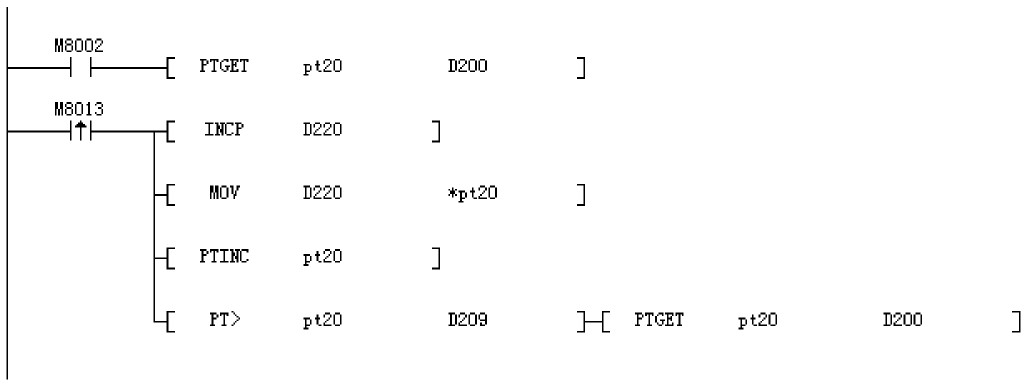

When the instruction energy flow is effective, the soft element directed by the PT0 pointer of the pointer type variable is added to D100. For example, if PT0 directs to D10, the instruction execution result is D200 = D10 + D100.

***Note***

To indirectly represent a specified soft element using a pointer type variable, an effective pointer address must be obtained by using a pointer address operation instruction first.

### 3.6.5 Use Example

This section uses a pointer type soft component as an example. The component cycles the value of D220 to the first 10 elements starting from D200 every 1 second.



***Note***

After a value is assigned to the address pointed to by the pointer, the pointer address is incremented by 1. Therefore, the value for the pointer address monitored by AutoShop in this program is inconsistent with the displayed data.

# 3.7 System Variables

## 3.7.1 Overview

This section describes the PLC operation status using system variables, such as the device model, version number, serial port information, and Ethernet and CAN communication status.

## 3.7.2 System Variable Categories

| SysVar (System Variable Category) | Description |
|---|---|
| _SYS_CAN | CAN communication information, such as the station No., baud rate, and online state of the slave station |
| _SYS_COM | Serial communication information, such as the station No., baud rate, and online state of the slave station |
| _SYS_ECAT_Master | EtherCAT master station status |
| _SYS_ECAT_SLAVE | EtherCAT slave station status |
| _EthIPScanner | EtherNet/IP system variable information |
| _SYS_ENCODER_AXIS | Data structure of the external encoder axis |
| _SYS_ETHERNET | Ethernet communication information, such as the IP address, MAC address, online state, and error diagnosis. |
| _SYS_INFO | PLC system information, such as the firmware version, real-time clock (RTC), module diagnosis, and system logs. |
| _SYS_MC_AXIS | Data structure of the motion control axis |
| _sGROUPAXIS_INFO | Status of a coordinate axis in the axis group |
| _sMCGROUP_INFO | Axis group status |
| _sGROUPPOS_INFO | Target position of a coordinate axis in the axis group |

## 3.7.3 _SYS_CAN for CAN Interface Running Information

Table 3–4 _CAN interface information

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _CAN.BaudRate | INT | Baud rate (kbps) | R | D8285 |
| _CAN.LoadRate | INT | Load rate (%) | R | D8240 |
| _CAN.RxPerSec | INT | Received frames per second (FPS) | R | D8290 |
| _CAN.TxPerSec | INT | Sent FPS | R | D8291-D8290 |
| _CAN.RxErrCnt | INT | Receive error counter | R | High-order 8 bits of D8989 |

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _CAN.TxErrCnt | INT | Send error counter | R | Low-order 8 bits of D8989 |
| _CAN.Protocol | INT | Communication protocol. 0: CANlink; 1: CANopen | R | D8280 |

Table 3–5 _CANLink interface information

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _CANLink.Address | INT | Station No. or address | R | D8284 |
| _CANLink.Heartbeat | INT | Heartbeat time (ms) | R | D8282 |
| _CANLink.NetworkStart | BOOL | Network startup | R | M8290 |
| _CANLink.SyncTrigger | BOOL | Sync triggering | R | M8291 |
| _CANLink.SyncWrErr | INT | Synchronous write error code | R | D8307 |
| _CANLink.ConfigErr | INT | Configuration error code | R | D8308 |
| _CANLink.NodeState[0] | INT | Local station status (=2: online; ≠2: offline) | R | D7800 |
| _CANLink.NodeState[1] | INT | 1# station status (=2: online; ≠2: offline) | R | D7801 |
| _CANLink.Online[0] | DINT | Station status on the CANlink configuration monitoring page of AutoShop, with one bit indicating a station | R | D8241 |
| _CANLink.Online[1] | DINT | Station status on the CANlink configuration monitoring page of AutoShop, with one bit indicating a station | R | D8242 |

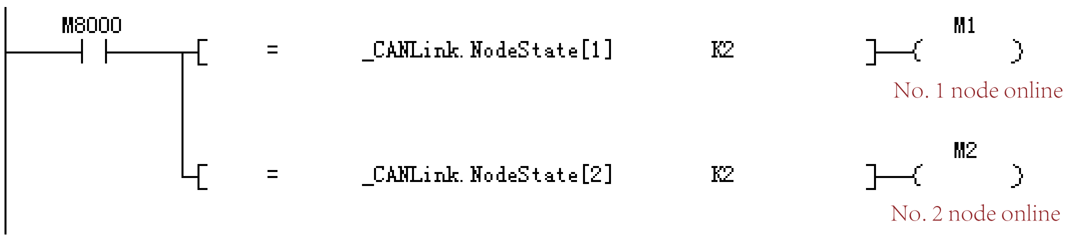
Table 3–6 _CANOpen interface information

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _CANOpen.NodeID | INT | Node ID | R | D8284 |
| _CANOpen.NodeState [0] | INT | Local station status (=5: online; ≠5: offline) | R | D7800 |
| _CANOpen.NodeState [1] | INT | 1# station status (=5: online; ≠5: offline) | R | D7801 |
| _CANOpen.EMCY. NodeID | INT | Emergency event node ID | R | |
| _CANOpen.EMCY. ErrorCode | INT | Emergency event error code | R | |
| _CANOpen.Debug | _sCOP_DEBUG | Commissioning information | R | |
| _CANOpen.Debug. NodeID | INT | Commissioning information | R | |
| _CANOpen.Debug.State | INT | Commissioning information | R | |
| _CANOpen.Debug.Index | INT | Commissioning information | R | |
| _CANOpen.Debug. SubIndexAndSize | INT | Commissioning information | R | |
| _CANOpen.Debug.Data | INT[4] | Commissioning information | R | |
| _CANOpen.Debug.Data [0] | INT | Commissioning information | R | |

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _CANOpen.Debug.Data [1] | INT | Commissioning information | R | |
| _CANOpen.Debug.Data [2] | INT | Commissioning information | R | |
| _CANOpen.Debug.Data [3] | INT | Commissioning information | R | |
| _CANOpen.ConfigError. NodeID | INT | Configuration error node ID | R | D8287 |
| _CANOpen.ConfigError. ConfigIndex | INT | Configuration No. | R | D8288 |
| _CANOpen.ConfigError. ErrorCode | DINT | Fault code | R | D8254 and D8255 |

## Program example

Determination on the online status of slave stations




## 3.7.4 _SYS_COM for Serial Port Running Information

Table 3–7 _COM serial port information

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _COM.BaudRate | DINT | Baud rate (bps) | R | Bit4 to bit7 of D8120 |
| _COM.DataBits | INT | Data bit | R | Bit0 of D8120 |
| _COM.Parity | INT | Parity bit | R | Bit1 and bit2 of D8120 |
| _COM.StopBits | INT | Stop bit | R | Bit3 of D8120 |
| _COM.Interface | INT | Physical interface | R | - |

The preceding table lists configuration information of the COM port. Each serial port corresponds to a separate system variable. _COM corresponds to COM0, and _COM1 to _COM15 correspond to COM1 to COM15 respectively.

Table 3–8 Modbus-based _MbMst master station (serial port) information

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _MbMst.Port | INT | Serial port number | R | - |
| _MbMst.Timeout | INT | Timeout interval (ms) | R | D8129*10 |
| _MbMst.Enable | BOOL | Enabled | R | - |
| _MbMst.Activate | BOOL | Activated | R | - |
| _MbMst.Busy | BOOL | Busy | R | - |
| _MbMst.Error | BOOL | Error | R | M8129 |
| _MbMst.ResponseTime | INT | Response time (ms) | R | - |

The preceding table lists Modbus-based information about serial ports of the master station. Each serial port corresponds to a separate system variable. _MbMst corresponds to COM0, and _MbMst1 to _MbMst15 correspond to COM1 to COM15 respectively.

Table 3–9 Modbus-based _MbMstEx master station (serial port) extension information

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _MbMstEx. SlvDisableSetFlag | DINT | Whether to disable slave stations | R/W | - |
| _MbMstEx.SlvDisable | BOOL[256] | Slave station disabled | R/W | - |
| _MbMstEx.SlvDisable[0] | BOOL | - | R/W | - |
| _MbMstEx.SlvDisable[1] | BOOL | - | R/W | - |
| _MbMstEx.SlvDisable[...] | BOOL | - | R/W | - |
| _MbMstEx.SlvDisable[255] | BOOL | - | R/W | - |
| _MbMstEx.RetryTimes | INT | Number of retries (Modbus instructions) | R/W | - |

The preceding table lists Modbus-based extension information about serial ports of the master station. Each serial port corresponds to a separate system variable. _MbMstEx corresponds to COM0, and _MbMstEx1 to _MbMstEx15 correspond to COM1 to COM15 respectively.

Table 3–10 Modbus-based _MbSlv slave station (serial port) information

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _MbSlv.Port | INT | Serial port number | R | - |
| _MbSlv.SlaveAddress | INT | Slave address | R | D8121 |
| _MbSlv.Connected | BOOL | Connected state | R | - |

The preceding table lists Modbus-based information about serial ports of the slave station. Each serial port corresponds to a separate system variable. _MbSlv corresponds to COM0, and _MbSlv1 to _MbSlv15 correspond to COM1 to COM15 respectively.

Table 3–11 Free protocol-based _SerialSR serial port information

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _SerialSR.port | INT | Serial port/Port number | R | - |
| _SerialSR.states | INT | Operation status | R | - |
| _SerialSR.sent | INT | Number of sent bytes | R | - |
| _SerialSR.received | INT | Number of received bytes | R | - |
| _SerialSR.mutexF | DINT | Interlock flag | R | - |
| _SerialSR.trigger | DINT | Trigger flag | R | - |
| _SerialSR.errorid | DINT | Error information | R | - |
| _SerialSR.timeout | DINT | Timeout interval (ms) | R | D8129*10 |

Table 3–12 Sendbuf to send buffer data

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _SerialSR.sendlen | DINT | Number of sent bytes | R | - |
| _SerialSR.sendbuf | INT[256] | Transmission buffer | R | - |
| _SerialSR.sendbuf[0] | INT | - | R | - |
| _SerialSR.sendbuf[1] | INT | - | R | - |

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _SerialSR.sendbuf[2] | INT | - | R | - |
| _SerialSR.sendbuf[...] | INT | - | R | - |
| _SerialSR.sendbuf[254] | INT | - | R | - |
| _SerialSR.sendbuf[255] | INT | - | R | - |

Table 3–13 Recvbuf to receive buffer data

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _SerialSR.recvlen | DINT | Number of received bytes | R | - |
| _SerialSR.recvbuf | INT[256] | Reception buffer | R | - |
| _SerialSR.recvbuf[0] | INT | - | R | - |
| _SerialSR.recvbuf[1] | INT | - | R | - |
| _SerialSR.recvbuf[2] | INT | - | R | - |
| _SerialSR.recvbuf[...] | INT | - | R | - |
| _SerialSR.recvbuf[254] | INT | - | R | - |
| _SerialSR.recvbuf[255] | INT | - | R | - |

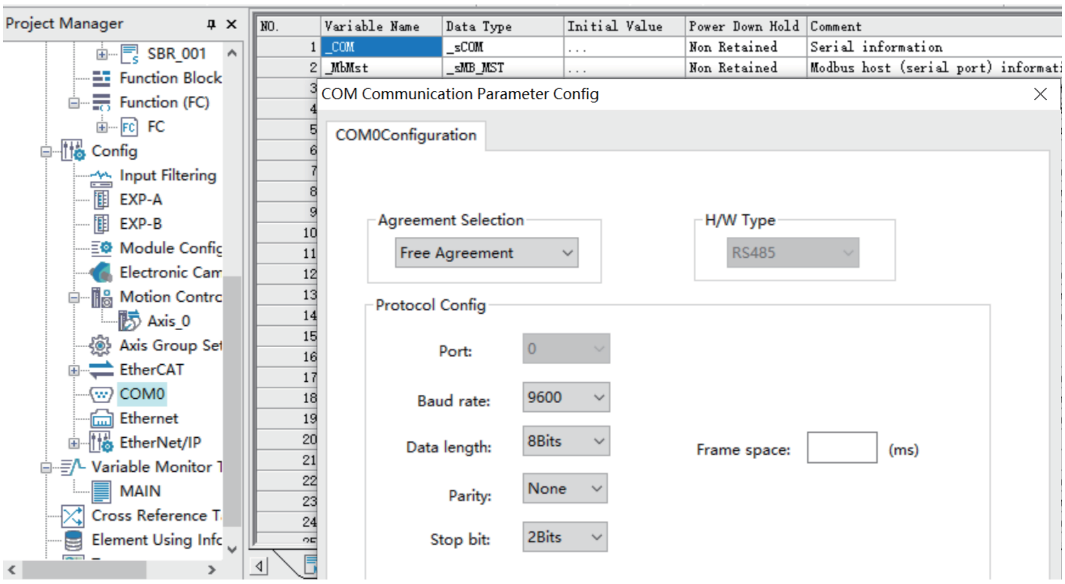
Table 3–14 Free protocol-based instruction configuration for a serial port

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _SerialSR.abort | INT | Serial port free protocol canceled | R/W | - |
| _SerialSR.startchar_en | INT | Reception start character enable (0 to 4) | R/W | - |
| _SerialSR.startchar | BYTE[4] | Reception start character | R/W | - |
| _SerialSR.startchar[0] | BYTE | - | R/W | - |
| _SerialSR.startchar[1] | BYTE | - | R/W | - |
| _SerialSR.startchar[2] | BYTE | - | R/W | - |
| _SerialSR.startchar[3] | BYTE | - | R/W | - |
| _SerialSR.endchar_en | INT | Reception end character enable (0 to 4) | R/W | - |
| _SerialSR.endchar | BYTE[4] | Reception end character | R/W | - |
| _SerialSR.endchar[0] | BYTE | - | R/W | - |
| _SerialSR.endchar[1] | BYTE | - | R/W | - |
| _SerialSR.endchar[2] | BYTE | - | R/W | - |
| _SerialSR.endchar[3] | BYTE | - | R/W | - |
| _SerialSR.Bytetimeout_en | BOOL | Idle interrupted frame reception enable | R/W | |
| _SerialSR.Bytetimeout | INT | Duration for judging idle interrupted frame reception (ms) | R/W | |

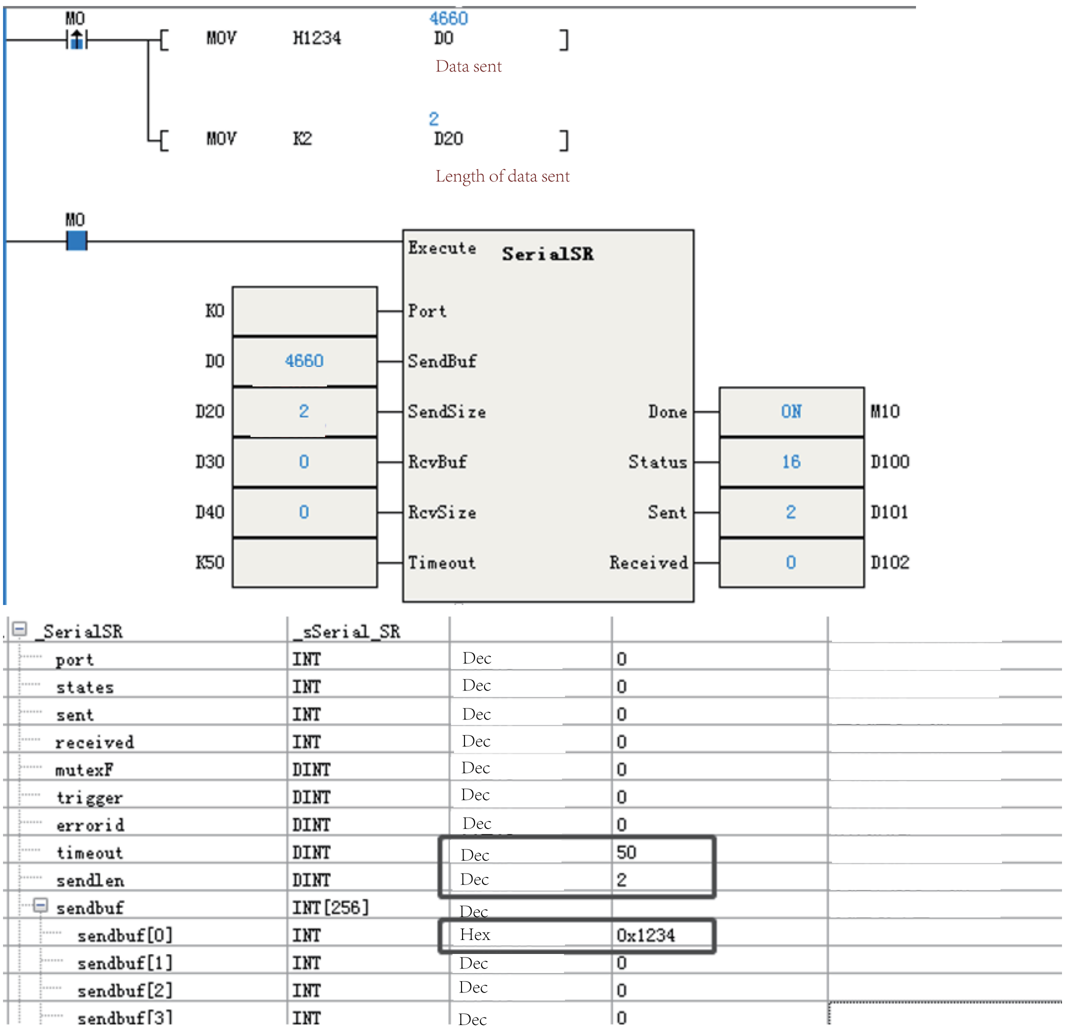
The preceding table lists free protocol-based instruction configuration for a serial port. Each serial port corresponds to a separate system variable. _SerialSR corresponds to COM0, and _SerialSR1 to _SerialSR15 correspond to COM1 to COM15 respectively.

## Program example

1. COM configuration information




2. SerialSR instruction sending



### 3.7.5 _SYS_COM_SAVE for Serial Port Parameter Settings

Table 3–15 _COMSet serial port parameter settings

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _COMSet.SetFlag | DINT | Parameter setting enable flag | R/W | - |
| _COMSet.BaudRate | DINT | Baud rate (bps) | R/W | - |
| _COMSet.DataBits | INT | Data bit | R/W | - |
| _COMSet.Parity | INT | Parity bit | R/W | - |
| _COMSet.StopBits | INT | Stop bit | R/W | - |
| _COMSet.Interface | INT | Physical interface | R/W | - |
| _COMSet.Protocol | INT | Communication protocol | R/W | - |

The preceding table lists parameter settings of the COM port. Each serial port corresponds to a separate system variable. _COMSet corresponds to COM0, and _COM1Set to _COM15Set correspond to COM1 to COM15 respectively.

Table 3–16 _COMProtocolSet serial port parameter settings

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _COMProtocolSet.port | INT | Serial port number | R | - |
| _COMProtocolSet. AddressSetFlag | INT | Whether to set the slave station number or address | R/W | - |
| _COMProtocolSet. Address | INT | Slave station number or address | R/W | - |

The preceding table lists protocol-based parameter settings of the COM port. Each serial port corresponds to a separate system variable. _COMProtocolSet corresponds to COM0, and _COM1ProtocolSet to _COM15ProtocolSet correspond to COM1 to COM15 respectively.

### 3.7.6 _SYS_ECAT_Master for Operation Status

Table 3–17 EtherCAT master station information

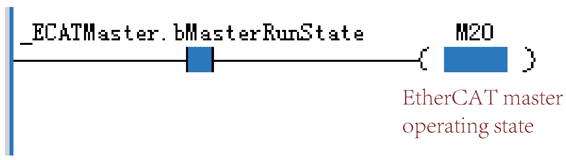
| Name | Data Type | Description | R/W |
|---|---|---|---|
| _ECATMaster.bMasterRunState | BOOL | Operation status of the master station (ON: running; OFF: stopped) | R |
| _ECATMaster.bLinkState | BOOL | Connection status of the master station (ON: normal; OFF: LAN cable disconnected) | R |
| _ECATMaster.bHeartBeat | BOOL | EtherCAT task heartbeat | R |
| _ECATMaster.dMaxCycleTime | DINT | Maximum cycle time (μs) | R |
| _ECATMaster.dMinCycleTime | DINT | Minimum cycle time (μs) | R |
| _ECATMaster.dCycleTime | DINT | Cycle time (μs) | R |
| _ECATMaster.dMaxExeTime | DINT | Maximum execution time (μs) | R |
| _ECATMaster.dMinExeTime | DINT | Minimum execution time (μs) | R |
| _ECATMaster.dExeTime | DINT | Execution time (μs) | R |
| _ECATMaster.dtx_frames | DINT | Total number of sent frames | R |
| _ECATMaster.drx_frames | DINT | Total number of received frames | R |
| _ECATMaster.dtx_frame_rates | DINT | Frame sending rate (frame/s) | R |

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _ECATMaster.drx_frame_rates | DINT | Frame receiving rate (frame/s) | R |
| _ECATMaster.dtx_bytes_rate | DINT | Byte sending rate (byte/s) | R |
| _ECATMaster.drx_bytes_rate | DINT | Byte receiving rate (byte/s) | R |
| _ECATMaster.dloss_frames | DINT | Number of lost EtherCAT frames | R |
| _ECATMaster.bResetTime | BOOL | Execution time and cycle time for resetting | R/W |
| _ECATMaster.bStartMaster | BOOL | Master station startup (When it is set to ON, the EtherCAT master station is restarted and then the value automatically turns to OFF.) | R/W |
| _ECATMaster.bStopMaster | BOOL | Master station stop (When it is set to ON, the EtherCAT master station is stopped and then the value automatically turns to OFF.) | R/W |
| _ECATMaster.bClearFrameCounter | BOOL | Frame sending and receiving counter upon resetting | R/W |
| _ECATMaster.iSlavesState | INT | Online status of all slave stations (1: All slave stations are online; 0: Some slave stations are offline.) | R |
| _ECATMaster.dLibVersion | DINT | EtherCAT library version | R |
| _ECATMaster.dMstVersion | DINT | EtherCAT master station version | R |
| _ECATMaster.dDriveVersion | DINT | Version of the EtherCAT network adapter driver | R |
| _ECATMaster.dtx_error_cnt | DINT | Number of EtherCAT sending errors | R |
| _ECATMaster.drx_timeout_cnt | DINT | Number of frame receiving timeout events by EtherCAT | R |
| _ECATMaster.drx_corrupt_cnt | DINT | Number of invalid frame receiving events by EtherCAT | R |
| _ECATMaster.drx_unmach_cnt | DINT | Number of mismatched frame receiving events by EtherCAT | R |
| _ECATMaster.dRxPDOLength | DINT | Total number of PDOs received by EtherCAT | R |
| _ECATMaster.dTxPDOLength | DINT | Total number of PDOs sent by EtherCAT | R |
| _ECATMaster.dConfigureState | DINT | EtherCAT configuration status | R |
| _ECATMaster.dDelay | DINT | EtherCAT synchronization regulator | R |

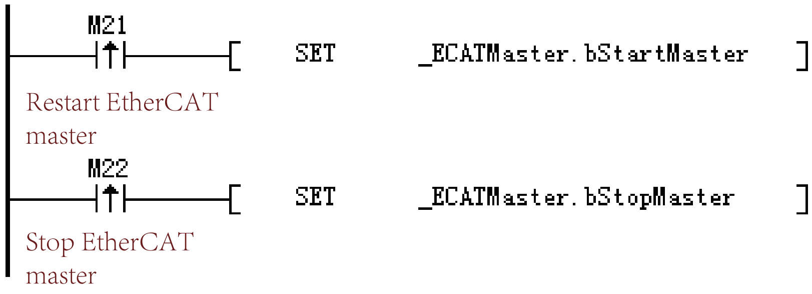
The preceding table lists information about the EtherCAT master station, such as the master station operation status and maximum cycle time.

## Program example

1. Monitoring on the EtherCAT master station status




2. Restartup of the EtherCAT master station




***Note***

The instruction enable is edge-triggered.

### 3.7.7 _SYS_ECAT_Slave for Operation Status

Table 3–18 EtherCAT slave station information

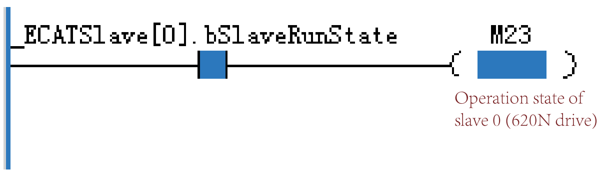
| Name | Data Type | Description | R/W |
|---|---|---|---|
| _ECATSlave | _sECTSLV_INFO [125] | Operation status of the EtherCAT slave station | - |
| _ECATSlave[0] | _sECTSLV_INFO | - | - |
| _ECATSlave[0].bSlaveRunState | BOOL | Operation status of the slave station (ON: running; OFF: stopped) | R |
| _ECATSlave[0].bSetAliasState | BOOL | Status of slave station alias writing (ON: busy) | R |
| _ECATSlave[0].bSetAliasError | BOOL | Failure of slave station alias writing | R |
| _ECATSlave[0].bSetAlias | BOOL | Setting of the slave station alias, valid on the rising edge (used for commissioning on the AutoShop configuration page) | R/W |
| _ECATSlave[0].wALState | INT | Status of the EtherCAT state machine (1/2/4/8) | R |
| _ECATSlave[0].wAlCode | INT | Fault Codes | R |
| _ECATSlave[0].wActAlias | INT | Actual station alias | R |
| _ECATSlave[0].wTarAlias | INT | Station alias to be written (used for commissioning on the AutoShop configuration page) | R/W |
| _ECATSlave[0].wStationAddress | INT | Actual station name | R |

***Note***

_ECATSlave is an array. For example, [0] represents configuration address 0.

### Program example

Monitoring on the EtherCAT slave station status



### 3.7.8 _SYS_EncAxis for Encoder Axis Information

Table 3–19 EncAxis encoder axis information

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _EncAxis[0] | _sENC_AXIS | - | R |
| _EncAxis[0].Axis | INT | Axis No. | R |
| _EncAxis[0].Reserced0 | INT | Reserved | R |
| _EncAxis[0].Unit | REAL | Unit | R |
| _EncAxis[0].UpperPosition | REAL | Upper limit position | R |
| _EncAxis[0].LowerPosition | REAL | Lower limit position | R |
| _EncAxis[0].Position | REAL | Position | R |
| _EncAxis[0].Velocity | REAL | Speed | R |
| _EncAxis[0].Reserced1 | DINT[2] | Reserved | R |
| _EncAxis[0].Reserced1[0] | DINT | - | R |
| _EncAxis[0].Reserced1[1] | DINT | - | R |

Table 3–20 EncAxis[0].Counter counter information

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _EncAxis[0].Counter | _sENC_CNT | Counter | R |
| _EncAxis[0].Counter.ID | INT | Counter ID | R |
| _EncAxis[0].Counter.DecodeMode | INT | Decoding mode | R |
| _EncAxis[0].Counter.Source | INT | Signal source | R |
| _EncAxis[0].Counter.CountMode | INT | Count mode | R |
| _EncAxis[0].Counter.ControlWord | INT | Control word | R |
| _EncAxis[0].Counter.StatusWord | INT | Status word | R |
| _EncAxis[0].Counter.CountValue | DINT | Count value | R |
| _EncAxis[0].Counter.Frequency | REAL | Frequency | R |

Table 3–21 EncAxis[0].Reset reset information

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _EncAxis[0].Reset | _sENC_RST | Reset | R |
| _EncAxis[0].Reset.Pin | INT | Reset pin | R |
| _EncAxis[0].Reset.Edge | INT | Reset edge | R |

Table 3–22 EncAxis[0].Preset preset information

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _EncAxis[0].Preset | _sENC_PRESET | Resetting | R |
| _EncAxis[0].Preset.Pin | INT | Preset pin | R |
| _EncAxis[0].Preset.Edge | INT | Preset edge | R |
| _EncAxis[0].Preset.Value | DINT | Preset value | R |
| _EncAxis[0].Preset.Position | REAL | Preset position | R |

Table 3–23 EncAxis[0].Probe probe information

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _EncAxis[0].Probe | _sENC_PROBE[2] | Probe | R |
| _EncAxis[0].Probe[0] | _sENC_PROBE | | R |
| _EncAxis[0].Probe[0].Pin | INT | Pin | R |
| _EncAxis[0].Probe[0].Edge | INT | Probe edge | R |
| _EncAxis[0].Probe[0].PositiveValue | DINT | Probe rising edge | R |
| _EncAxis[0].Probe[0].NegativeValue | DINT | Probe falling edge | R |
| _EncAxis[0].Probe[0].PositivePosition | REAL | Probe rising edge position | R |
| _EncAxis[0].Probe[0].NegativePosition | REAL | Probe falling edge position | R |
| _EncAxis[0].Probe[1] | _sENC_PROBE | | R |
| _EncAxis[0].Probe[1].Pin | INT | Pin | R |
| _EncAxis[0].Probe[1].Edge | INT | Probe edge | R |
| _EncAxis[0].Probe[1].PositiveValue | DINT | Probe rising edge | R |
| _EncAxis[0].Probe[1].NegativeValue | DINT | Probe falling edge | R |
| _EncAxis[0].Probe[1].PositivePosition | REAL | Probe rising edge position | R |
| _EncAxis[0].Probe[1].NegativePosition | REAL | Probe falling edge position | R |

Table 3–24 EncAxis[0].Match comparison interruption

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _EncAxis[0].Match | _sENC_MATCH[2] | Compare | R |
| _EncAxis[0].Match[0] | _sENC_MATCH | | R |
| _EncAxis[0].Match[0].Value | DINT | Value | R |
| _EncAxis[0].Match[0].Position | REAL | Position | R |
| _EncAxis[0].Match[0].Enable | BOOL | Enable | R |
| _EncAxis[0].Match[0].InterruptEnable | BOOL | Interruption enable | R |
| _EncAxis[0].Match[0].OutputEnable | BOOL | Output enable | R |
| _EncAxis[0].Match[0].InterruptMap | INT | Interruption association | R |
| _EncAxis[0].Match[0].OutputPin | INT | Output pin | R |
| _EncAxis[0].Match[0].OutputMode | INT | Output mode | R |
| _EncAxis[0].Match[0].OutputWidth | REAL | Output width | R |
| _EncAxis[0].Match[1] | _sENC_MATCH | | R |
| _EncAxis[0].Match[1].Value | DINT | Value | R |
| _EncAxis[0].Match[1].Position | REAL | Position | R |
| _EncAxis[0].Match[1].Enable | BOOL | Enable | R |
| _EncAxis[0].Match[1].InterruptEnable | BOOL | Interruption enable | R |
| _EncAxis[0].Match[1].OutputEnable | BOOL | Output enable | R |
| _EncAxis[0].Match[1].InterruptMap | INT | Interruption association | R |
| _EncAxis[0].Match[1].OutputPin | INT | Output pin | R |
| _EncAxis[0].Match[1].OutputMode | INT | Output mode | R |
| _EncAxis[0].Match[1].OutputWidth | REAL | Output width | R |

## 3.7.9 _SYS_Ethernet for Ethernet Information

Table 3–25 Ethernet network port information

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _Ethernet.MACAddress | INT[3] | Physical address | R |
| _Ethernet.MACAddress[0] | INT | - | R |
| _Ethernet.MACAddress[1] | INT | - | R |
| _Ethernet.MACAddress[2] | INT | - | R |
| _Ethernet.IPAddress | DINT | Local IP address | R/W |
| _Ethernet.Mask | DINT | Subnet mask | R/W |
| _Ethernet.Gateway | DINT | Gateway | R/W |
| IPCommand | INT | IP command | R/W |

The preceding variable table lists local information such as the IP address and MAC addresses.

Table 3–26 Modbus-TCP-based MbTcpMst master station information

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _MbTcpMst[0] | _sMB_TCP_MST | - | R |
| _MbTcpMst[0].IPAddress | DINT | IP address of a slave station | R |
| _MbTcpMst[0].Port | INT | Port number of a slave station | R |
| _MbTcpMst[0].Timeout | INT | Timeout interval (ms) | R |
| _MbTcpMst[0].Number | INT | Configuration number | R |
| _MbTcpMst[0].Enable | BOOL | Enabled | R |
| _MbTcpMst[0].Connected | BOOL | Connected state | R |
| _MbTcpMst[0].Busy | BOOL | Busy | R |
| _MbTcpMst[0].Error | BOOL | Error | R |
| _MbTcpMst[0].ResponseTime | INT | Response time (ms) | R |
| _MbTcpMst[...] | _sMB_TCP_MST | - | R |

The preceding table lists Modbus-TCP-based information about Ethernet of the master station.

Table 3–27 Modbus-TCP-based MbTcpMst slave station information

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _MbTcpSlv.Port | INT | Port number | R |
| _MbTcpSlv.SlaveAddress | INT | Slave address | R |
| _MbTcpSlv.Connected | BOOL | Connected state | R |
| _MbTcpSlv.Connections | INT | Number of connections | R |
| _MbTcpSlv.IPAddress | DINT[32] | List of client IP addresses | R |
| _MbTcpSlv.IPAddress[0] | DINT | - | R |
| _MbTcpSlv.IPAddress[1] | DINT | - | R |
| _MbTcpSlv.IPAddress[2] | DINT | - | R |
| _MbTcpSlv.IPAddress[...] | DINT | - | R |
| _MbTcpSlv.IPAddress[30] | DINT | - | R |
| _MbTcpSlv.IPAddress[31] | DINT | - | R |

The preceding table lists ModbusTCP-based information about the client linked to the PLC slave station.

### 3.7.10 _EthIPScanner for Status Information

Table 3–28 EIP system variable information

| Name | Data Type | Description | R/W |
|---|---|---|---|
| EthIPScanner[0].Instance | DINT | Label instance ID | R |
| EthIPScanner[0].Connected | DINT | Connecting status<br>1: Initializing<br>2: Invalid network path<br>3: No response<br>4: Response error<br>5: Timeout<br>6: Connection closed | R |
| EthIPScanner[0].GeneralStatus | INT | General error state | R |
| EthIPScanner[0].ExtendedStatus | INT | Extended error state | R |
| EthIPScanner [0].Reserved | DINT[6] | Reserved field R | R |
| ... | ... | ... | ... |
| EthIPScanner[255].Instance | DINT | Label instance ID | R |
| EthIPScanner[255].Connected | DINT | Connecting status<br>1: Initializing<br>2: Invalid network path<br>3: No response<br>4: Response error<br>5: Timeout<br>6: Connection closed | R |
| EthIPScanner[255].GeneralStatus | INT | General error state | R |
| EthIPScanner[255].ExtendedStatus | INT | Extended error state | R |
| EthIPScanner [255].Reserved | DINT[6] | Reserved field R | R |

***Note***

- EthIPScanner[n-1] represents the tag data with instance value n, and EthIPScanner[n-1].Instance has a value of n. The array subscript corresponds one-to-one with Instance, with a difference of 1.
- To determine that "the tag with instance value n has normal communication", the system variable EthIPScanner [n-1] must meet the following conditions:
  - CLASS1 type tag: Connected==1 && GeneralStatus==0 && ExtendedStatus==0
  - CLASS3 type tag: Connected==104 && GeneralStatus==0 && ExtendedStatus==0
  - UCMM type tag: Connected==100 && GeneralStatus==0 && ExtendedStatus==0

### 3.7.11 _SYS_INFO PLC for Operation Information

Table 3–29 Device information (DevInfo)

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _DevInfo.Device | INT | Device model ID | R | - |
| _DevInfo.Vender | INT | Manufacturer ID | R | - |
| _DevInfo.HWVersion | DINT | Hardware version | R | - |
| _DevInfo.SWVersion | DINT | Software version | R | D8100 and D8101 |

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _DevInfo.FPGAVersion | DINT | FPGA version | R | D8104 and D8105 |
| _DevInfo.NSTDVersion | DINT | Customized version | R | - |

The preceding table lists the PLC device information.

Table 3–30 OSM system monitor

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _OSM.CPU | INT | CPU usage | R |
| _OSM.Memory | INT | Memory usage | R |

The preceding table lists the CPU and memory usage for CPU performance diagnosis.

Table 3–31 User program information

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _Program.TotalSize | DINT | Total program capacity | R | |
| _Program.UsedSize | DINT | Program capacity used | R | |
| _Program.Interval | DINT | Program task cycle (μs) | R | |
| _Program.CurPeriod | DINT | Current program task cycle (μs) | R | D8010 |
| _Program.MinPeriod | DINT | Minimum program task cycle (μs) | R | D8011 |
| _Program.MaxPeriod | DINT | Maximum program task cycle (μs) | R | D8012 |
| _Program.CurRunTime | DINT | Current program running time (μs) | R | |
| _Program.MinRunTime | DINT | Minimum program running time (μs) | R | |
| _Program.MaxRunTime | DINT | Maximum program running time (μs) | R | |
| _Program.AveRunTime | DINT | Average program running time (μs) | R | |
| _Program.Reset | BOOL | Reset cycle time | R/W | |

The preceding table lists the execution cycle of the program and task, which can be used to judge the program execution logic complexity.

Table 3–32 List of current errors (CurErrLst)

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _CurErrLst.Quantity | INT | Number of current errors | R |
| _CurErrLst.ErrorInfo | _sERR_INFO[32] | List of current errors | R |
| _CurErrLst.ErrorInfo[0] | _sERR_INFO | | R |
| _CurErrLst.ErrorInfo[0].ErrorCode | INT | Fault code | R |
| _CurErrLst.ErrorInfo[0].ComponentID | INT | Component ID | R |
| _CurErrLst.ErrorInfo[0].Location | DINT | Error position | R |
| _CurErrLst.ErrorInfo[0].Timestamp | DINT | Timestamp, indicating the number of seconds from 00:00:00 on January 1, 1970 to the error generation time | R |

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _CurErrLst.ErrorInfo[1] | _sERR_INFO | | R |
| _CurErrLst.ErrorInfo[1].ErrorCode | INT | Fault code | R |
| _CurErrLst.ErrorInfo[1].ComponentID | INT | Component ID | R |
| _CurErrLst.ErrorInfo[1].Location | DINT | Error position | R |
| _CurErrLst.ErrorInfo[1].Timestamp | DINT | Timestamp, indicating the number of seconds from 00:00:00 on January 1, 1970 to the error generation time | R |
| CurErrLst.ErrorInfo[...] | | | |
| _CurErrLst.ErrorInfo[30] | _sERR_INFO | | R |
| _CurErrLst.ErrorInfo[30].ErrorCode | INT | Fault code | R |
| _CurErrLst.ErrorInfo[30].ComponentID | INT | Component ID | R |
| _CurErrLst.ErrorInfo[30].Location | DINT | Error position | R |
| _CurErrLst.ErrorInfo[30].Timestamp | DINT | Timestamp, indicating the number of seconds from 00:00:00 on January 1, 1970 to the error generation time | R |
| _CurErrLst.ErrorInfo[31] | _sERR_INFO | | R |
| _CurErrLst.ErrorInfo[31].ErrorCode | INT | Fault code | R |
| _CurErrLst.ErrorInfo[31].ComponentID | INT | Component ID | R |
| _CurErrLst.ErrorInfo[31].Location | DINT | Error position | R |
| _CurErrLst.ErrorInfo[31].Timestamp | DINT | Timestamp, indicating the number of seconds from 00:00:00 on January 1, 1970 to the error generation time | R |

The preceding table lists PLC error logs, up to 32 records. You can check details in the AutoShop fault record. For details about error codes, see *"19.3 Fault Codes" on page 552*.

Table 3–33 DateTime RTC

| Name | Data Type | Description | R/W | Comparison with H3U |
|---|---|---|---|---|
| _DateTime.Second | INT | Second, ranging from 0 to 60, in which 60 is the leap second | R | D8013 |
| _DateTime.Minute | INT | Minute, ranging from 0 to 59 | R | D8014 |
| _DateTime.Hour | INT | Hour, ranging from 0 to 23 | R | D8015 |
| _DateTime.Day | INT | Day in a month, ranging from 1 to 31 | R | D8016 |
| _DateTime.Month | INT | Month, ranging from 1 to 12 | R | D8017 |
| _DateTime.Year | INT | Year | R | D8018 |
| _DateTime.WeekDay | INT | Day of a week, ranging from 0 to 6, in which 0 indicates Sunday and 1 indicates Monday | R | D8019 |
| _DateTime.YearDay | INT | Number of the day counted from January 1 of each year, ranging from 0 to 365, in which 0 indicates January 1 | R | |
| _DateTime.Timestamp | DINT | Total number of seconds from 00:00:00 on January 1, 1970 to the current time | R | |

The preceding table lists RTC information.

Table 3–34 ExtSlt local extension module diagnosis information

| Name | Data Type | Description | R/W |
| --- | --- | --- | --- |
| _ExtSlt[0] | _sEXT_SLT | | R |
| _ExtSlt[0].ConfigModule | INT | Module type of the AutoShop configuration | R |
| _ExtSlt[0].MountedModule | INT | Type of the installed electrical module | R |
| _ExtSlt[0].LogicVersion | DINT | Version of the logic device (module version) | R |
| _ExtSlt[0].SWVersion | DINT | Software version (module version) | R |
| _ExtSlt[0].Error | BOOL | Error status (ON: failed; OFF: normal) | R |
| _ExtSlt[1] | _sEXT_SLT | | R |
| _ExtSlt[1].ConfigModule | INT | Configuration module type | R |
| _ExtSlt[1].MountedModule | INT | Installed module type | R |
| _ExtSlt[1].LogicVersion | DINT | Version of the logic device | R |
| _ExtSlt[1].SWVersion | DINT | Software version | R |
| _ExtSlt[1].Error | BOOL | Error | R |
| _ExtSlt[...] | _sEXT_SLT | | |
| _ExtSlt[15] | _sEXT_SLT | | R |
| _ExtSlt[15].ConfigModule | INT | Configuration module type | R |
| _ExtSlt[15].MountedModule | INT | Installed module type | R |
| _ExtSlt[15].LogicVersion | DINT | Version of the logic device | R |
| _ExtSlt[15].SWVersion | DINT | Software version | R |
| _ExtSlt[15].Error | BOOL | Error | R |

Table 3–35 M8000/D8000 element

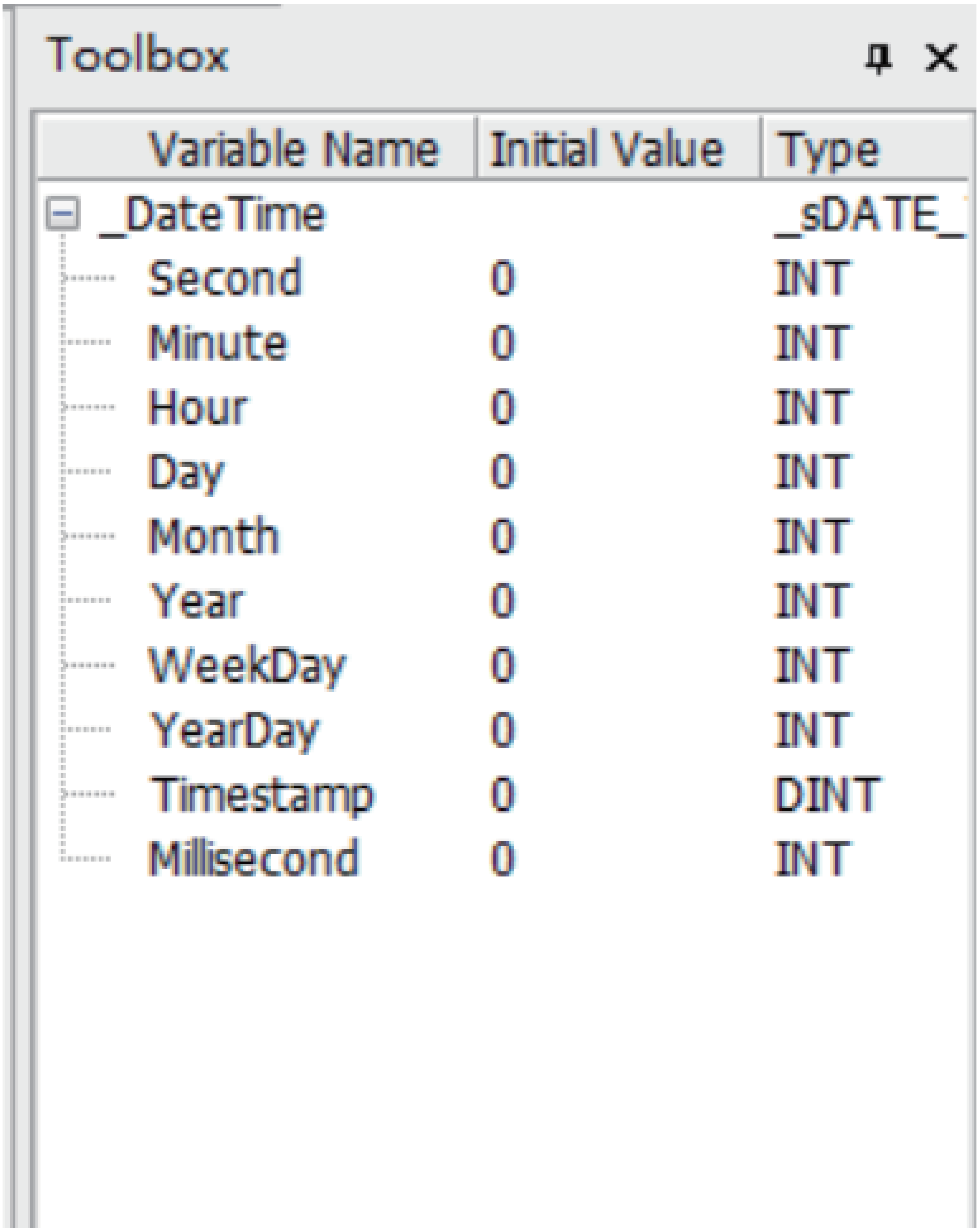
| Name | Data Type | Description | R/W |
| --- | --- | --- | --- |
| M8000 | BOOL | ON during running of the user program | R |
| M8001 | BOOL | Negated M8000 state | R |
| M8002 | BOOL | ON in the first operation cycle of the user program | R |
| M8003 | BOOL | Negated M8002 state | R |
| M8011 | BOOL | Oscillating clock with a cycle of 10 ms | R |
| M8012 | BOOL | Oscillating clock with a cycle of 100 ms | R |
| M8013 | BOOL | Oscillating clock with a cycle of 1s | R |
| M8014 | BOOL | Oscillating clock with a cycle of 1 min | R |
| M8020 | BOOL | Zero flag | R |
| M8021 | BOOL | Borrow flag | R |
| M8022 | BOOL | Carry flag | R |
| M8029 | BOOL | Multi-cycle instruction execution completion flag, applicable to the RAMP, SORT, and SORT2 instructions | R |
| M8040 | BOOL | SFC STL status transition disable | R |
| M8161 | BOOL | OFF: 16-bit mode; ON: 8-bit mode;<br>Bit processing mode for ASCII/HEX/CCD/LRC/CRC/RS | R |
| M8163 | BOOL | Switchover flag of BINDA instruction output characters (retained or switched to 0000h) | R |
| M8165 | BOOL | SORT2 instruction descending sort enable flag | R |
| M8168 | BOOL | SMOV instruction data format, including OFF-BCD and ON-HEX | R |
| M8333 | BOOL | Flag indicating all BKCMP instruction matrix comparison results are 1 | R |

| Name | Data Type | Description | R/W |
|---|---|---|---|
| D8066 | INT | Critical errors in user programs and instructions (triggered, not reset) | R |
| D8067 | INT | Minor errors in user programs and instructions (triggered, not reset) | R |

The preceding table lists information about M8000/D8000 components. A small number of such components are reserved.

## Program example

RTC monitoring table



### 3.7.12 _SYS_MC_Axis for Motion Control Axis Information

Table 3–36 McAxis axis operation status

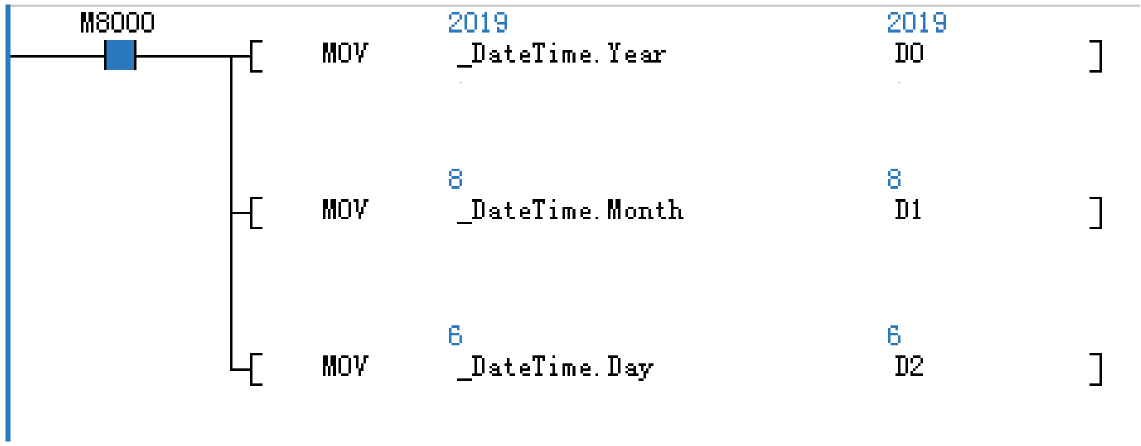
| Name | Data Type | Description | R/W |
|---|---|---|---|
| _McAxis[0] | _sMCAXIS_INFO | - | - |
| _McAxis[0].bPowerState | BOOL | Axis enable state | R |
| _McAxis[0].bDebugState | BOOL | Axis commissioning state | R |
| _McAxis[0].fSetPosition | REAL | Position setting | R |
| _McAxis[0].fSetVelocity | REAL | Speed reference | R |
| _McAxis[0].fSet_Acc_Dec | REAL | Acceleration/Deceleration rate reference | R |
| _McAxis[0].fSetTorque | REAL | Torque reference | R |
| _McAxis[0].fActPosition | REAL | Current position | R |
| _McAxis[0].fActVelocity | REAL | Current speed | R |
| _McAxis[0].fAct_Acc_Dec | REAL | Current acceleration/deceleration rate | R |
| _McAxis[0].fActTorque | REAL | Current torque | R |
| _McAxis[0].wPLCOpenState | INT | PLCOpen state machine<br>0: PowerOff<br>1: ErrorStop<br>2: Stopping<br>3: StandStill<br>4: DiscreteMotion<br>5: ContinuousMotion<br>7: Homing<br>8: SynchronizedMotion | R |
| _McAxis[0].wConfigState | INT | Configuration status<br>0: Init (axis in the initialization state)<br>1: Configure finish (configuration reading completed)<br>2: Sync finish (synchronized with EtherCAT tasks)<br>3: Wait Communication (communication with the servo drive established)<br>4: Slave ready (initialization completed for the servo drive controlled by axes)<br>5: Axis ready (communication established) | R |
| _McAxis[0].wAxisError | INT | Axis fault[Note] | R |
| _McAxis[0].wServoError | INT | Drive fault[Note] | R |
| _McAxis[0].bEnterDebug | BOOL | Monitoring mode (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].bPowerOn | BOOL | Enabled (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].bStop | BOOL | Stopped (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].bReset | BOOL | Reset (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].bJogP | BOOL | Jog+ (online commissioning mode of AutoShop axes) | R/W |

| Name | Data Type | Description | R/W |
| --- | --- | --- | --- |
| _McAxis[0].bJogN | BOOL | Jog- (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].bHome | BOOL | Homing (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].bSetPos | BOOL | Current position setting (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].bAbsPos | BOOL | Absolute positioning (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].bRevPos | BOOL | Reciprocating (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].bRelPos | BOOL | Relative positioning (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].bVelocity | BOOL | Continuous motion (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].bTorque | BOOL | Torque mode (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].wDebugMotionType | INT | Commissioning motion type (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].fJogVelocity | REAL | Jog speed (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].fPositionOffser | REAL | Homing offset (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].fPresetPosition | REAL | Reset position (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].fTarPosition1 | REAL | Target position 1 (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].fTarVelocity1 | REAL | Target speed 1 (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].fTarAcceleration1 | REAL | Target acceleration rate 1 (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].fTarDecelaration1 | REAL | Target deceleration rate 1 (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].wCurveType1 | INT | Curve type 1 (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].fTarPosition2 | REAL | Target position 2 (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].fTarVelocity2 | REAL | Target speed 2 (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].fTarAcceleration2 | REAL | Target acceleration rate 2 (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].fTarDecelaration2 | REAL | Target deceleration rate 2 (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].wCurveType2 | INT | Curve type 2 (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].dUnused | DINT | Reserved | R |
| _McAxis[0].fTarTorque | REAL | Target torque (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].fTarTorqueSlop | REAL | Torque slope (online commissioning mode of AutoShop axes) | R/W |
| _McAxis[0].wControlWord | INT | Control word | R |

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _McAxis[0].wStatusword | INT | Status word | R |
| _McAxis[0].dSetPosition | DINT | Target position | R |
| _McAxis[0].dActPosition | DINT | Current position | R |
| _McAxis[0].dSetVelocity | DINT | Speed reference | R |
| _McAxis[0].dActVelocity | DINT | Current speed | R |
| _McAxis[0].dSetTorque | INT | Torque reference | R |
| _McAxis[0].dActTorque | INT | Current torque | R |
| _McAxis[0].dDO | DINT | Digital output | R |
| _McAxis[0].dDI | DINT | Digital input | R |
| _McAxis[0].wModesOfOperation | INT | Control mode<br>6: Homing mode<br>8: Synchronous position mode<br>10: Synchronous torque mode | R |
| _McAxis[0].<br>wModesOfOperationDisplay | INT | Current control mode<br>6: Homing mode<br>8: Synchronous position mode<br>10: Synchronous torque mode | R |
| _McAxis[0].wTouchFunction | INT | Touch probe function | R |
| _McAxis[0].wTouchStatus | INT | Touch probe status | R |
| _McAxis[0].dTouch1PPos | DINT | Touch probe 1 positive edge | R |
| _McAxis[0].dTouch2PPos | DINT | Touch probe 2 positive edge | R |
| _McAxis[0].dTouch1NPos | DINT | Touch probe 1 falling edge | R |
| _McAxis[0].dTouch2NPos | DINT | Touch probe 2 negative edge | R |
| _McAxis[0].wErrorCode | INT | Fault type[Note] | R |
| _McAxis[0].wAxisRingPos | INT | Axis configuration position | R |
| _McAxis[0].wAxisID | INT | Axis ID | R |
| _McAxis[0].fUnits | REAL | Axis gear ratio | R |
| _McAxis[0].bMotionState | BOOL | Motion status, indicating whether an axis is in motion | R |
| _McAxis[0].bphlimit | BOOL | Positive limit input status of hardware | R |
| _McAxis[0].bnhlimit | BOOL | Negative limit input status of hardware | R |
| _McAxis[0].bhomestate | BOOL | Home switch input status of hardware | R |
| _McAxis[0].bpslimit | BOOL | Software positive limit reached or not | R |
| _McAxis[0].bnslimit | BOOL | Software negative limit reached or not | R |
| _McAxis[0].dLocialAxisSetPos | DINT | Local pulse axis position setting | R |
| _McAxis[...] | _sMCAXIS_INFO | - | R |

[Note]: For details about axis faults and drive faults, see *"12.8 Fault Categories" on page 426*.

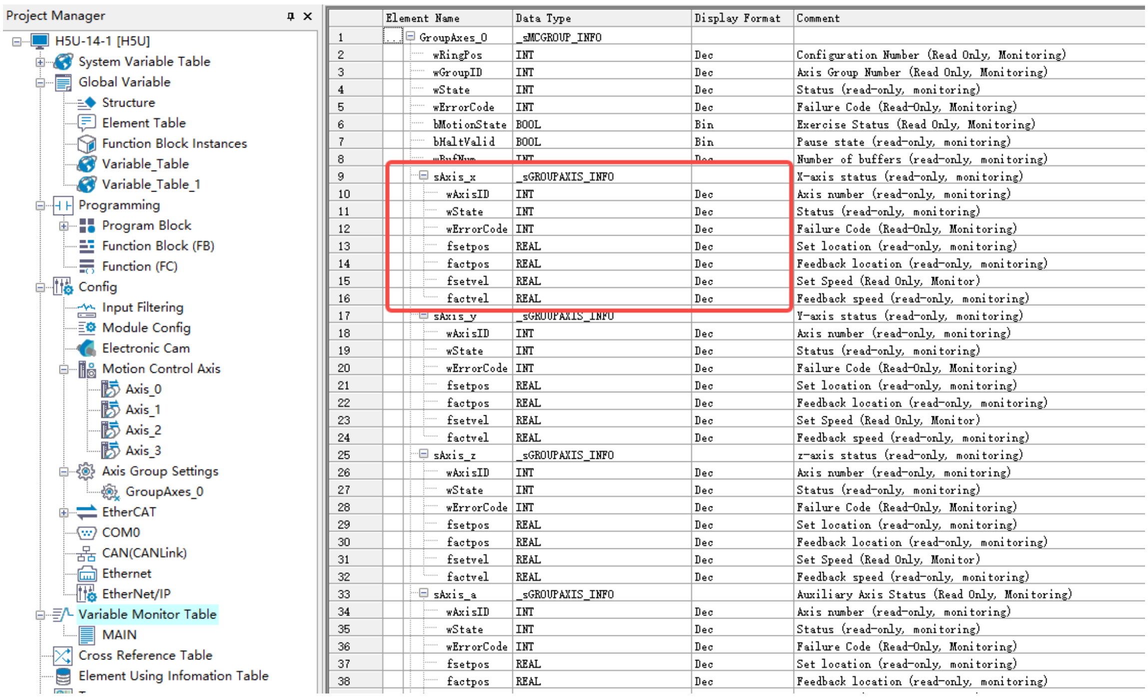
### Program example



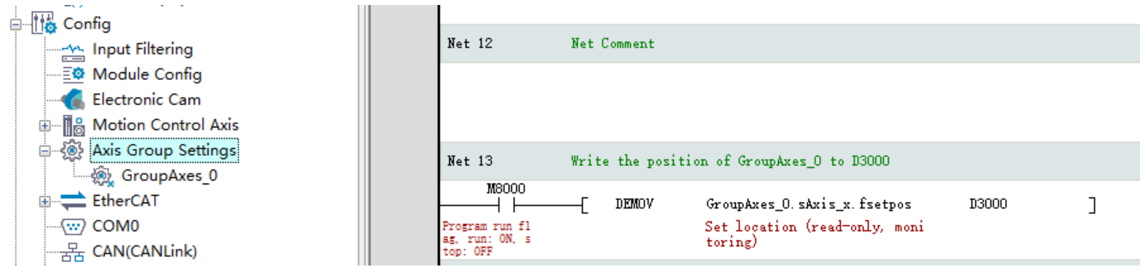

## 3.7.13 _sGROUPAXIS_INFO for Status of Coordinate Axes within Axis Group

| Name | Type | Description |
|---|---|---|
| wAxisID | INT16 | Axis ID |
| wState | INT16 | The status of an axis' PLCOpen state machine<br>0: PowerOff<br>1: ErrorStop<br>2: Stopping<br>3: StandStill<br>4: DiscreteMotion<br>5: ContinuousMotion<br>7: Homing<br>8: SynchronizedMotion |
| wErrorCode | INT16 | The fault code of an axis |
| fsetpos | REAL | Position reference |
| factpos | REAL | Feedback position |
| fsetvel | REAL | Velocity reference |
| factvel | REAL | Feedback velocity |

This system variable exists in the axis group _sMCGROUP_INFO and is used to represent the state of individual axes within the axis group.




For example, write the position reference of the X-axis into the D3000 in the PLC:



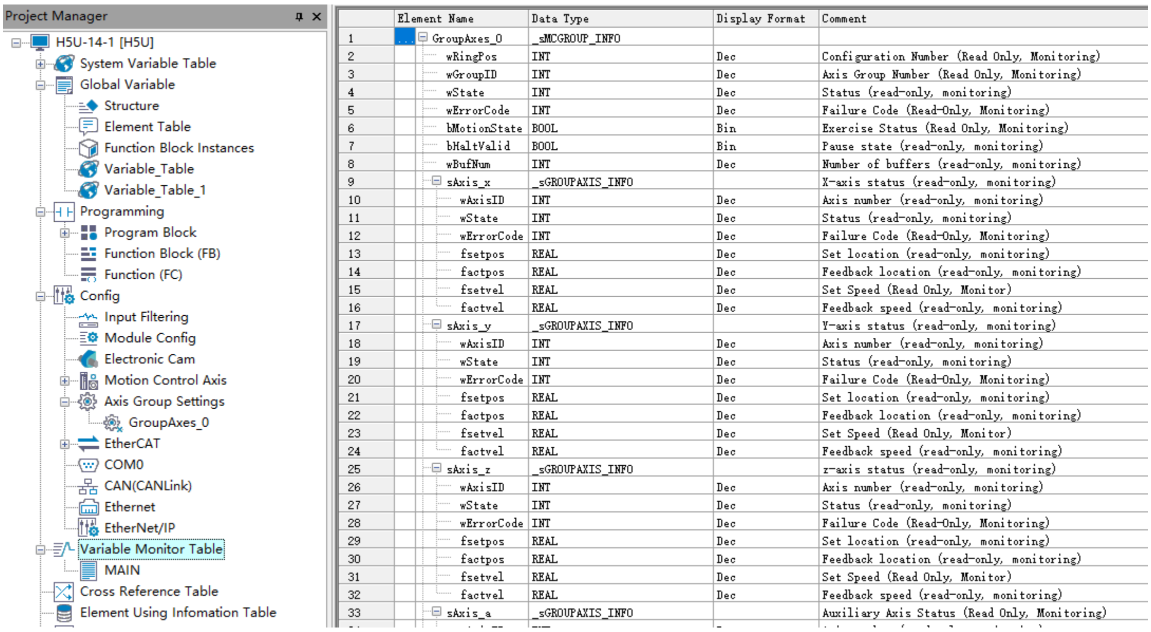

## 3.7.14 _sMCGROUP_INFO for Axis Group Status

| Name | Type | Description |
|---|---|---|
| wRingPos | INT16 | Axis group number |
| wGroupID | INT16 | Axis number |

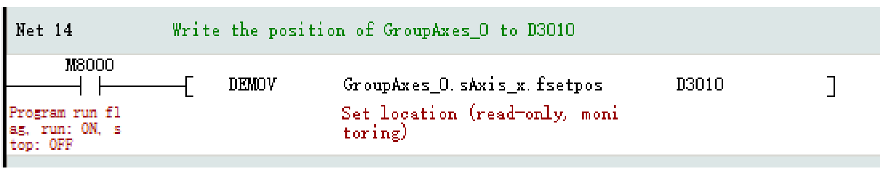
| Name | Type | Description |
|---|---|---|
| wState | INT16 | Axis group status<br>0: Init<br>The axis configuration in the axis group is not completed.<br>1: Disabled<br>Not all axes in the axis group are enabled.<br>2: Single Stop<br>An axis in the axis group calls the instruction MC_Gtop.<br>3: Single Homing<br>An axis in the axis group calls the instruction MC_Home.<br>4: Single motion<br>An axis in the axis group calls single-axis motion instructions such as MC_MoveAbsolute.<br>5: ErrorStop<br>An axis in the axis group is in a fault state.<br>6: StandStill<br>All axes in the axis group are in the StandStill state.<br>7: Stopping<br>The instruction MC_GroupStop is called.<br>8: Synchronous Motion<br>A linear interpolation or circular interpolation instruction is called. |
| wErrorCode | INT16 | Fault code |
| bMotionState | BOOL | Motion status<br>FALSE: Not in motion<br>TRUE: In motion |
| bHaltValid | BOOL | Halt status<br>FALSE: Halt not applied<br>TRUE: Halt applied |
| wBufNum | INT16 | The number of buffered curves |
| sAxis_x | _sGROUPAXIS_INFO | The status of the X-axis |
| sAxis_y | _sGROUPAXIS_INFO | The status of the Y-axis |
| sAxis_z | _sGROUPAXIS_INFO | The status of the Z-axis |
| sAxis_a | _sGROUPAXIS_INFO | The status of the auxiliary axis |
| fSetvel | REAL | Velocity reference<br>In linear interpolation mode, it indicates the interpolation velocity of a space straight line.<br>In circular interpolation mode, it indicates the linear velocity of a circular arc. |
| fSetacc_dec | REAL | Acceleration/deceleration reference<br>Indicates the change rate of setvel. |
| fSetvel_buf | REAL | The velocity reference of a buffered curve<br>In linear interpolation mode, it indicates the interpolation velocity of a space straight line.<br>In circular interpolation mode, it indicates the linear velocity of a circular arc. |

| Name | Type | Description |
|---|---|---|
| fSetacc_dec_buf | REAL | The acceleration/deceleration reference of a buffered curve<br>Indicates the change rate of fSetvel_buf |
| fSetdis | REAL | Distance reference<br>In linear interpolation mode, it indicates the distance at which a space straight line moves after the instruction is executed.<br>In circular interpolation mode, it indicates the length of a circular arc in which the circular arc moves after the instruction is executed. |
| fLeftdis | REAL | Left distance<br>In linear interpolation mode, it indicates the left distance for this section of a space straight line after the instruction is executed.<br>In circular interpolation mode, it indicates the length of a space circular arc left after the instruction is executed. |
| fCenter_x | REAL | The coordinates of point X at the center of a circular arc during circular interpolation |
| fCenter_y | REAL | The coordinates of point Y at the center of a circular arc during circular interpolation |
| fCenter_z | REAL | The coordinates of point Z at the center of a circular arc during circular interpolation |
| fRadius | REAL | The radius of a circular arc during circular interpolation |
| fStartAng | REAL | The start angle during circular interpolation |
| fSetAng | REAL | The motion angle during circular interpolation |

This system variable is used to indicate the status of the entire axis group:




For example, write the X-axis coordinates of the center of an axis group to D3010:

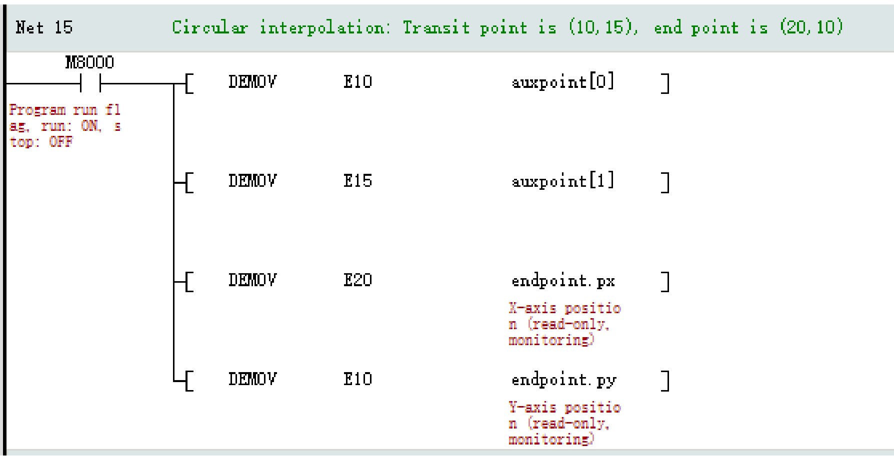


### 3.7.15 _sGROUPPOS_INFO for Target Positions of Coordinate Axes within Axis Group

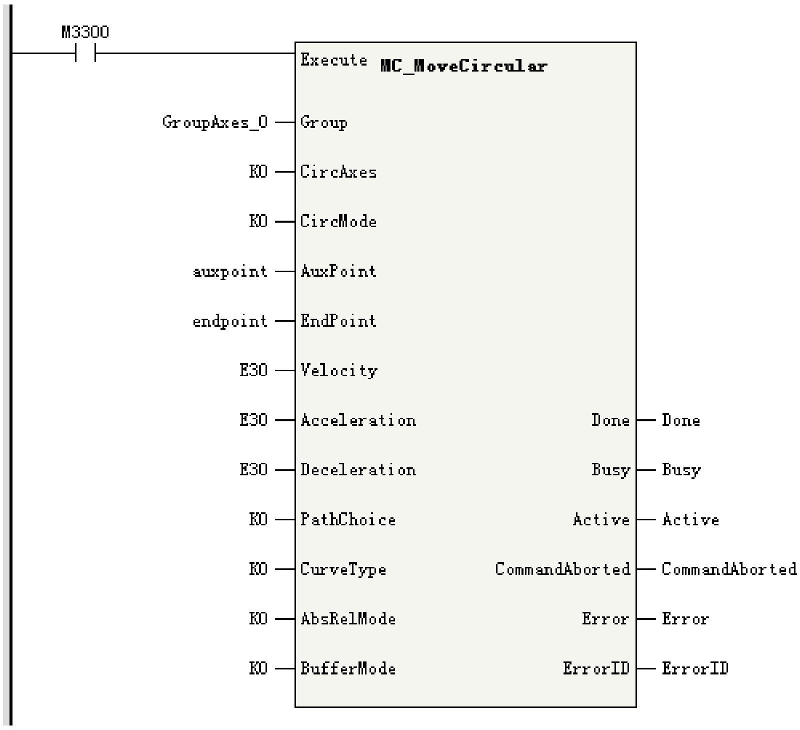
| Name | Type | Description |
|---|---|---|
| px | REAL | The position of the X-axis |
| py | REAL | The position of the Y-axis |
| pz | REAL | The position of the Z-axis |
| pa | REAL | The position of the auxiliary axis |

This structure sets the target position of a circular arc as an input parameter to the MC_MoveCircular.

1. Create a global variable
2. Assign values to the global variable




3. Call the instruction MC_MoveCircular



# 3.8 Timer

## 3.8.1 Overview

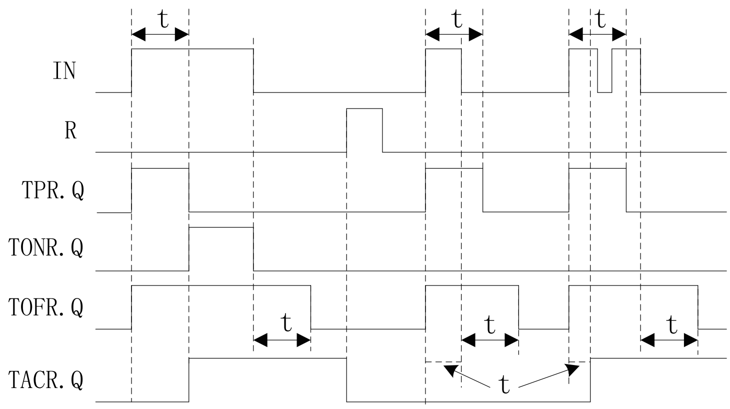
H5U supports four types of timers with the reset function, including the pulse timer (TPR), connection delay timer (TONR), off delay timer (TOFR), and accumulation timer. For details, see the IEC61131-3 standard.

The time base of the timers is 1 ms, and the timer count value and state are updated when the timer instruction is executed. The program supports a maximum of 4096 timer instructions. The instruction parameters of these four types of timers are the same, which are listed as follows:

Table 3–37 Timer instruction parameters

| Name | Definition | Data Type | Description |
|---|---|---|---|
| IN | Instruction execution input | / | Start input |
| PT | Input variable | DINT | Delay time |
| R | Input variable | BOOL | Reset input |
| Q | Output variable | BOOL | Timer output |
| ET | Output variable | DINT | Current timing time |

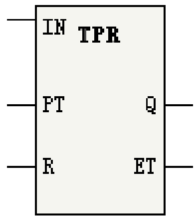
**Timer timing**




## 3.8.2 Pulse Timer - TPR

When the IN input of the timer instruction changes from OFF to ON, the timer starts timing and the output Q turns ON. At this time, no matter how the IN input flow changes, Q remains ON for the time period specified by PT. When the timing duration reaches the time period specified by PT, Q changes to OFF.

During timing of the timer, ET outputs the current timing duration. After the timing duration reaches the value specified by PT, if the IN input flow is ON, the ET value is retained; if the IN input flow is OFF, the ET value becomes 0.



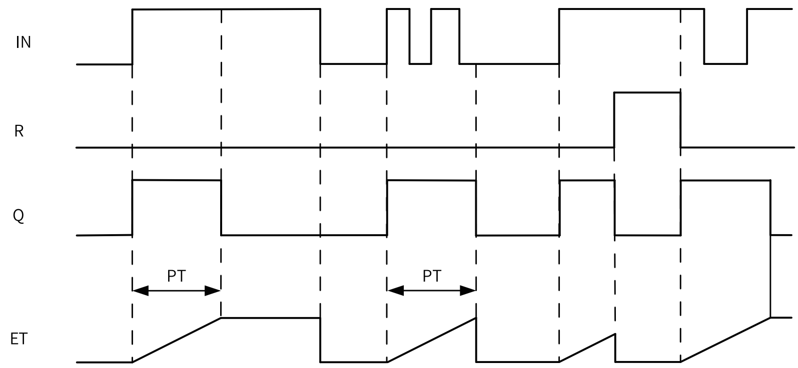

During timing, if the reset input R changes from OFF to ON, the timing duration of the TPR timer is reset to 0, and the output Q turns OFF. After the reset input R turns OFF, if the IN input flow is active, the timer resumes timing.

Parameter description:

PT ranges from 0 to 2147483647 ms (about 24 days). If the value of PT is less than or equal to 0, it is considered 0.

## Timing diagram

The following figure shows the timing diagram of the parameters IN, R, Q, and ET.

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***Note***

The output parameters "ET" and "Q" are updated when this instruction is executed. Therefore, the change in the state of "Q" is not at the time when the elapsed time after the timer starts equals "PT", but at the time when the instruction is executed for the first time after the elapsed time after the timer starts reaches "PT". That is, the delay of the output parameters can be up to one cycle.

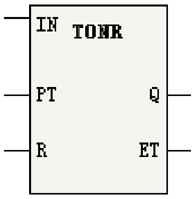
---

## 3.8.3 Connection Delay Timer - TONR

When the IN input of the timer instruction changes from OFF to ON, the timer starts timing and the output Q turns ON. During the period when the IN input flow remains ON, the running time of the timer is the time specified by PT. After the timing duration reaches the time period specified by PT, Q turns ON. During the timing process or after timing is completed, when the IN input flow changes to OFF, timing ends and Q turns OFF.

When the IN input flow is ON, ET outputs the current timing duration during timing of the timer, and the ET value is retained after the timing duration reaches the value specified by PT. When the IN input flow is OFF, the ET value becomes 0.

During timing, if the reset input R changes from OFF to ON, the timing duration of the TONR timer is reset to 0, and the output Q turns OFF. After the reset input R turns OFF, to resume timer timing, you need to set the IN input flow to ON again.



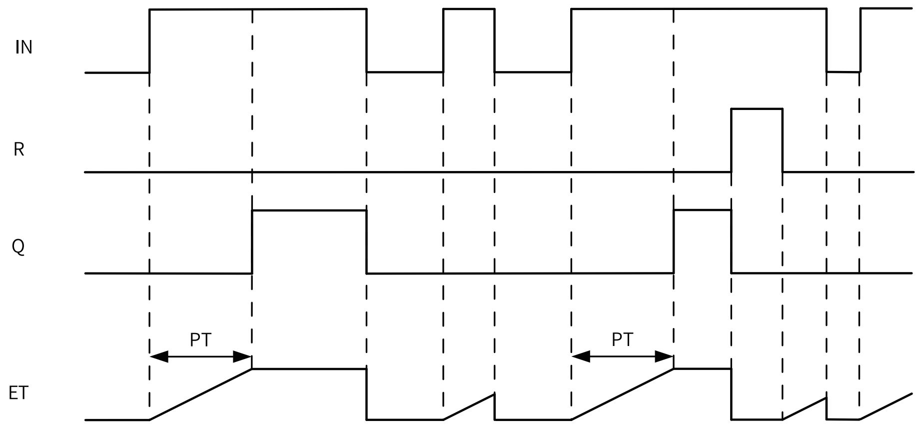

During timing, if the reset input R changes from OFF to ON, the timing duration of the TONR timer is reset to 0, and the output Q turns OFF. After the reset input R turns OFF, if the IN input flow is active, the timer resumes timing.

Parameter description:

PT ranges from 0 to 2147483647 ms (about 24 days). If the value of PT is less than or equal to 0, it is considered 0.

## Timing diagram

The following figure shows the timing diagram of the parameters IN, R, Q, and ET.



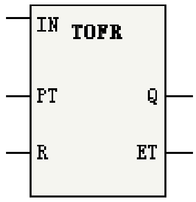

### *Note*

The output parameters "ET" and "Q" are updated when this instruction is executed. Therefore, the change in the state of "Q" is not at the time when the elapsed time after the timer starts equals "PT", but at the time when the instruction is executed for the first time after the elapsed time after the timer starts reaches "PT". That is, the delay of the output parameters can be up to one cycle.

## 3.8.4 Off Delay Timer - TOFR

When the IN input of the timer instruction changes from OFF to ON, the timer starts timing and the output Q turns ON. When the IN input flow changes from ON to OFF, during the period when the IN input flow remains ON, the running time of the timer is the time specified by PT. After the timing duration reaches the time period specified by PT, Q turns OFF.

When the IN input flow is ON, the ET output is 0. When the IN input changes from ON to OFF, ET outputs the current timing duration during timing of the timer, and the ET value is retained after the timing duration reaches the value specified by PT.



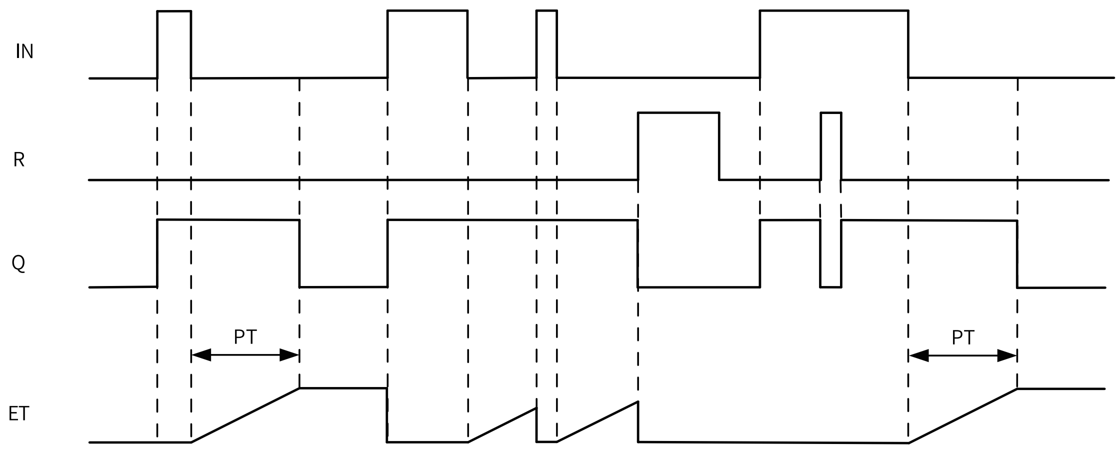

When the IN input flow is ON, if the reset input R changes from OFF to ON, the output Q turns OFF; if R resumes OFF, the output Q resumes ON. When the IN input flow changes from ON to OFF, if the reset input R changes from OFF to ON during the timing process or after timing is completed, the output Q turns OFF, and ET is reset to 0. After the reset input R turns OFF, to resume timer timing, you need to set the IN input flow to OFF again.

Parameter description:

PT ranges from 0 to 2147483647 ms (about 24 days). If the value of PT is less than or equal to 0, it is considered 0.

### Timing diagram

The following figure shows the timing diagram of the parameters IN, R, Q, and ET.

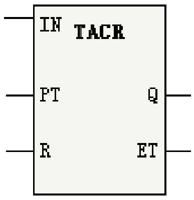



> ***Note***
>
> The output parameters "ET" and "Q" are updated when this instruction is executed. Therefore, the change in the state of "Q" is not at the time when the elapsed time after the timer starts equals "PT", but at the time when the instruction is executed for the first time after the elapsed time after the timer starts reaches "PT". That is, the delay of the output parameters can be up to one cycle.

## 3.8.5 Accumulation Timer - TACR

When the IN input flow of the timer instruction is ON, if the timer value has not reached the time period specified by PT, the timer continues to count, and the output Q is OFF; when the timing duration reaches the time period specified by PT, Q turns ON. During the timing process, if IN changes from ON to OFF, the timing duration is retained. When IN turns ON again, the timer starts counting from the current retained value. After the time specified by PT is reached, Q becomes ON.

When the IN input flow is ON, ET outputs the current timing value. After the timing duration reaches the time period specified by PT, the ET value is retained. When the IN input flow turns OFF, ET remains unchanged.



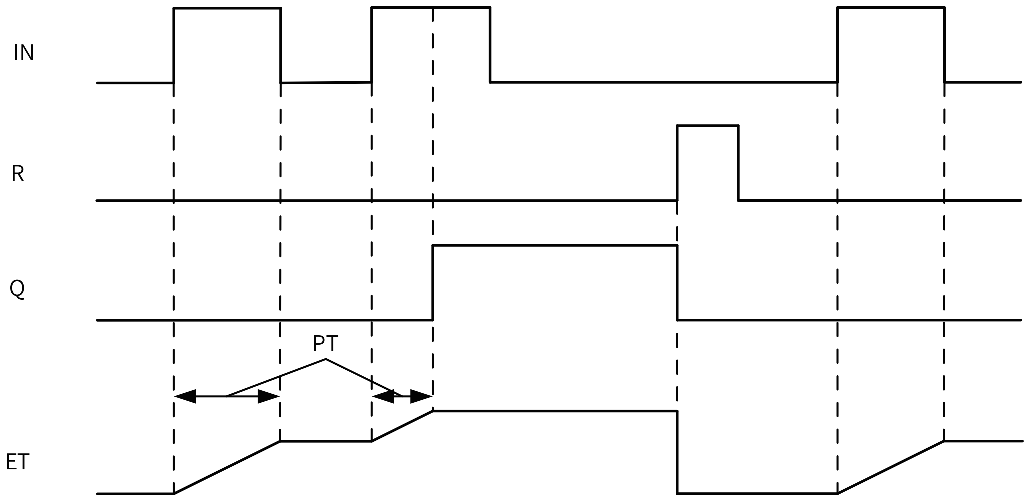

During the timing process or after timing is completed, if the reset input R changes from OFF to ON, the output Q turns OFF, and ET is reset to 0. After the reset input R turns OFF, if the IN input flow is active, the timer resumes timing.

Parameter description:

PT ranges from 0 to 2147483647 ms (about 24 days). If the value of PT is less than or equal to 0, it is considered 0.

## Timing diagram

The following figure shows the timing diagram of the parameters IN, R, Q, and ET.



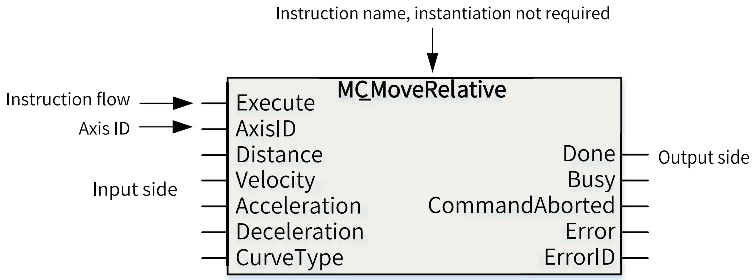

### *Note*

The output parameters "ET" and "Q" are updated when this instruction is executed. Therefore, the change in the state of "Q" is not at the time when the elapsed time after the timer starts equals "PT", but at the time when the instruction is executed for the first time after the elapsed time after the timer starts reaches "PT". That is, the delay of the output parameters can be up to one cycle.

# 3.9 Graphical Block Instructions

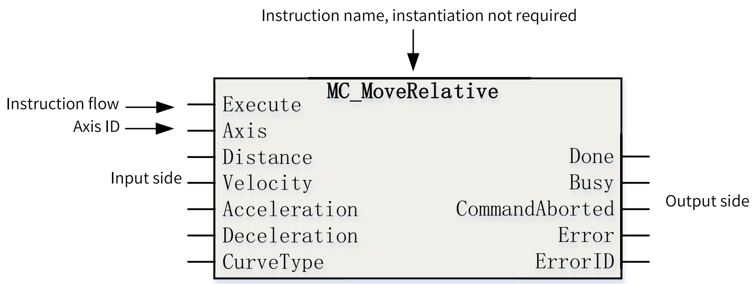
## 3.9.1 Instruction Composition

Some instructions support graphical block programming. An graphical block instruction is composed of the instruction name, flow signal, input side, and output side. The following figure shows the composition of a graphical block instruction of a motion control axis.




The floating-point numbers such as the target position and target velocity in the instructions are single-precision floating-point data. Therefore, the values in the instructions must meet the requirements of the range and precision of single-precision floating-point data when being processed in the PLC program. That is, a value should fall between –3.4E38 and +3.4E38, with a maximum of 7 significant digits. If a value has more than 7 significant digits, the excess part will be automatically rounded.

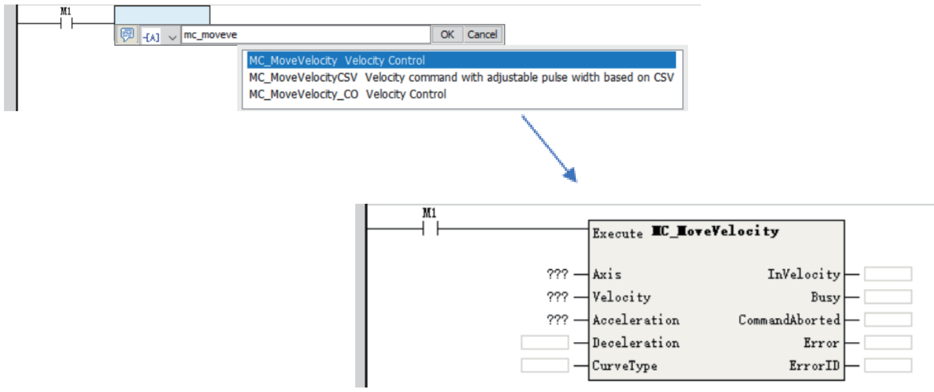
Since AutoShop 4.0.0.0 with PCB software 3.0.0.0, the motion control axis control instructions (EtherCAT/pulse output, pulse input) of graphical blocks support access by axis name. "AxisID" is changed to "Axis", and access by axis ID is still supported.



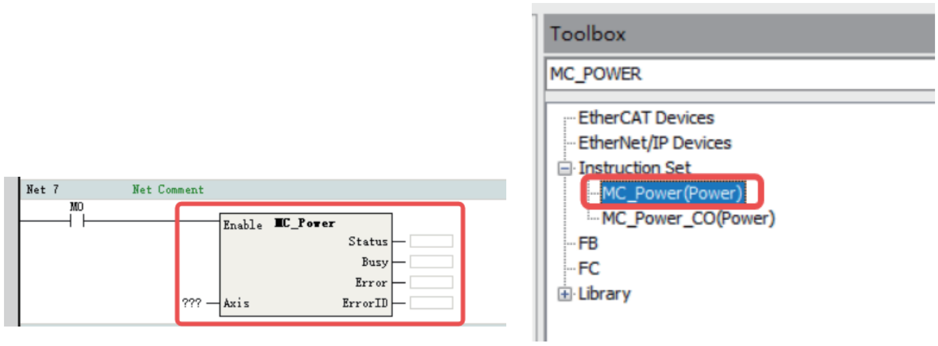

## 3.9.2 Programming

During programming, you only need to enter the name of a graphical block instruction and simply press the "Enter" key to add the graphical block instruction to the program network. You can also directly edit the instruction parameters.

- When editing a ladder diagram, enter an instruction name or select an instruction name according to the instruction prompt and click "OK". The graphical block instruction is added to the ladder diagram network.




- Enter parameters in the graphical block instruction to complete editing of the graphical block instruction.
  In the instruction, parameters (with "???") next to ① are mandatory, and parameters next to ② are optional. If a parameter is not used, the default parameter value is used automatically in the instruction input, and the state cannot be obtained in the instruction output in the program or during monitoring and debugging.
- All instructions under "Instruction Set" in the "Toolbox" pane are in graphical block mode. During programming, you can directly double-click an instruction under "Instruction Set" to add the instruction to the current focus position of the ladder diagram.




①: Double-click an instruction to add it to the ladder diagram. ②: The instruction is added successfully.

### 3.9.3 Labeling Function

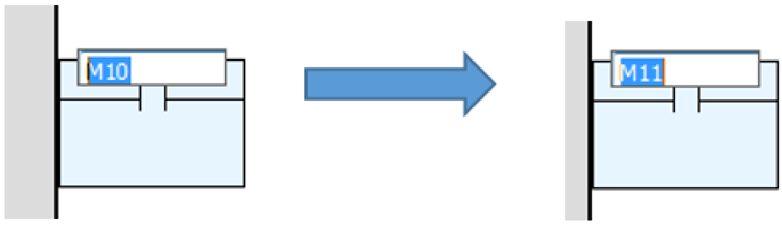
Graphical blocks can be used to quickly increase or decrease label numbers and implement incremental paste.

#### Quickly Increasing/Decreasing Label Numbers

When editing the ladder diagram, you can press "Alt"+"UP"/"DOWN" to quickly increase or decrease the label number of an element or array subscript.


Change “M10” to “M11” with keys Alt+UP after selecting “M10”.

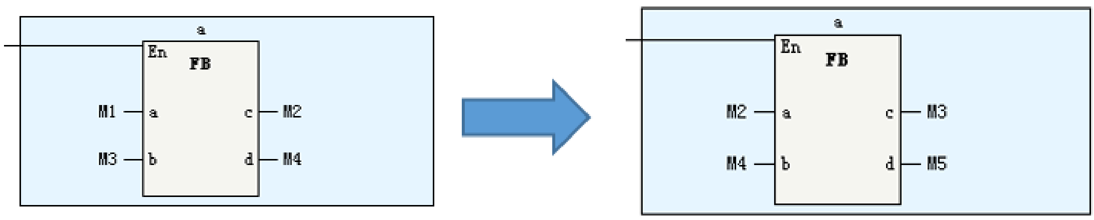
- This function can be used during command editing.




- For complex array variables, you can select the array subscript that needs to be increased or decreased.

Operate on the digit “7” through selecting the subscript of “A”.

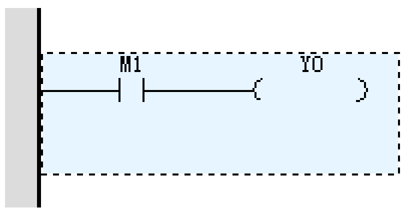
- When a function block is selected, the operation will be performed on all pins.



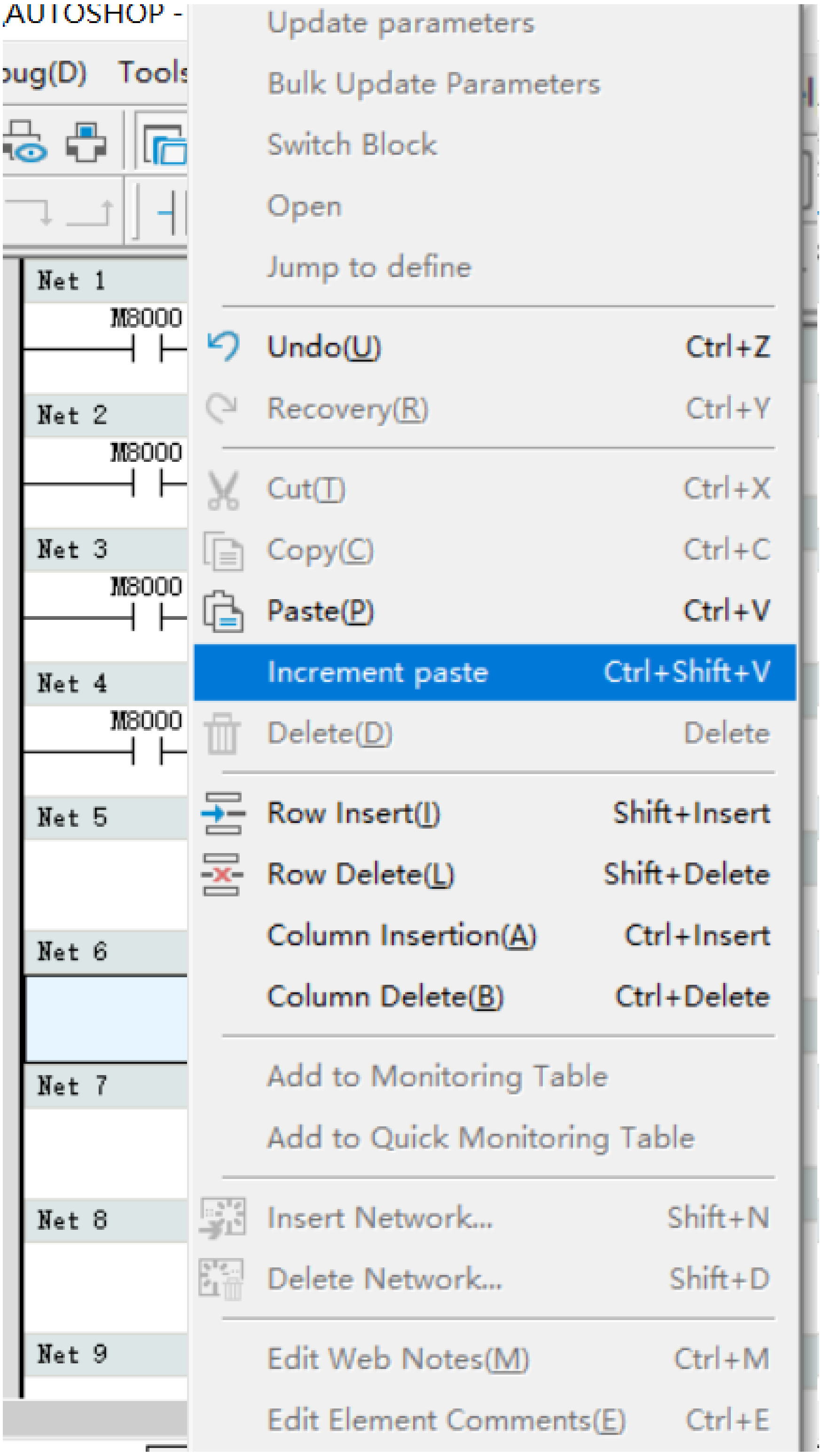

## Incremental Paste

When editing the ladder diagram, you can use the incremental paste function to continuously paste the copied elements for multiple times. At the same time, the element number or array subscript can be specified during the process.

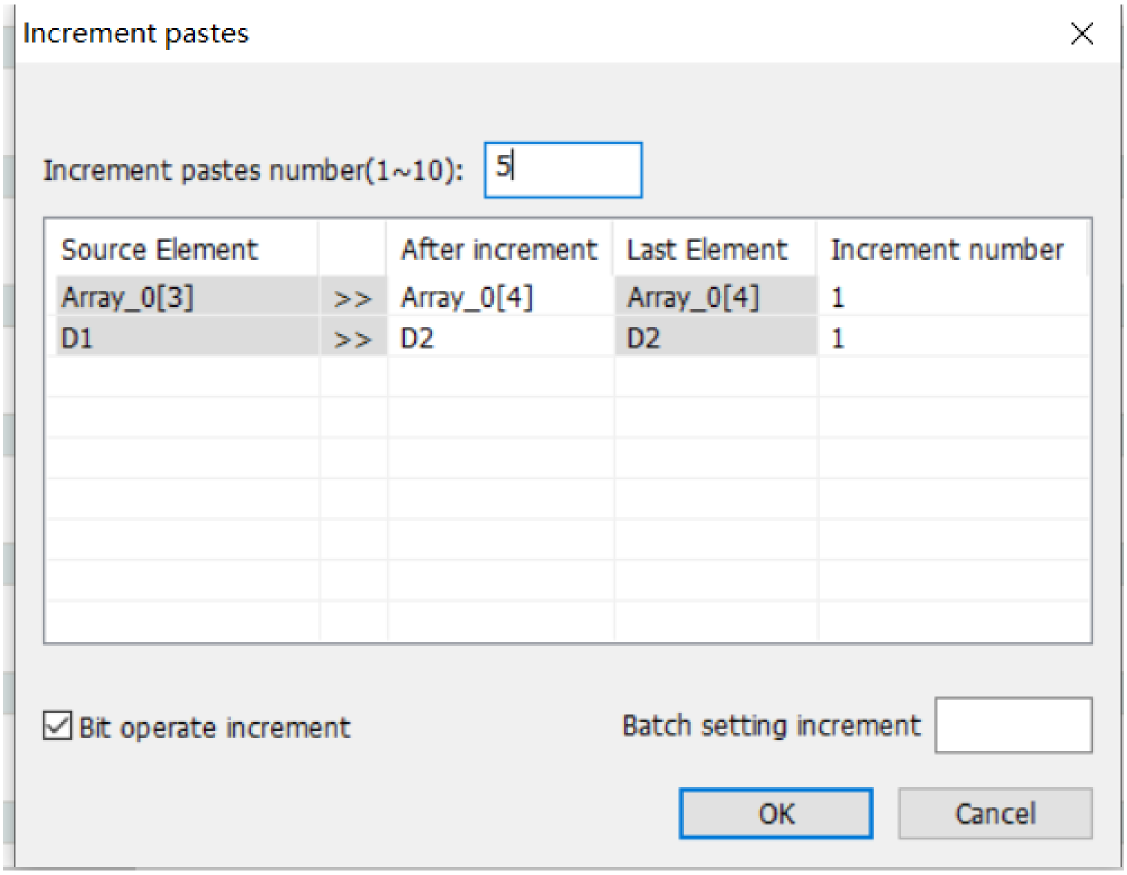
1. Select an element in the ladder diagram and press "Ctrl"+"C", or right-click the element and choose "Copy".




2. Right-click the destination position and choose "Increment paste" from the shortcut menu (or press "Ctrl"+"Shift"+"V").

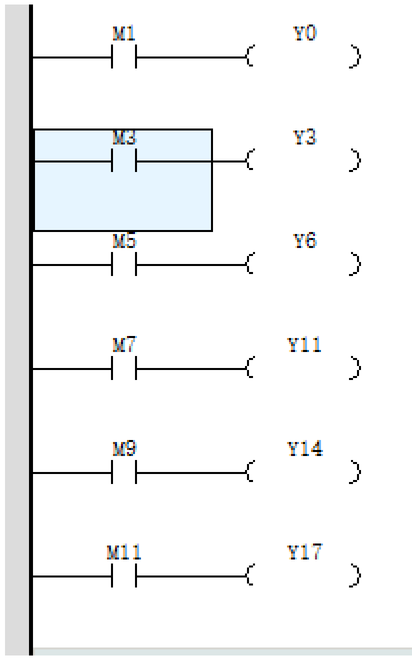



3. Specify the increment value and paste times in the displayed configuration window.




- "Incremental pastes number (1–10)": You can set the paste times.
- "After increment": You can enter the expected value after increment, and "Increment number" is automatically calculated based on this value.
- "Increment number": You can set the increment in the target element each time a paste operation is performed.
- "Bit operate increment": During bit operation of an element, if this option is selected, the increment applies to the bit operation of the target element.
- "Batch setting increment": You can set the increments in batches.

4. Click "OK". The paste operation is performed based on the configuration.




# 3.10 Subprograms

## 3.10.1 Overview

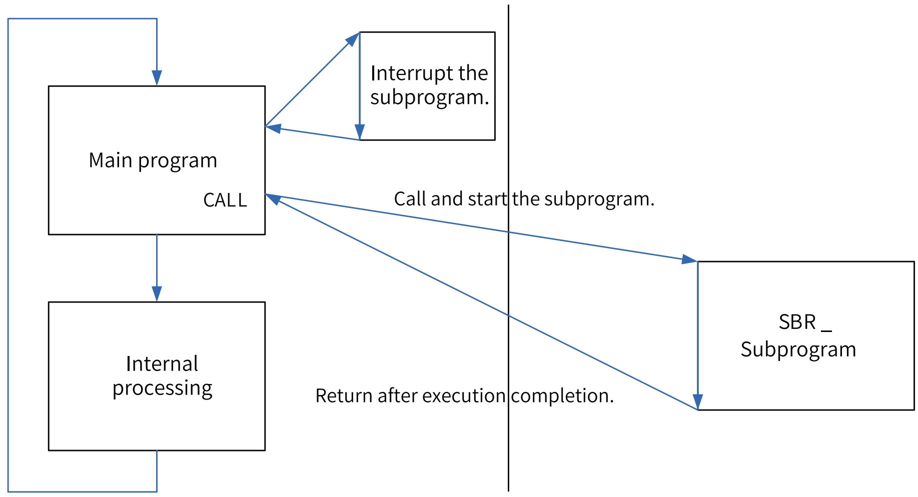
### 3.10.1.1 Subprogram Overview

The following table lists the subprogram categories and corresponding description.

| Code | Name | Description |
|---|---|---|
| SBR | Subprogram | Up to 1024 subprograms are supported. Subprograms can be set as common subprograms or encrypted subprograms.<br>Common subprograms and encrypted subprograms have infinite capacity and share the system capacity of 200,000 steps. |
| INT | Interrupt subprogram | External interruption: X000 to X003 input interrupt, including the rising edge, falling edge, and rising and falling edges |
| | | Timed interruption: 4 points (time base = 1 ms) |
| | | Comparison interruption: 16 points ranging from 1 to 16 |

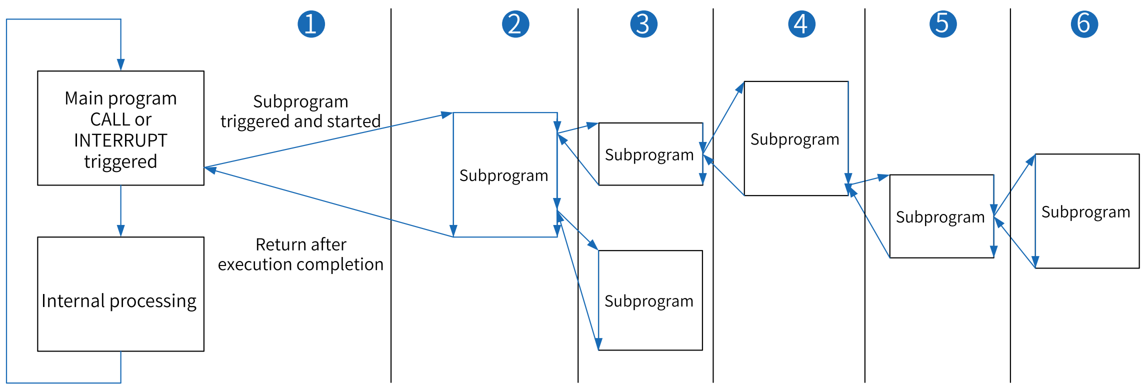
### 3.10.1.2 Subprogram Execution Mechanism

The following figure shows the execution logic and circular scanning methods of the main program and subprograms.




### Subprogram nesting levels

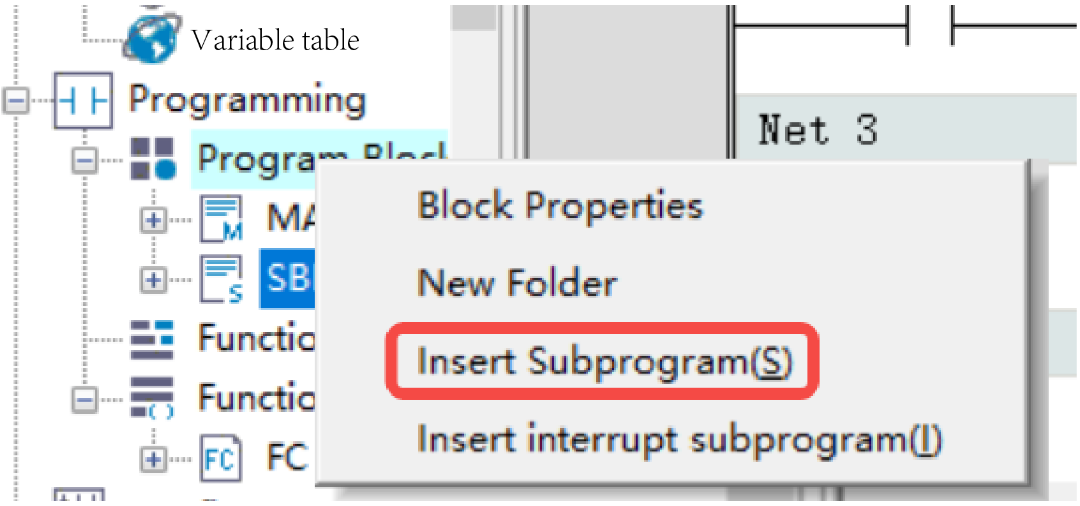
A subprogram supports up to six nesting levels. The main program calls the subprogram as level 1. The nesting level increases by 1 upon each call. If the nesting is returned, the nesting level does not increase. The following figure shows the details.



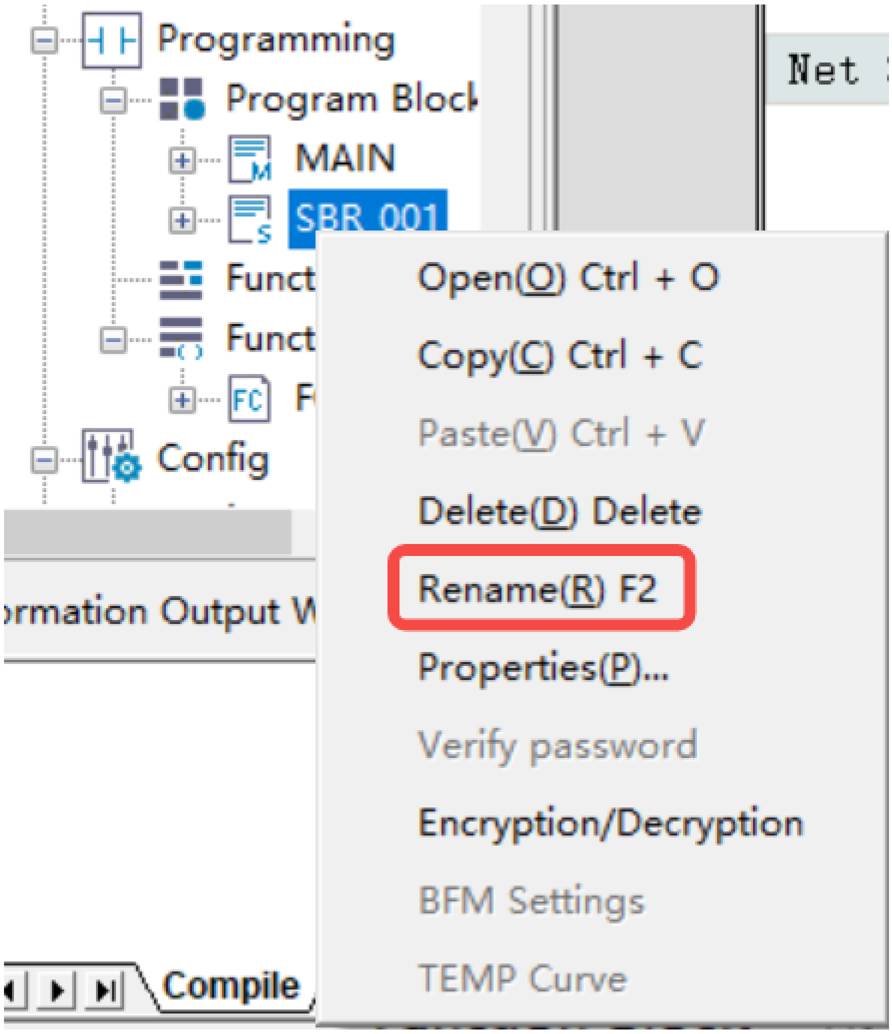

## 3.10.2 General Subprogram Application

### 3.10.2.1 Creating a General Subprogram

In the "Project Manager" tree, unfold "Programming", right-click "Function block" or a folder under "Function block", and select "Insert Subprogram". The new subprogram is displayed under "Function block".




Subprogram naming rule: SBR_SN, in which the subprogram SN can be changed during renaming or property modification.



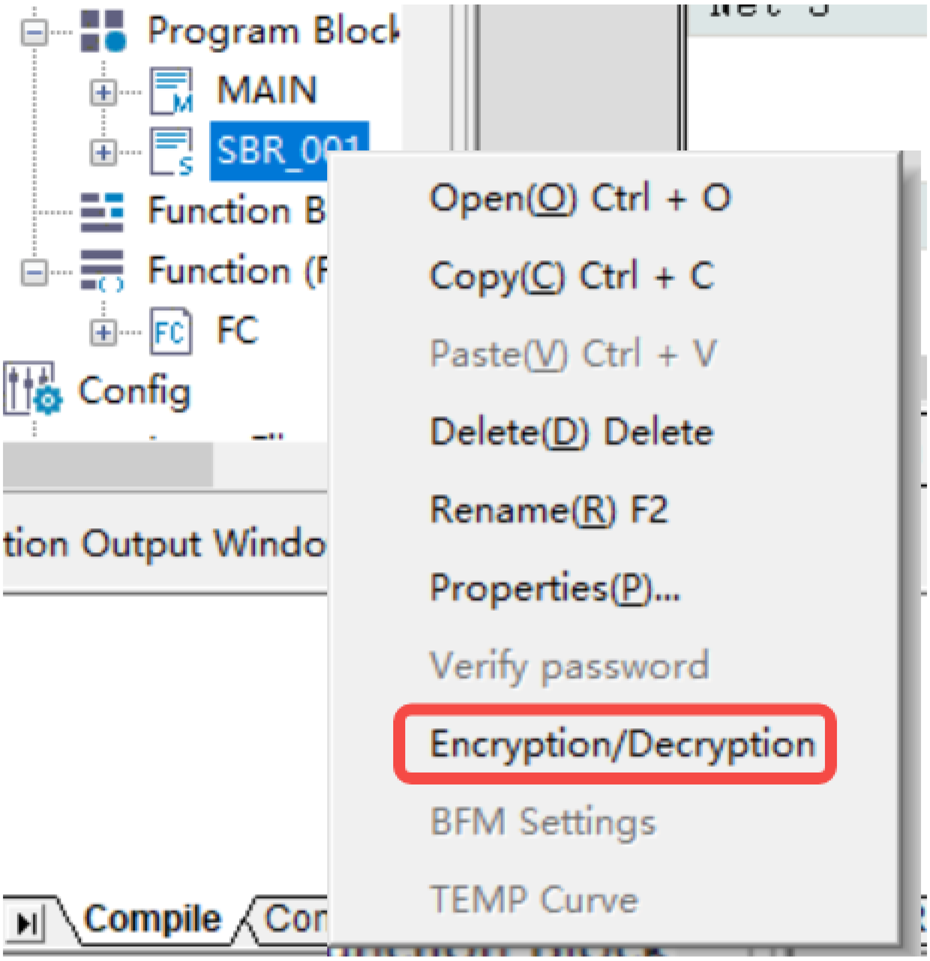

### 3.10.2.2 Calling a General Subprogram

The following figure shows how to call a general subprogram.

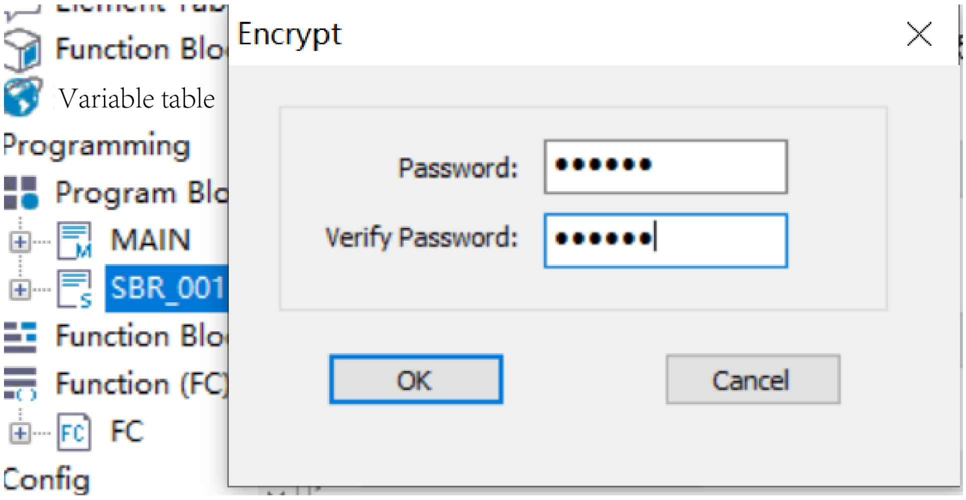

### 3.10.3 Encrypted Subprogram Application

#### 3.10.3.1 Encrypting a General Subprogram

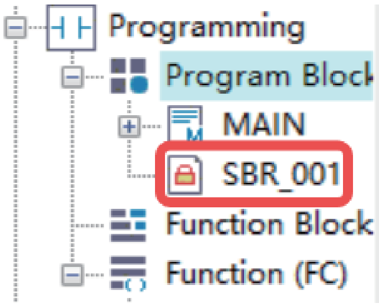
1. Encrypt the SBR_001 general subprogram as an example. Right-click SBR_001 and select "Encryption/Decryption".




2. In the "Encrypt" dialog box that is displayed, set "Password" and "Verify Password".

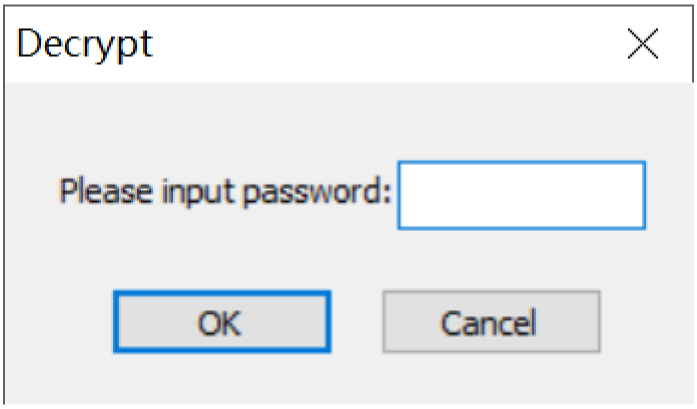



After encryption, the SBR_001 general subprogram is shown in the following figure.




If you repeat the preceding operations on the encrypted general subprogram, the subprogram will be decrypted.

To access an encrypted general subprogram, you can double-click it or right-click it and select "Verify password". In the pop-up dialog box, input the correct password.




#### 3.10.3.2 Calling an Encrypted Subprogram

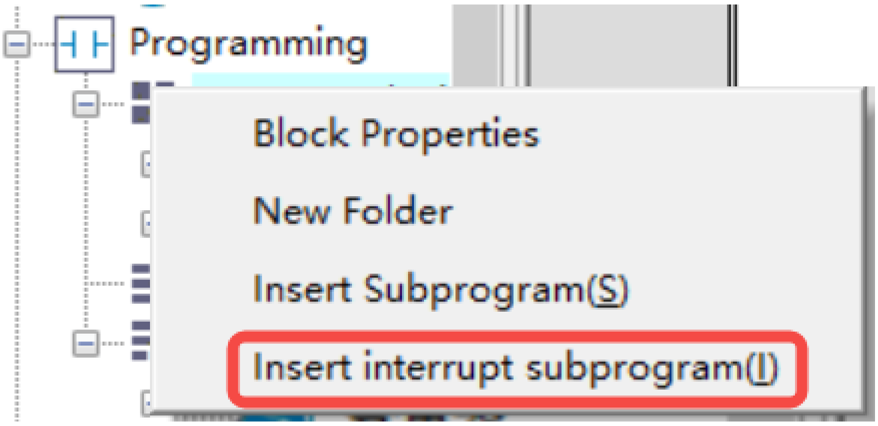
The method of calling an encrypted subprogram is the same as that of calling a general subprogram.

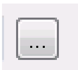
## 3.10.4 Interrupt Subprogram Application

### 3.10.4.1 External Interrupt Subprogram

External interrupt subprograms must be immediately executed to respond to external input signals. External interrupt subprograms are executed regardless of scan cycles.

1. In the "Project Manager" tree, unfold "Programming", right-click "POU" or a folder under "POU", and select "Insert interrupt subprogram".

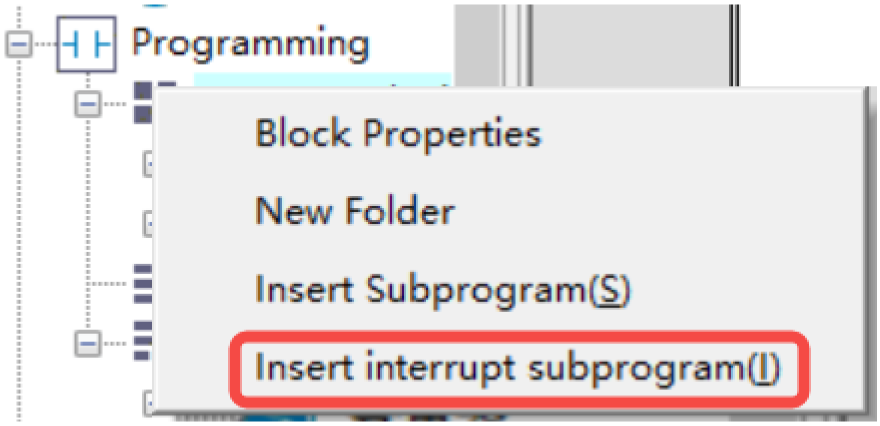


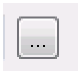

2. Right-click the inserted interrupt subprogram (such as INT_001 in the figure above) and select "Properties" to open the interrupt subprogram settings page as shown in the following figure.
3. Click  next to the "Interrupt Event" field to open the interrupt selection page.
4. Select an external interrupt, such as X0 input interrupt, and then select the corresponding property, such as "Rising Edge", "Falling Edge", and "Rising Edge And Falling Edge".
5. Write interrupt subprograms in INT_001.
6. Enable EI in the main program. When the external interrupt conditions are met, the corresponding interrupt subprogram will be executed.

### 3.10.4.2 Timed Interrupt Subprogram

Timed interrupt subprograms apply to scheduled execution of set program blocks. Timed interrupt subprograms are executed regardless of scan cycles.

1. In the "Project Manager" tree, unfold "Programming", right-click "POU" or a folder under "POU", and select "Insert interrupt subprogram".




2. Right-click the inserted interrupt subprogram (such as INT_001 in the figure above) and select "Properties" to open the interrupt subprogram settings page as shown in the following figure.
3. Click  next to the "Interrupt Event" field to open the interrupt selection page.
4. Select a timed interrupt and set Timing (ms) to a value ranging from 1 ms to 1000 ms.
5. Write interrupt subprograms in INT_001.
6. Enable EI in the main program. When the timed interrupt conditions are met, the corresponding interrupt subprogram will be executed.

#### 3.10.4.3 Comparison Interrupt Subprogram

Comparison interrupt subprograms must be immediately executed to respond to the setpoint of the counter axis. Comparison interrupt subprograms are executed regardless of scan cycles.
For details about the procedure, see *"13.6.7 Comparison Interruption" on page 446*.

## 3.11 Function Blocks and Functions (FB/FC)

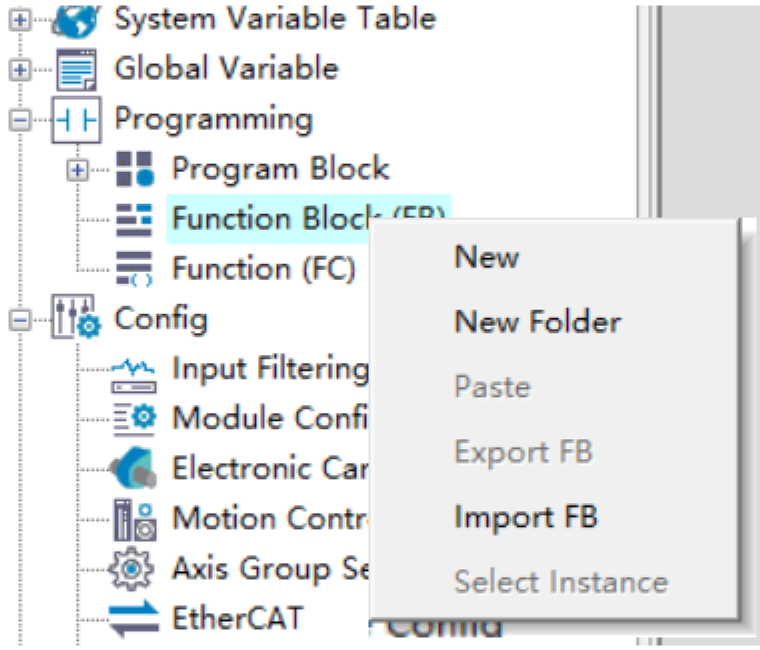
### 3.11.1 Function Blocks (FB)

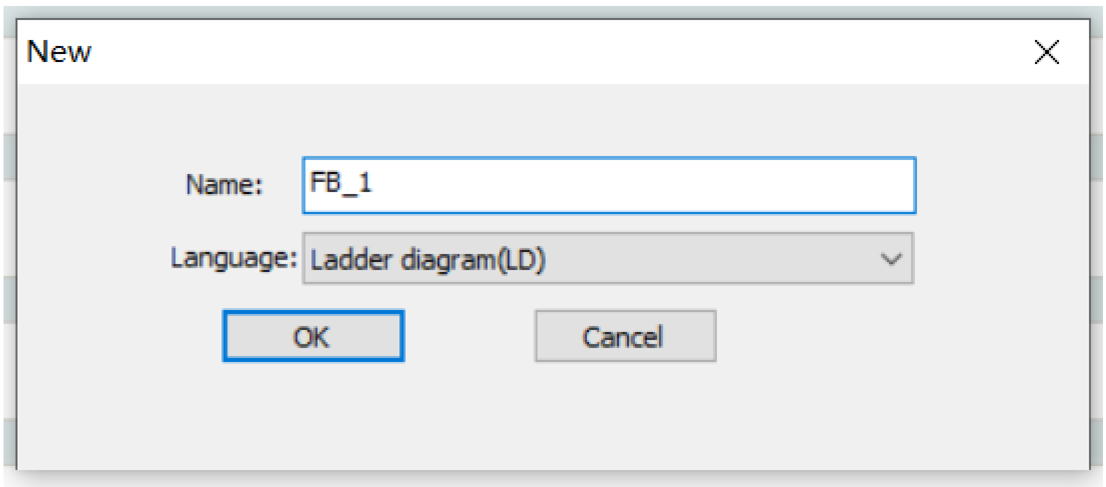
A function block (FB) abstractly encapsulates the part used repeatedly in a program into a general program block that can be called repeatedly within the program. Using encapsulated function blocks in programming can improve program development efficiency, reduce programming errors, and improve program quality.
Different instances can be created based on the same function block. These instances can output one or more values during execution. The system allocates memory for internal variables of each instance, and these variables describe the running state of the function block. With the same input parameters, different instances provide different calculation results.

The basic steps of using a function block are as follows: Create a function block -> Program the function block -> Instantiate the function block -> Run the function block -> Encapsulate the function block -> Import the function block.

## Creating a Function Block

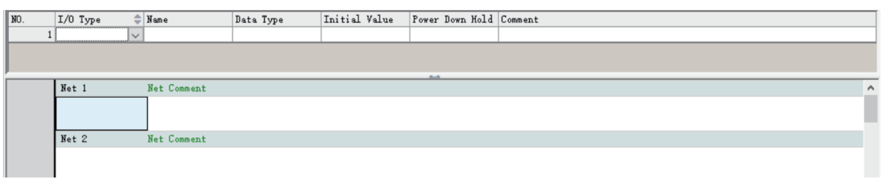
Expand the "Programming" node in the project management window, right-click "Function Block (FB)", or right-click a folder under "Function Block (FB)", choose "New", enter a name in the displayed dialog box, and click "OK". A function block is created successfully.

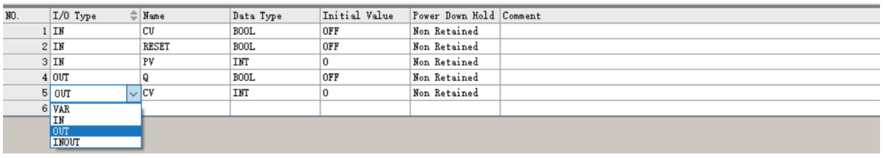



## Programming the Function Block

Function blocks can be programmed in the ladder diagram or structured text. Double-click the created function block under "Function Block (FB)" to go to the function block program editing interface. Compared with ordinary program editing, the function block program editing interface has an additional input/output and local variable definition window.





| NO. | I/O Type | Name | Data Type | Initial Value | Power Down Hold | Comment |
|---|---|---|---|---|---|---|
| 1 | IN | CU | BOOL | OFF | Non Retained | |
| 2 | IN | RESET | BOOL | OFF | Non Retained | |
| 3 | IN | PV | INT | 0 | Non Retained | |
| 4 | OUT | Q | BOOL | OFF | Non Retained | |
| 5 | OUT | CV | INT | 0 | Non Retained | |
| 6 | | | | | | |



①: Input/output and local variable definition window

1. "I/O Type": attribute of the function block variable

| Variable Type | Type Description | Description |
|---|---|---|
| IN | Input variable | The parameter is provided by the logic block that calls the variable, and the input is transferred to the instruction of the logic block. |
| OUT | Output variable | The parameter is provided to the logic block that calls the variable, that is, structure data is output from the logic block. |
| INOUT | Input/Output variable | An input/output variable can not only be transferred to the called logic block, but also can be modified inside the called logic block. |
| VAR | Local variable | A local variable is only valid in the current logic block and cannot be accessed externally. |

2. "Name": name of the variable
3. "Data Type"

   The supported data types include BOOL, INT, DINT, REAL, BYTE, IP, and STRING. You can also define array variables and structure variables. To use structure variables, you need to create structure members in the structure of global variables.

4. "Initial Value"

   You can set the initial value of a variable when execution starts.

5. "Power Down Hold"

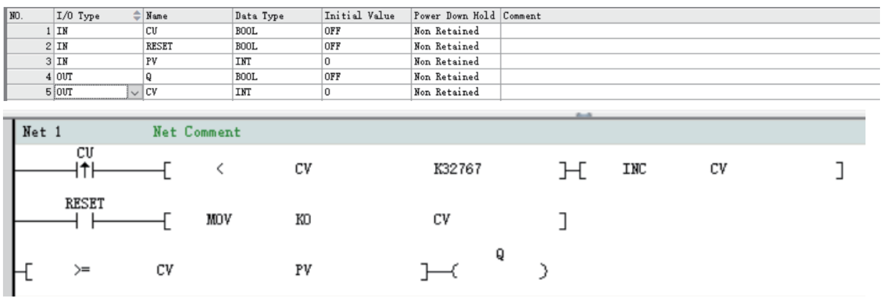
   This attribute allows you to choose whether to retain the value of a variable upon power failure.

   - "Non Retained": The variable resumes the specified initial value after power-on.
   - "Retained": If you select "Re-initialize retentive variables when downloading", the variable resumes the specified initial value during program downloading; otherwise, it retains the previous value.

The function block program adopts ladder diagram programming. It can call functions (FC) or function blocks (FB) and supports up to 8 levels of nested calls.

In addition to variables, the function block program can also use supported elements, such as M8000, as global variables.

## Example: Counting Up with FB Encapsulation

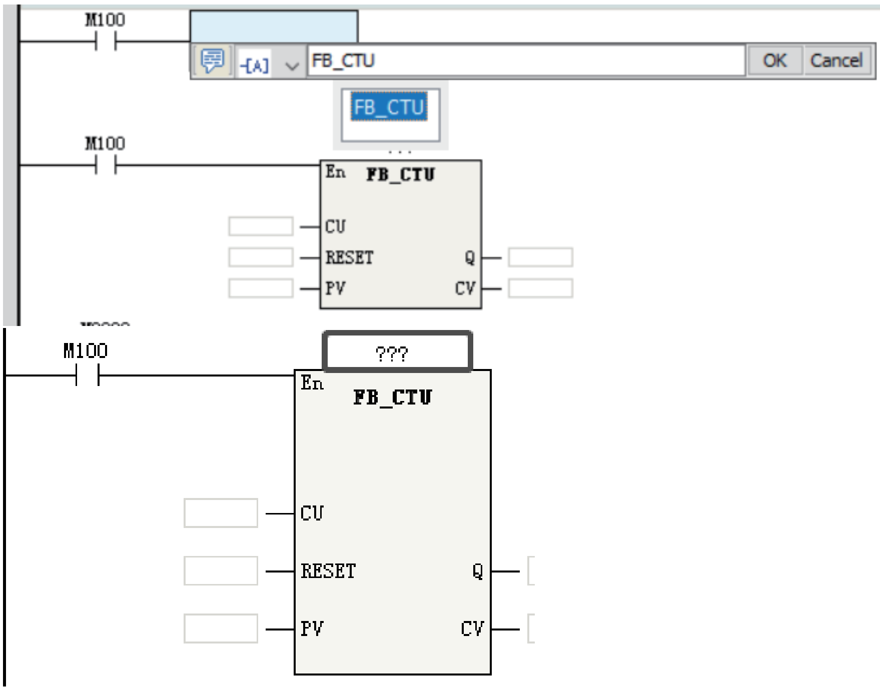


| NO. | I/O Type | Name | Data Type | Initial Value | Power Down Hold | Comment |
|---|---|---|---|---|---|---|
| 1 | IN | CU | BOOL | OFF | Non Retained | |
| 2 | IN | RESET | BOOL | OFF | Non Retained | |
| 3 | IN | PV | INT | 0 | Non Retained | |
| 4 | OUT | Q | BOOL | OFF | Non Retained | |
| 5 | OUT | CV | INT | 0 | Non Retained | |

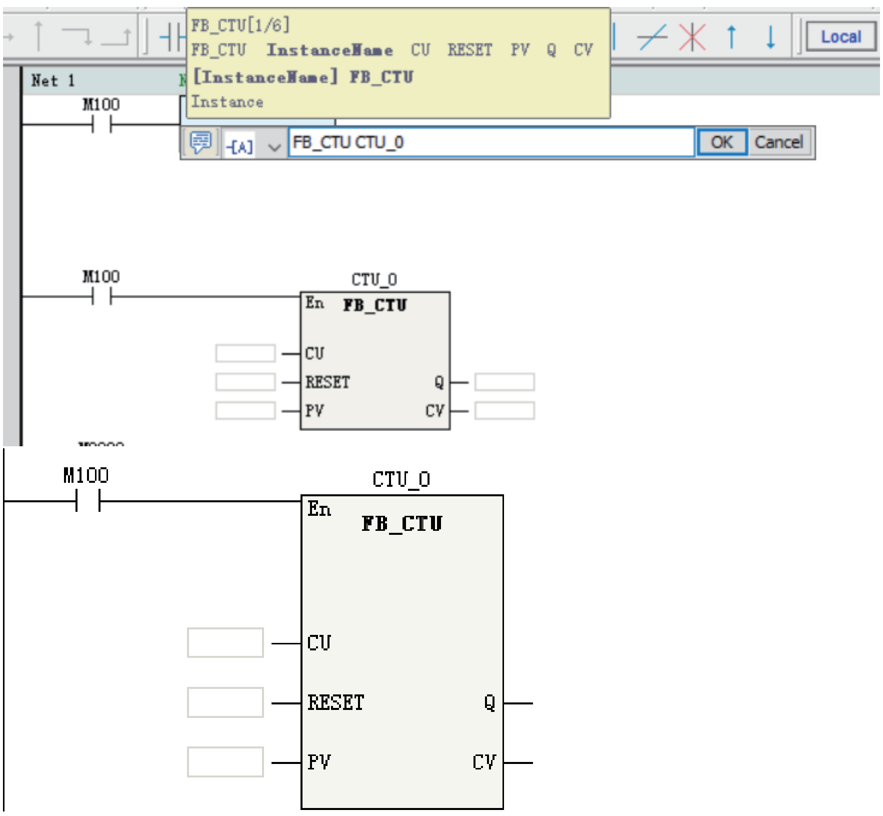
## Instantiating and Calling the Function Block

After the FB program is compiled, the function block needs to be instantiated.

- Method 1: Directly enter the FB name in the ladder diagram application, and then enter the instance name in "???" at the top of the function block instruction to instantiate the function block.

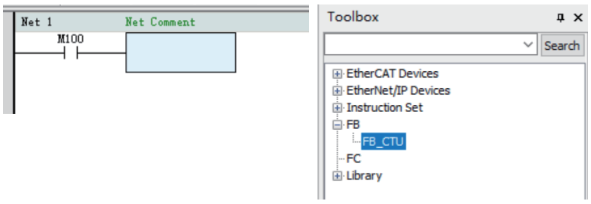



- Method 2: Directly enter the FB name+Instance name in the ladder diagram application and click "OK" to instantiate the function block.



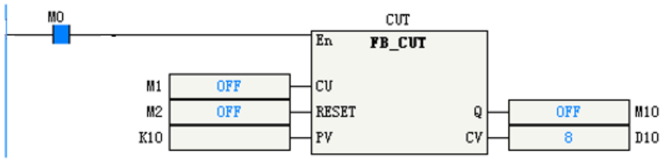
After instantiation is completed, edit the instruction parameters in the FB instruction as required by the program to call the instantiated function block.

- Method 3: Double-click the FB instruction under "FB" of the "Toolbox" pane to add the FB instruction to the selected position in the ladder diagram. Then enter the instance name in the graphic block instruction to complete the instantiation definition.

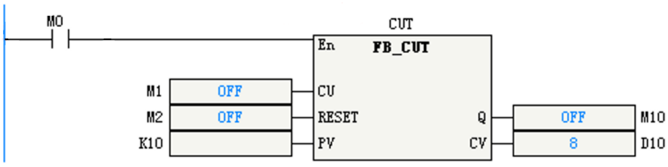



## Running the Function Block

After the function block is instantiated, the En of the function block is connected to the ladder network. When the En network flow is ON, the function block program is executed, and the output of the function block changes with the input state and internal variable state. When the En network flow is OFF, the function block program is not executed, and output of the function block is not refreshed.




When the counter function block CUT flow is ON, the function block is executed. The output CV increases by 1 when the input condition CU changes on the rising edge.

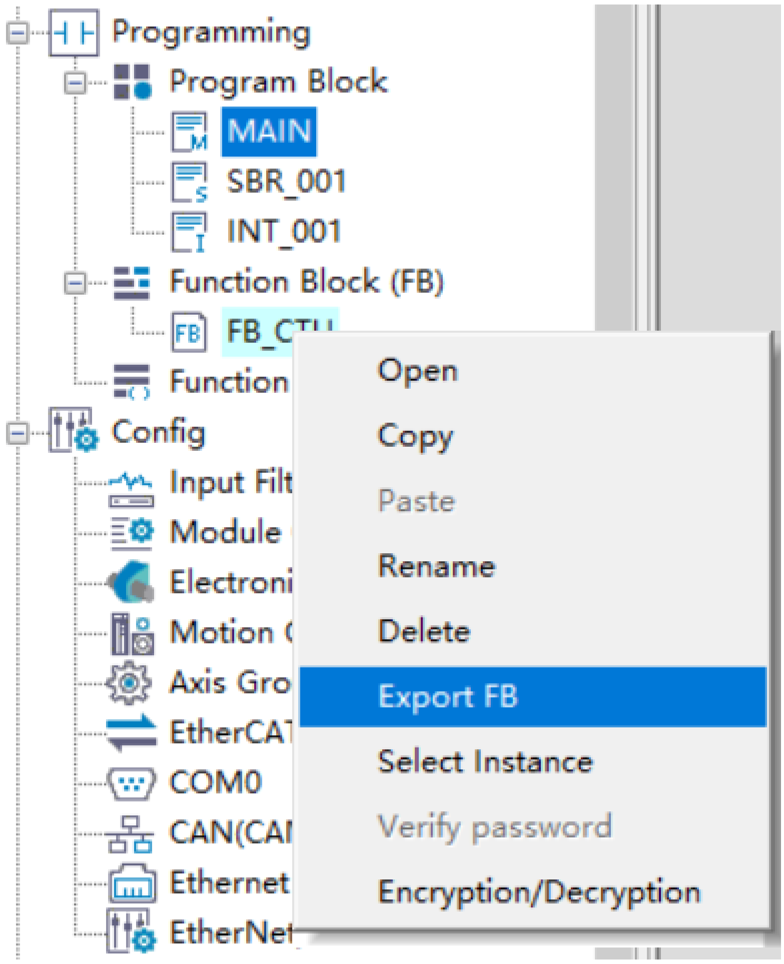



When the counter function block CUT flow is OFF, the function block is not executed. The output CV is not refreshed when the input condition CU changes on the rising edge.

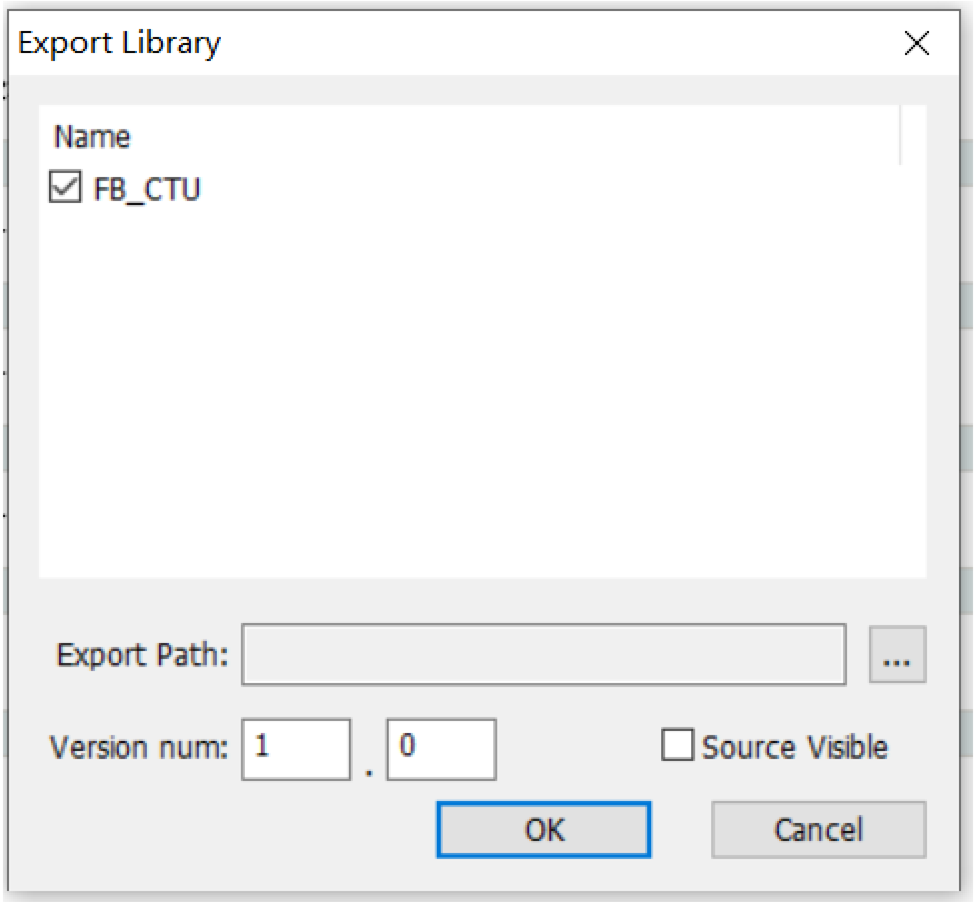
## Encapsulating the Function Block

The function block can be encapsulated into a library after editing and debugging. The function block encapsulated into a library can be multiplexed in different programs through library management of AutoShop.

1. Right-click "Function Block (FB)" under "Programming" and choose "Export FB".




2. Select the function block to be encapsulated and set the version in the displayed "Export Library" window. Select "Source Visible" as required. If the source code is visible, after importing the library in the project, you can debug or modify the function block program. If the source code is invisible, after the library is imported, the function block program can only be called but not viewed or modified in the project.




3. Specify "Export Path" and click "OK". The FB is exported to the specified location, and a function block in .fe format is generated.

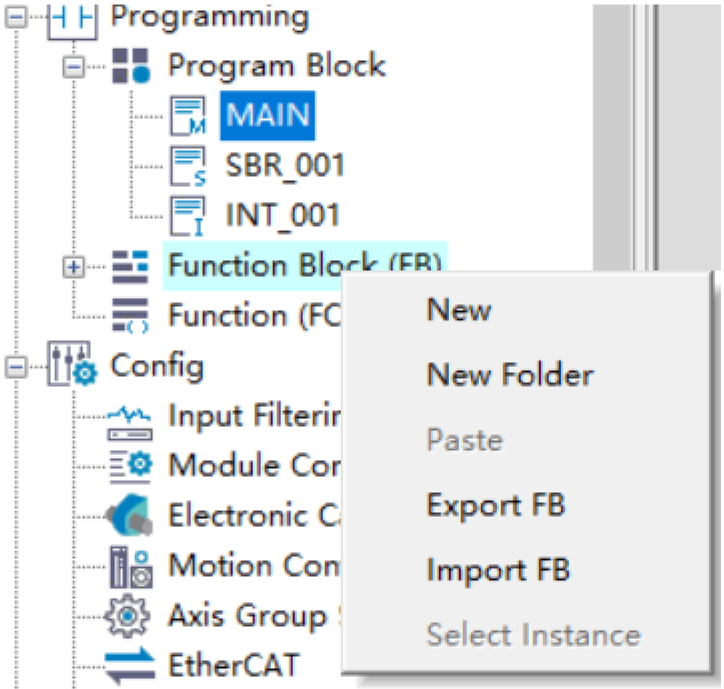
Caution

Encrypted function blocks, function blocks that call encrypted function blocks, and function blocks that call encrypted functions cannot be selected for export.

## Importing the Function Block

After the function block is exported as a library, it can be called in other programs after being imported. You can import the function block library in either of the following two ways.

- Method 1: Right-click "Function Block (FB)" under "Programming" in the project management window and choose "Import FB" to import the library.




This method can only be used to import function blocks of which the source code is visible. After importing, you can double-click to open the function block program and edit and debug it. The function block library imported using this method is managed in the project. If you want to call the function block in a new project, you need to re-import the library.

- Method 2: Right-click "Library" in the "Toolbox" pane and choose "Import FB" to import the library. This method can be used to import function blocks of which the source code is visible or invisible. The libraries imported this way are managed as custom libraries, and the function blocks in the libraries can be used directly when a new project is created. You can double-click the function block library imported in the toolbox to directly add it to the ladder diagram program as an instruction. If you need to view or modify a function block program of which the source code is visible, you need to import it in the project management window.

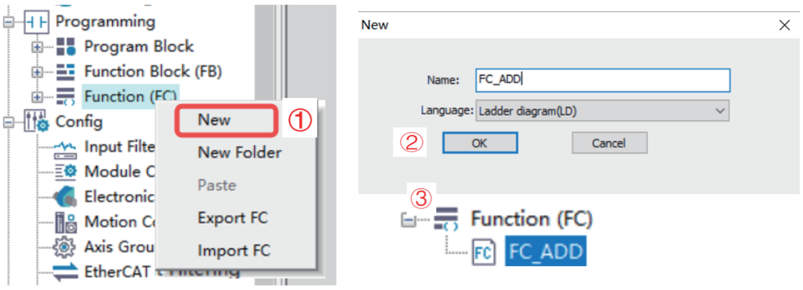
### 3.11.2 Functions (FC)

A function (FC) is an independently encapsulated program block. The program block can define input/output parameters and non-static internal variables. That is, when a function is called with the same input parameters, the output results are the same. An important feature of a function is that its internal variables are static, and there is no internal state storage. You will obtain the same output with the same input parameters. This is the main difference between a function and a function block.
FC, as a basic arithmetic unit, is often used in various mathematical operations. For example, sin(x) and sqrt(x) are typical functions.

The basic steps of using a function are as follows: Create a function -> Program the function -> Call the function -> Run the function -> Encapsulate the function.

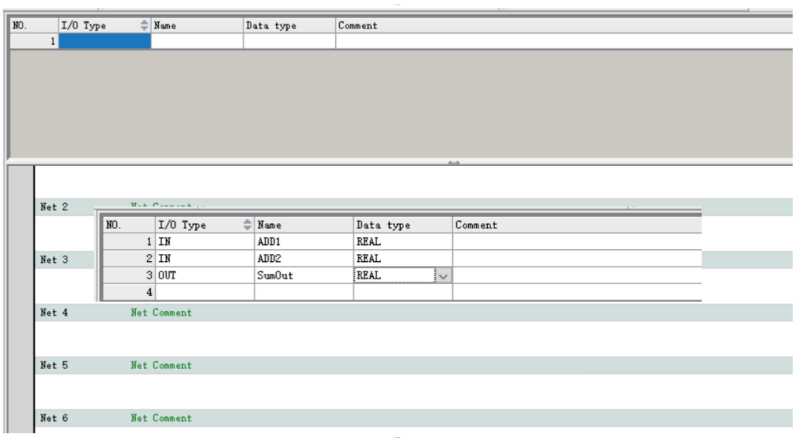
## Creating a Function

Expand the "Programming" node in the project management window, right-click "Function (FC)", or right-click a folder under "Function (FC)", choose "New", enter a name in the displayed dialog box, and click "OK". A function is created successfully.




## Programming the Function

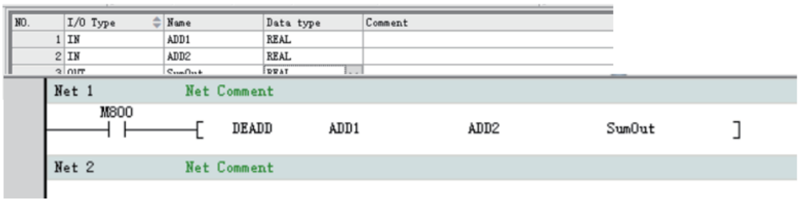
Functions can be programmed only in the ladder diagram. Double-click the created function under "Function (FC)" to go to the function program editing interface. The editing interface of the function program is similar to that of the function block. Compared with ordinary program editing, the function program editing interface has an additional input/output and local variable definition window.




In the input/output and local variable definition window, you can define the input (IN), output (OUT), input/output (INOUT), and local variable (VAR) of a function block. The supported data types include BOOL, INT, DINT, REAL, BYTE, IP, and STRING. You can also define array variables and structure variables. To use structure variables, you need to create structure members in the structure of global variables.

- Compared with variables of function blocks, variables of functions do not support configuration of initial values, and all local variables are non-retentive.
- The function program adopts ladder diagram programming. It can call functions. A function can be called by other functions, function blocks, and programs.
- In addition to variables, the function program can also use M8000 as an always ON variable.
- In a function program, instructions related to states or executed for multiple cycles, such as LDP and MC_Power, cannot be used.

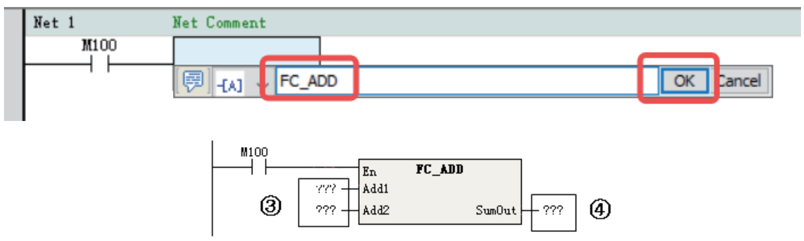
### Example: Encapsulating the Addition Function




### Calling the Function

The function program can be called directly or used in an application after it is compiled.

- Method 1: Directly enter the function name in the ladder diagram application, press "Enter", and then edit the input/output parameters in the graphic block instruction.

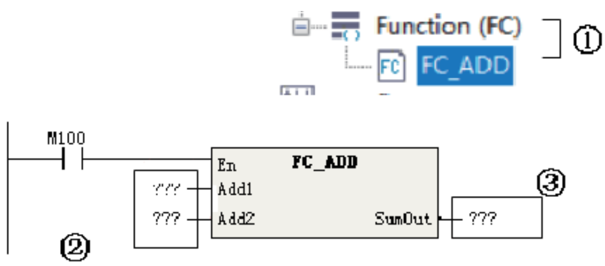



①: Enter the function name.

②: Click "OK".

③/④: Add input/output variables.

- Method 2: After a function program is created, the corresponding instruction is generated under "FC" in the "Toolbox" pane. Double-click the FC instruction under "FC" to add the FC instruction to the selected position in the ladder diagram.



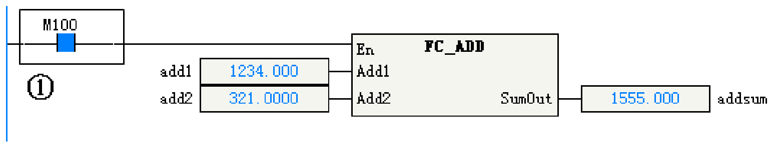

①: Double-click the FC instruction to add it.

②: Add input parameters.

③: Add output parameters.

### Running the Function

After the function is called, the En of the function is connected to the ladder network. When the En network flow is ON, the function program is executed, and the output of the function is refreshed according to the input state operation. When the En network flow is OFF, the function program is not executed, and output of the function is not refreshed.



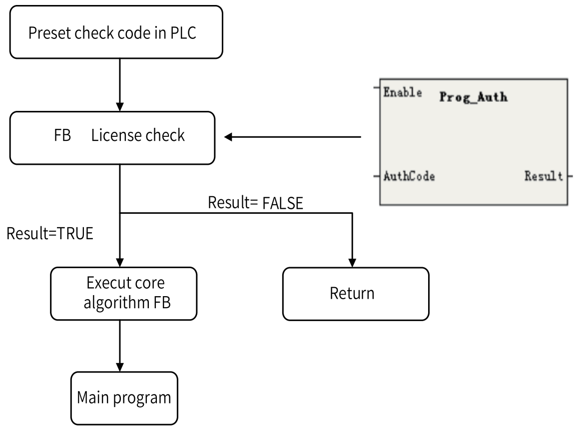

①: The function is executed when the En network flow is ON.

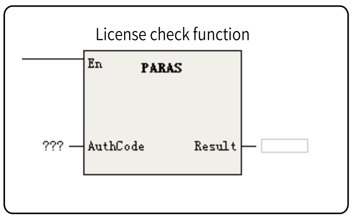
## Encapsulating the Function

The encapsulation procedure of functions is similar to that of function blocks. For details, see the description of "Encapsulating the Function Block".

## 3.11.3 Authorization Function Block

By using the Prog_Auth function, the core algorithm function block is controlled and compiled into a library file. Only authorized PLCs that pass the verification can use this library file, thus protecting the intellectual property of the equipment manufacturer.

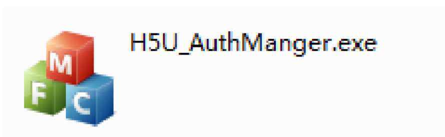



1 - Check code
2 - Results returned (BOOL type); ON: Succeed; OFF: Failed

## Setting Authorization Code

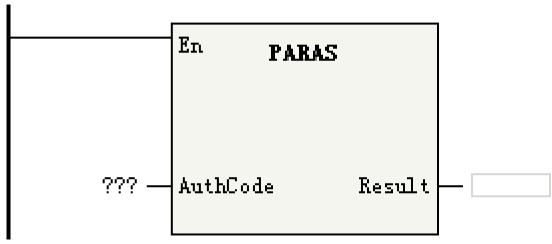
1. Run "H5U_AuthManger.exe" in the software installation directory.



2. Enter the IP address of the PLC, enter the 8-digit authorization code, and click "Set Authorization Code".
3. Click "Generate Verification Code". A string of characters is generated in the "Instruction Authorization Verification Code" text box.
4. You can also verify or clear the authorization code (only after you enter the authorization code) in the software.

### Adding a Program Block

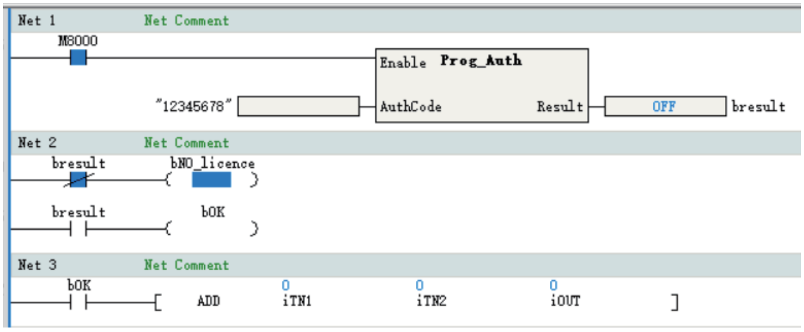
1. Open the function block to be authorized, and add the PARAS function block.




2. Enter the instruction authorization verification code generated by the software in "AuthCode".
3. The function block is authorized. If the authorization code of the PLC is inconsistent with that in the function block, the program in the function block cannot run.

### Example

Since the verification code obtained by using Prog_Auth is inconsistent with the preset verification code in the PLC, the return value is "OFF", and the ADD instruction of the program is not executed.




## 3.11.4 FB Initial Values

The initial values of FB settings can be modified based on the FB type or FB instance.

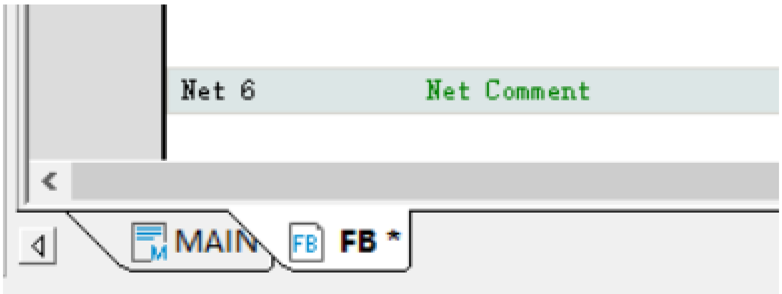
- Modifying the initial values based on the FB type is equivalent to modifying the initial values of the type.
- Modifying the initial values based on an FB instance is equivalent to modifying the initial values of the instance.
- If the initial values of an instance are modified, the member variables of the FB instance display the values after modification, and the background color of the cells is yellow.
- If the initial values of an instance are not modified, the member variables of the FB instance display the default values, and the background color of the cells is white.

The initial values of the FB type are the default values of the instance. When the initial values of an instance are modified back to the default values, the background color of the cells changes from yellow to white.

## Modifying Initial Values When the FB Is Not Nested

Modify the initial value of the FB type from 0 to 10. Use the default value as the initial value of the FB instance, that is, the initial value 10 of the FB type.

| NO. | I/O Type | Name | Data Type | Initial Value | Power Down Hold | Comment |
|---|---|---|---|---|---|---|
| 1 | VAR | param_1 | INT | 10 | Non Retained | |
| 2 | | | | | | |




| NO. | I/O Type | Name | Data Type | Initial Value | Power Dow... | Comment |
|---|---|---|---|---|---|---|
| 1 | VAR | var_1 | FB | ... | Non Retained | |
| 2 | | | | | | |

Toolbox

| Variable Name | Initial Value | Type | Comment |
|---|---|---|---|
| var_1 | | FB | |
| param_1 | 10 | INT | |

Modify the initial value of the FB instance from 10 to 100. The initial value of the FB instance is 100. At this time, if you attempt to modify the initial value of the FB type to 11, you will find that the initial value of the FB instance remains unchanged (still 100).

Toolbox

| Variable Name | Initial Value | Type | Comment |
|---|---|---|---|
| var_1 | | FB | |
| param_1 | 100 | INT | |

In the ladder diagram, double-click "FB" to display the FB instance. At this time, the initial value of the FB instance is displayed in the FB view instead of the initial value of the FB type. If the initial value of the variable is modified to be inconsistent with the FB, the background color will be yellow. Modifying the initial value on this interface is the same as modifying the initial value of the instance in the function block instance table.

| NO. | I/O Type | Name | Data Type | Initial V... | Power Dow... | Comment |
|---|---|---|---|---|---|---|
| 1 | VAR | param_1 | INT | 100 | Non Retained | |
| 2 | | | | | | |

## Modifying Initial Values When the FB Is Nested

Add a variable fb1 in the FB type, and set the data type to "FB_1". Modify the initial value of FB_1 from 1000 to 1001. The member variable fb1 of the FB type automatically takes the default value 1001 as the initial value, and the member variable fb1 of the FB instance also automatically takes the default value 1001 as the initial value.

| NO. | I/O Type | Name | Data Type | Initial V... | Power Dow... | Comment |
|---|---|---|---|---|---|---|
| 1 | VAR | param_1 | INT | 11 | Non Retained | |
| 2 | VAR | fb1 | FB_1 | ... | Non Retained | |
| 3 | | | | | | |

Toolbox

| Variable Name | Initial Value | Type | Comment |
|---|---|---|---|
| var_1 | | FB | |
| param_1 | 11 | INT | |
| fb1 | | FB_1 | |
| param_1 | 1001 | INT | |

| NO. | Variable Name | Data Type | Initial V... | Comment | Length |
|---|---|---|---|---|---|
| 1 | var_1 | FB | ... | | nBitLen:16 |
| 2 | | | | | |

Toolbox

| Variable Name | Initial Value | Type | Comment |
|---|---|---|---|
| var_1 | | FB | |
| param_1 | 11 | INT | |
| fb1 | | FB_1 | |
| param_1 | 1001 | INT | |

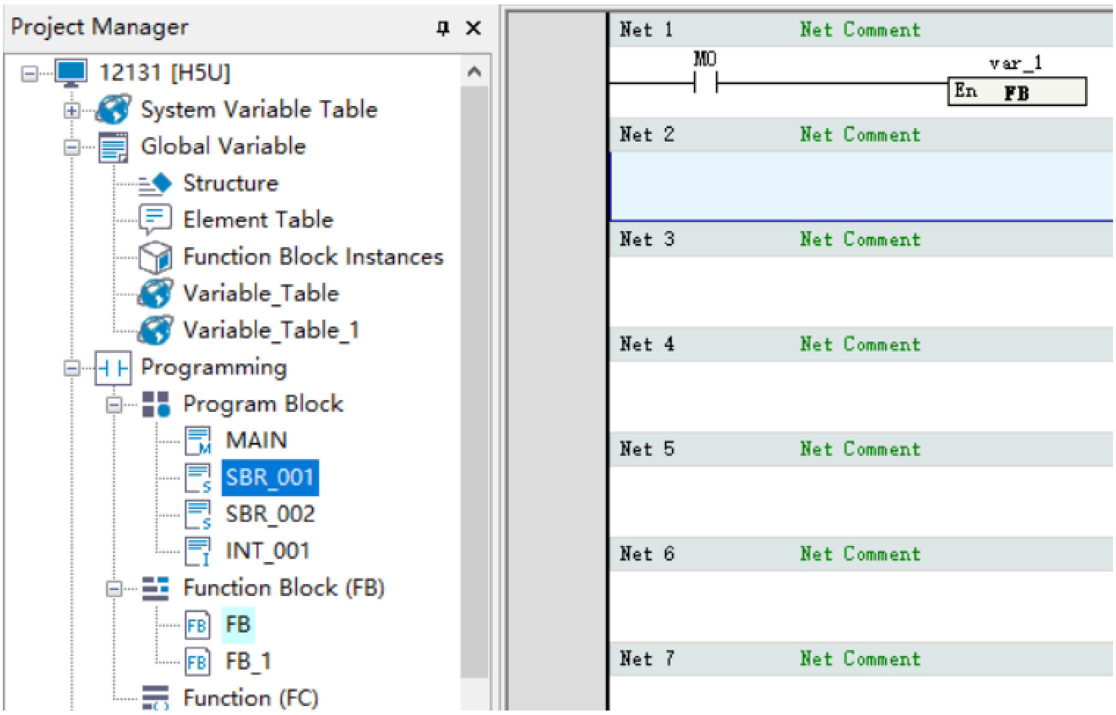
FB is the middle layer between the instance and FB_1. Modify the initial value of FB_1 to 1500 on the FB type interface. Then the initial value of the FB type changes to 1500, and the background color changes to yellow. At this time, the initial value of FB_1 of the FB instance is also 1500, but the background color is white, indicating that the default value is used.

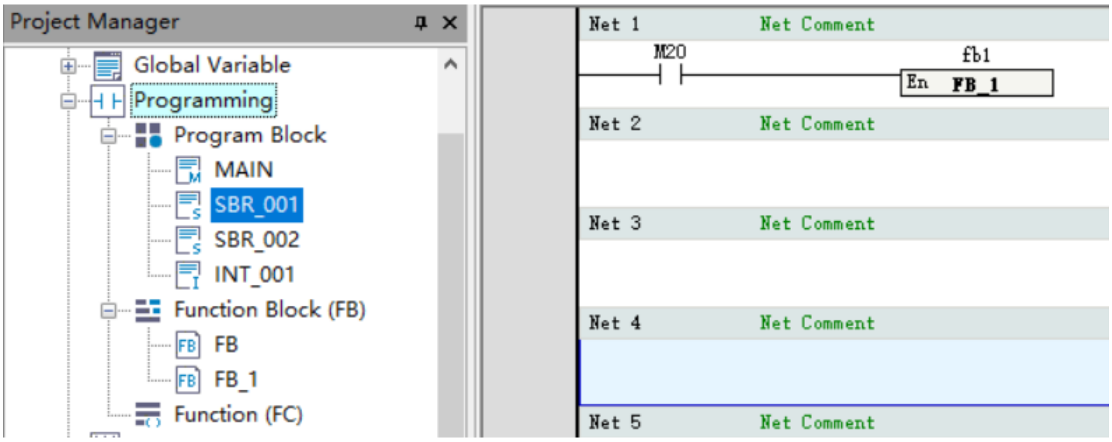
| NO. | I/O Type | Name | Data Type | Initial V... | Power Dow... | Comment |
|---|---|---|---|---|---|---|
| 1 | VAR | param_1 | INT | 11 | Non Retained | |
| 2 | VAR | fb1 | FB_1 | ... | Non Retained | |

Toolbox

| Variable Name | Initial Value | Type | Comment |
|---|---|---|---|
| fb1 | | FB_1 | |
| param_1 | 1500 | INT | |

- Enter the instance interface from the main program. The initial value of the FB instance is displayed. Double-click "FB_1" to enter the FB_1 instance interface, and modify the initial value to 2000. Open the FB_1 type, and the initial value is still 1001. Open the FB instance FB_1, and the initial value is 2000.




At this time, the tab name is "FB_1(var_1.fb1)".

- Double-click "FB" in the "Project Manager" navigation tree. You can see that the initial value of FB_1 on the FB type interface is 1500. Double-click "FB_1" in the ladder diagram of the FB type interface to enter the FB_1 instance interface. You can see that the initial value of the FB_1 instance is 1500. Modify it to 2500. Then return to the FB type interface to check the initial value of FB_1. You will find that it also changes to 2500.

| NO. | I/O Type | Name | Data Type | Initial Value | Power Dow... | Comment |
|---|---|---|---|---|---|---|
| 1 | VAR | param_1 | INT | 2500 | Non Retained | |

At this time, the tab name is "FB_1(fb1)".

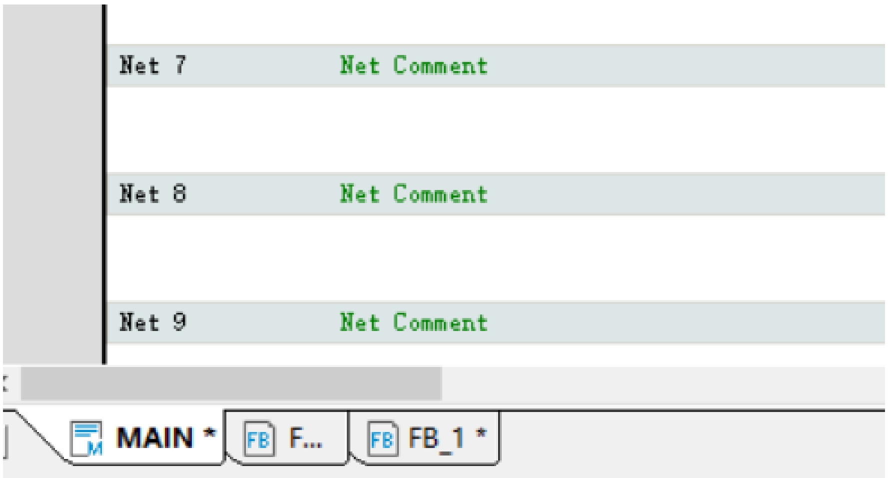
| NO. | I/O Type | Name | Data Type | Initial V... | Power Dow... | Comment |
|---|---|---|---|---|---|---|
| 1 | VAR | param_1 | INT | 11 | Non Retained | |
| 2 | VAR | fb1 | FB_1 | ... | Non Retained | |

Toolbox

| Variable Name | Initial Value | Type | Comment |
|---|---|---|---|
| fb1 | | FB_1 | |
| param_1 | 2500 | INT | |

### Tab at the Bottom of the FB View

The tab displayed at the bottom of the FB view contains the following information from left to right: node name, instance name, and unsaved flag. The node name is the name of the project tree node, and the instance name refers to the instance name in parentheses. The following figures show the details.



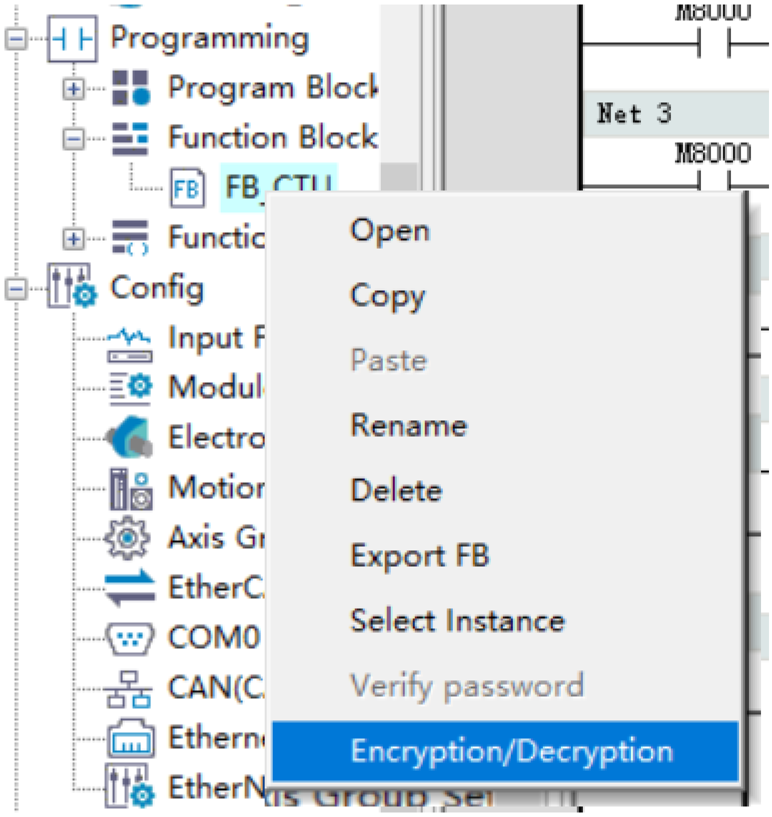

As shown in the preceding figure, "FB" is the node name, "var_1.fb1" is the instance name, and "*" indicates unsaved.

Since the tab needs to be parsed, characters including the period (.), asterisk (*), and parentheses (()) are not allowed when FBs and structures are renamed.

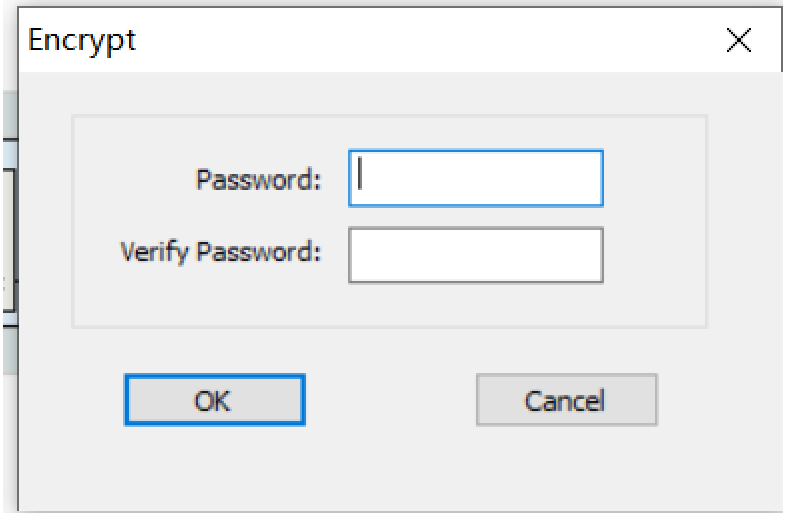
## 3.11.5 Encrypting FB or FC

This section takes encryption of function blocks as an example. The process is similar for encrypting functions. After encryption, the method of calling the function blocks or functions remains unchanged.

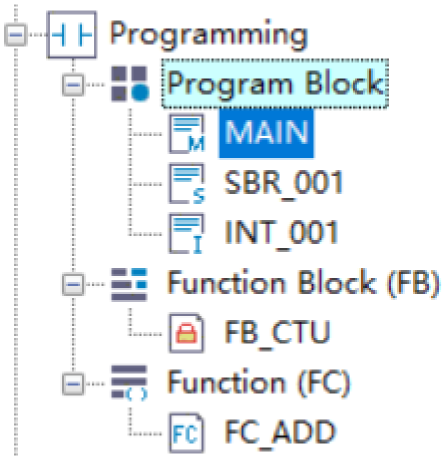
1. Choose "Programming" > "Function Block (FB)" in the project management window, right-click "FB", and choose "Encryption/Decryption".




2. Enter and confirm the password in the displayed "Encrypt" dialog box.

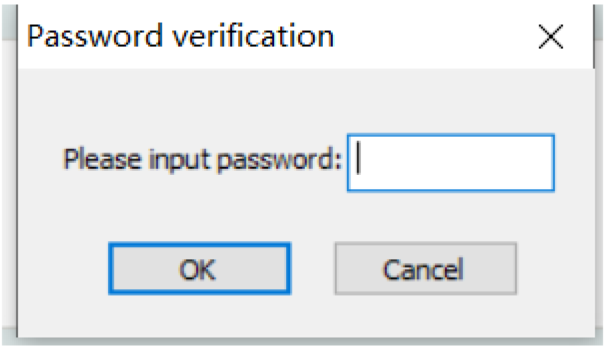



The following figure shows a function block after encryption.




Performing the preceding steps on an encrypted function block will decrypt it and restore it to its original unencrypted state.

To access an encrypted function block, you can double-click the encrypted node, or right-click the encrypted node and choose "Password verification" from the shortcut menu, and enter the correct password in the displayed dialog box.

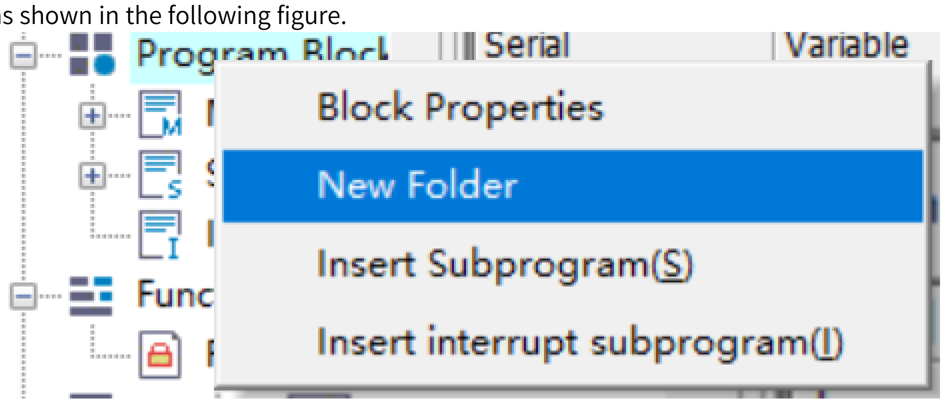



## 3.12 Folder

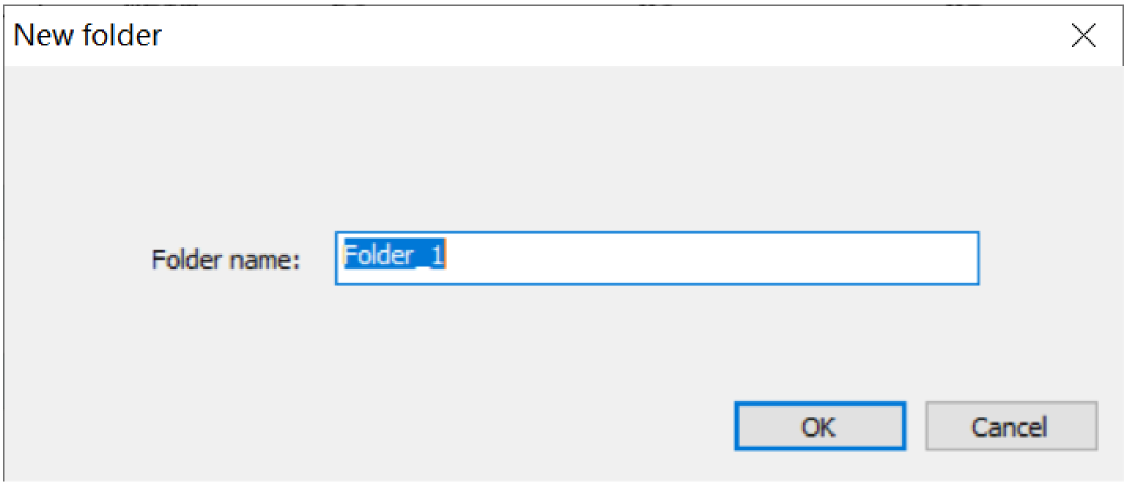
You can use folders to classify and batch operate program blocks, function blocks, and functions.

### Creating a folder

1. Right-click "POU", "Function block", or "Function", and select "New folder". For example, right-click "POU", as shown in the following figure.




2. In the "New folder" dialog box that is displayed, set "Folder name" and click "OK". A folder is created.



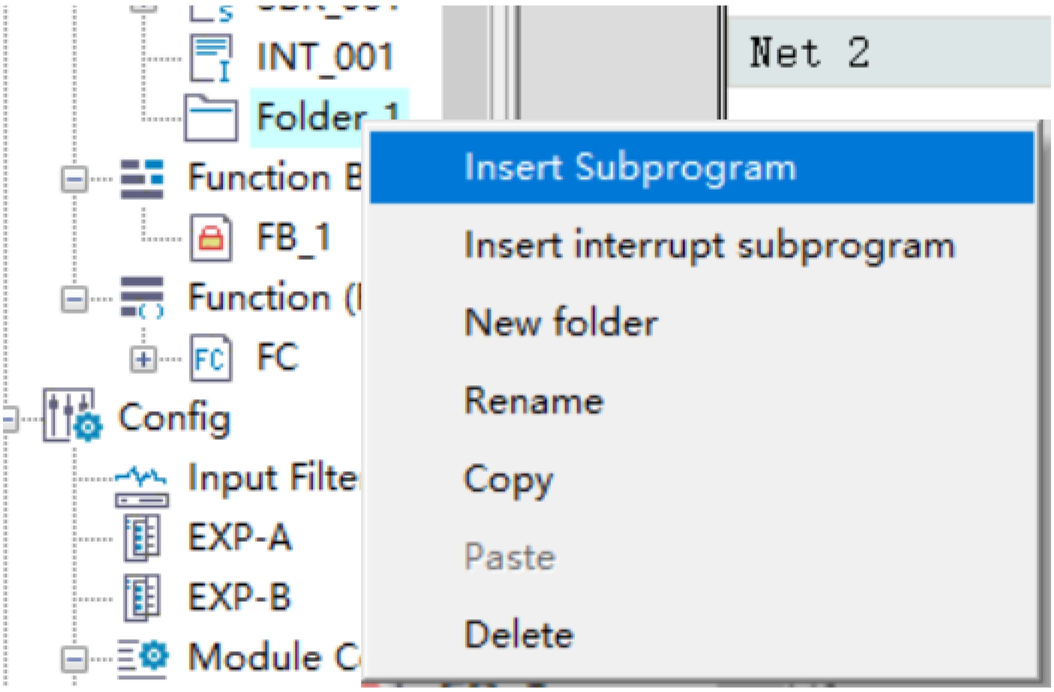

### *Note*

Nested folders can contain up to four levels. Each folder name must not:

- Be empty.
- Contain special characters such as space, asterisk (*), pipe (|), backslash (\), less-than sign (<), comma (,), period (.), forward slash (/), left parenthesis ((), right parenthesis ()), and question mark (?), or start with underscore (_), numbers, SYS, or _SYS_.
- Be the same as the name of any soft element forms, standard data types, instructions, or constants.
- Be any keywords such as ARRAY, TRUE, FALSE, ON, OFF, and NULL.
- Be the same as the name of any files or folders at the same level.

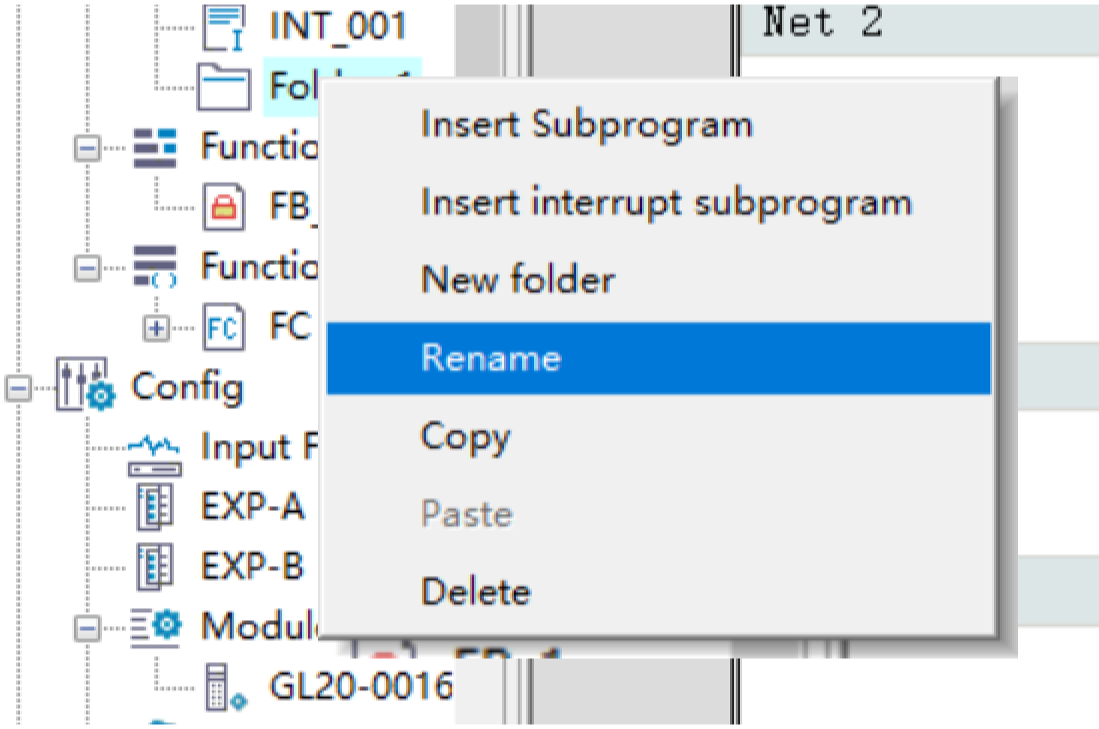
3. Right-click the new folder and select "Insert Subprogram" to add the new subprogram file.

   You can drag program files from other folders to a specified folder.

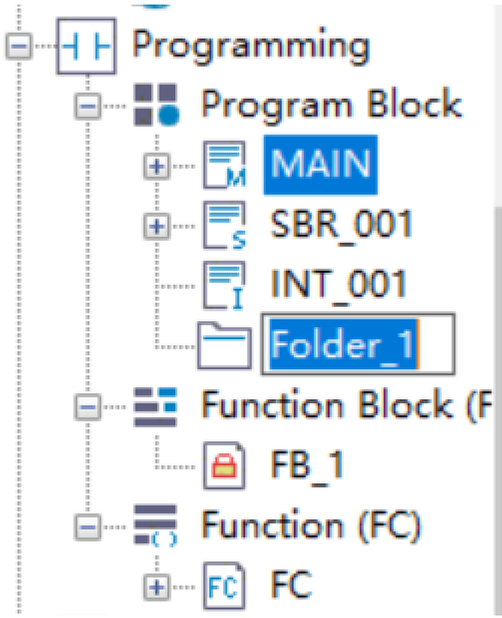



## Renaming a folder

1. Right-click a folder to be renamed and select "Rename", as shown in the following figure.

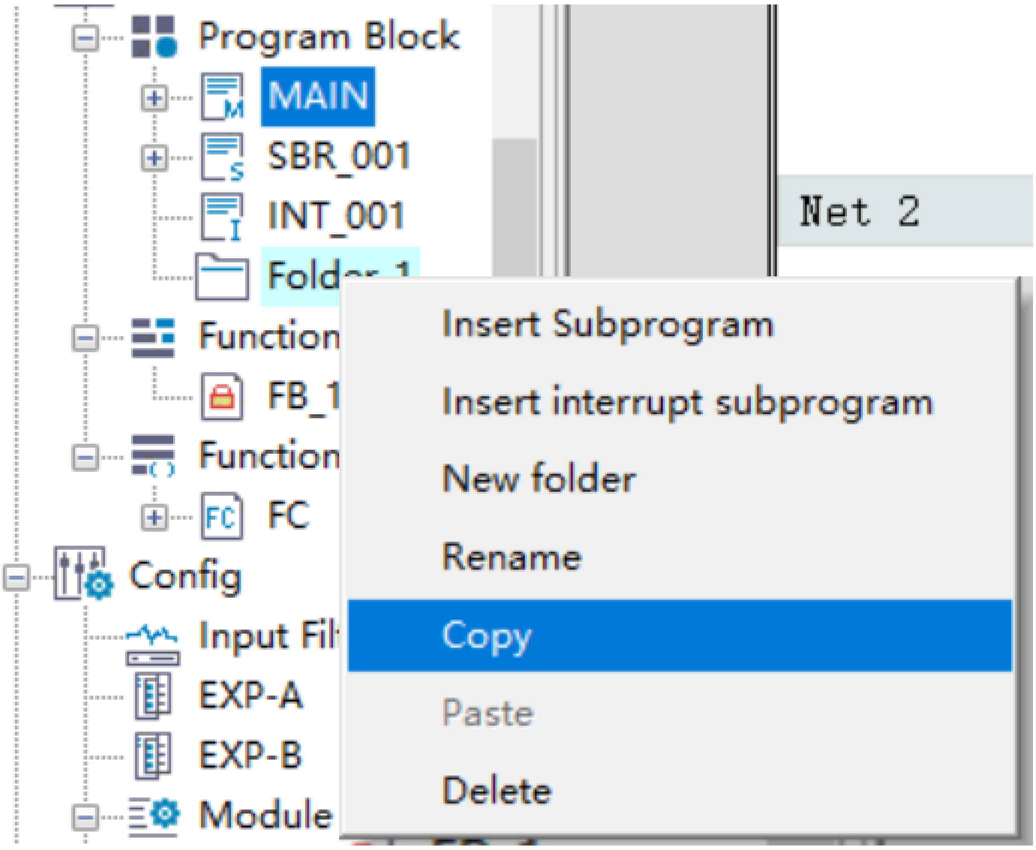



2. Enter the new folder name in the folder name text box and press "Enter", as shown in the following figure.




## Copying and pasting a folder

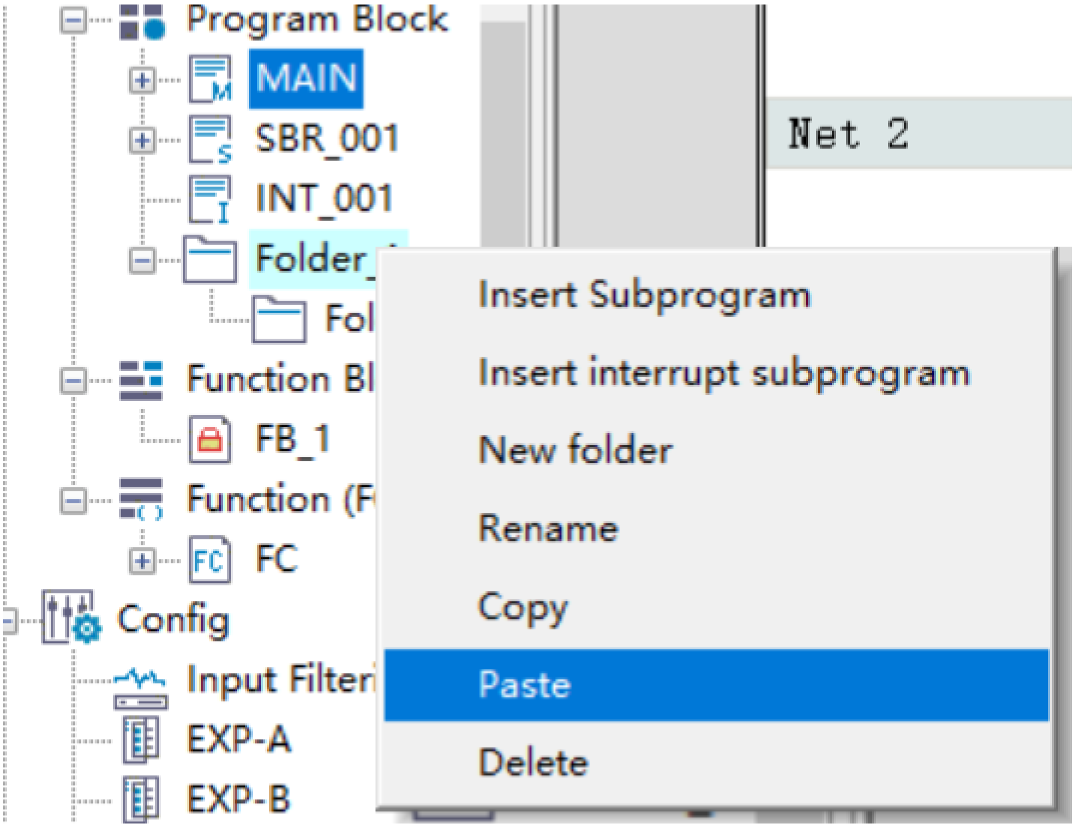
1. Right-click a folder to be copied and select "Copy" to copy the folder and the sub folders and files in the folder to the clipboard, as shown in the following figure.




Caution

Folders containing an encrypted program cannot be copied.

2. When the clipboard contains valid content, right-click the target node, and select "Paste" to paste the content in the clipboard to the target node, as shown in the following figure.

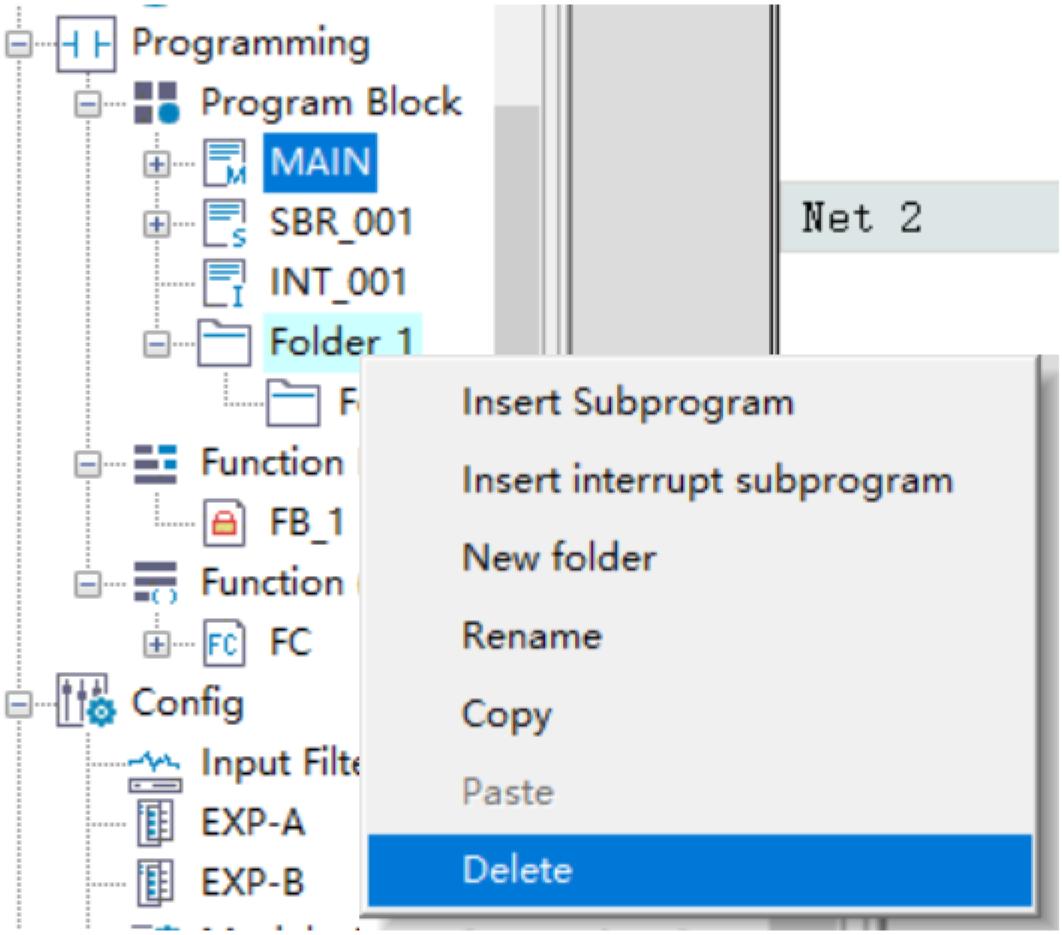



Caution

- Pasting fails when the target node contains a file or folder with the same name as the folder in the clipboard.
- Pasting fails if the target node and the folder in the clipboard will produce nested folders of more than four levels.

## Deleting a folder

1. Right-click a folder to be deleted and select "Delete", as shown in the following figure.




**Caution**

Folders containing an encrypted program cannot be deleted.

2. In the dialog box that is displayed, click "OK" to delete the selected folder and sub folders and files in the folder.

# 4 Programming Languages

## 4.1 Programming Language (LiteST)

### 4.1.1 Overview

LiteST is an high-level text-based programming language for automation systems. Its syntax structure is similar to that of PASCAL. It provides a simple standard structure to make programming fast and efficient. LiteST uses many traditional characteristics of high-level languages, including variables, operators, and control statements. LiteST provides a freer text-based programming mode than IL because extra placeholders are added to ensure a hierarchical structure of the program frame for easy reading and understanding. LiteST also provides easier migration and repeatability than graphical programming modes such as LD.

Example:

```
IF A>0 THEN
    X:=10;
ELSE
    X:=0;
END_IF;
```

***Note***

This function requires a firmware version of V5.14.0.0 or later for the H5U series, or a firmware version of V5.67.0.0 or later for the Easy series, and an AutoShop software version of V4.8.1.0 or later.

### 4.1.2 Expressions

Block diagrams of different functions are basic elements in the LD programming environment. Similar to LD, expressions are basic elements for LiteST. An expression consists of operators and operands. An operand can be a constant, a variable, a function call, or other expressions.

- Constant, such as 20, 1.43, and 16#10
- Variable, such as iVar and D0:E
- Function call, whose value is the return value of a call, such as Fun1(1,2,4)
- Other expressions: such as 10+3, var1 OR var2, (x+y)/z, and iVar1:=iVar2+22

In an expression, operands are evaluated using operators in sequence defined by a particular operator priority. Operators with top priority must be first used for evaluation. Other operators with lower priority are used by priority in descending order. Operators with the same priority must be used in order from left to right in the expression.

For example, if A, B, C, and D are INT variables and are set to 1, 2, 3, and 4 respectively, A+B-C*ABS(D) must be –9 and (A+B-C)*ABS(D) must be 0.

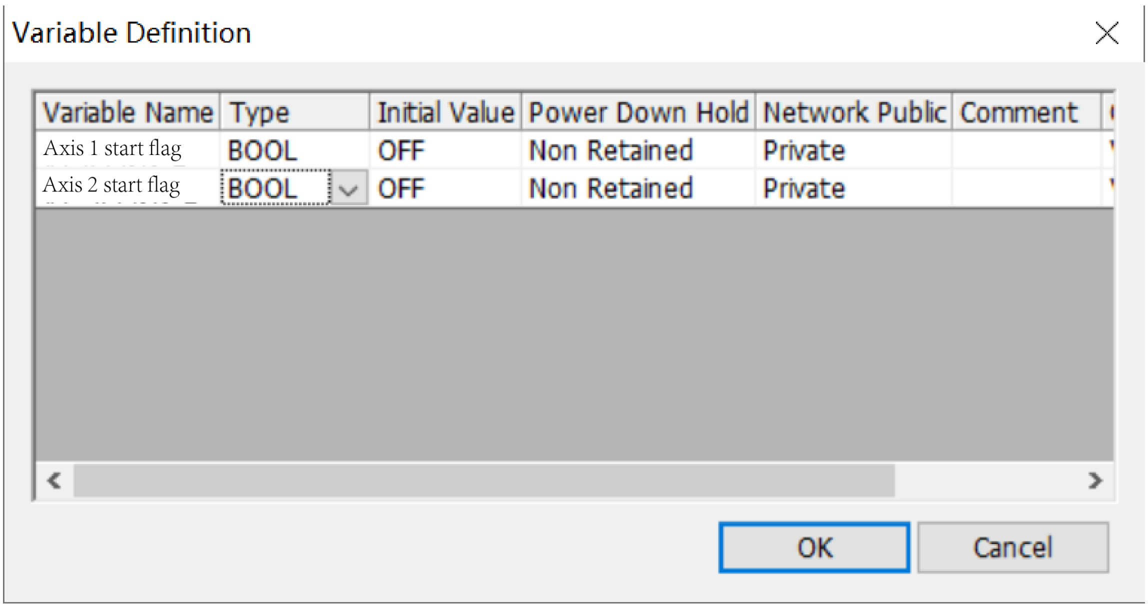
When an operator has two operands, the leftmost operand must be evaluated first. For example, in SIN (X)*COS(Y), SIN(X) must be evaluated first, then COS(Y), and finally the product of the overall expression.

Table 4–1 LiteST operators

| Operation Type | Sign | Example | Priority |
|---|---|---|---|
| Bracket | (Expression) | (A+B/C), (A+B)/C, A/(B+C) | 9 (highest) |
| Function call | Function name (separated by commas (,) in the parameter list) | LN(A), MAX(X,Y) | 8 |
| Opposite | - | -A | 7 |
| Unary plus (+) | + | +B | 7 |
| Negate | NOT | NOT C | 7 |
| Multiply | * | A*B | 6 |
| Divide | / | A/B | 6 |
| Modulo | MOD | A MOD B | 6 |
| Plus | + | A+B | 5 |
| Minus | - | A-B | 5 |
| Compare | <, >, <=, >= | A<B | 4 |
| Equal | = | A=B | 4 |
| Not equal | <> | A<>B | 4 |
| Logic AND | AND | A AND B | 3 |
| Logic XOR | XOR | A XOR B | 2 |
| Logic OR | OR | A OR B | 1 (lowest) |

## 4.1.3 Variables

You can compile variables during LiteST program editing and press Enter or click in the area outside the program basic block to display the variable definition box. The default variable type is INT. During a function call or an instruction call, the data type can be automatically identified.



LiteST supports various data types such as D, R, and W. For example, D0 s a 16-bit integer, DO:D is a 32-bit integer, and DO:E is a 32-bit floating-point number. The following figure shows the details.

```
//REAL TYPE
D0:E:=f_Test1;
//DINT TYPE
D2:D:=REAL_TO_DINT(f_Test1);
```

### 4.1.4 Constants

Constants can be expressed in may ways:

1. A constant is a decimal number by default, for example, a:=100.
2. A constant can contain underlines (_), for example, a:=10#100_10, a:=16#FF_AE_12, and a:=2#1100_1111_11_10, as shown in the following figure.
3. LiteST also allows LD expression as constants. That is, K100 indicates constant 100, H indicates a 16-bit number, and E indicates a floating-point number.

### 4.1.5 FB, FC, Subprogram, and Interrupt

FB: In terms of input parameters, only axis parameters are variables requiring pin input and other pins do not need to be input. In addition, output pins do not need to be input.

FC: Input parameter pins must be input. Otherwise, a compilation error is reported. Output parameters can be left empty.

Subprogram: A subprogram is called in non-parametric function format, for example, SBR_001().

Interrupt: Interrupts do not need to be manually called. EI() must be called to enable interrupts and DI () must be called to disable interrupts.

**Precautions**

- Up to eight hierarchies can be called for FB and FC nesting.
- Up to six hierarchies can be called for SBR nesting.

### 4.1.6 Intelligent Input and Prompts

#### 4.1.6.1 Quick Input

After entering the instruction name, press the tab key to complement the instruction pin. If the default parameter next to the pin is "???", the parameter must be input. Otherwise, the parameter can be input or not as required.

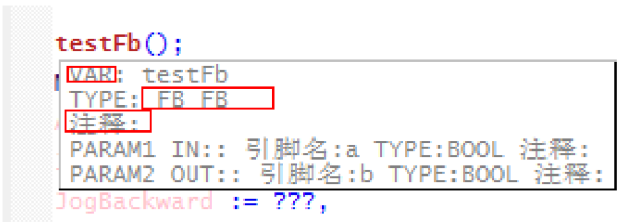
```
MC_Jog(Enable := ???,
    Axis := ???,
    JogForward := ???,
```

```
JogBackward := ???,
Velocity := ???,
Acceleration := ???,
Deceleration:= ,
CurveType:= ,
Busy => ,
CommandAborted => ,
Error => ,
ErrorID => );;
```

#### 4.1.6.2 Mouse Hover Prompt

When you hover the mouse over a variable, the variable name, type, and comment are displayed.

When you hover the mouse over an FB, FC, or instruction, the function name, function type, function comment, input and output parameters, pin name, type, and comment are displayed.




### 4.1.7 Syntax Instructions

#### 4.1.7.1 Overview

The overall LiteST program consists of instructions separated by semicolons (;).

Table 4–2 LiteST syntax instructions

| Instruction | Function | Example |
|---|---|---|
| := | Assignment | A := B |
| Function block call | Function block call and output | TONR(IN := b0,PT := dVar,R := b0,Q => ,ET => ); |
| IF | Selection | IF A>0 THEN<br>X:=10;<br>ELSE<br>X:=0;<br>END_IF; |

| Instruction | Function | Example |
|---|---|---|
| CASE | Multiway branch | CASE A OF<br>1: X:=1;<br>2: X:=2;<br>3: X:=3;<br>ELSE<br>X:=0;<br>END_CASE; |
| WHILE | WHILE loop | A := 0;<br>WHILE A <= 1000 DO<br>A := A+7;<br>END_WHILE; |
| REPEAT | REPEAT loop | A := 1;<br>TOTAL := 0;<br>REPEAT<br>TOTAL := TOTAL + A;<br>A := A+1;<br>UNTIL A>10<br>END_REPEAT; |
| FOR | FOR loop | FOR i:=0 TO 100 DO<br>X[i]:=0;<br>END_FOR; |
| EXIT | EXIT loop | EXIT; |
| CONTINUE | Interrupting the current loop | CONTINUE; |
| RETURN | Return | RETURN; |
| (*Text*) | Comment | (*Comment out multiple lines<br>IF A=3 THEN<br>  A:=5;<br>END_IF;<br>*) |
| //Text | Single-line comment | //A:=5; |
| ; | Empty statement | ; |

### 4.1.7.2 Assignment Instructions

In an assignment statement, the evaluation result of the expression is used to replace the current values of one or multiple element variables. An assignment statement must contain a variable reference on the left, followed by the assignment operator ":=" and then the evaluation expression.

Example:

A:=B*10

After execution, the value of A is 10 times the value of B.

#### 4.1.7.3 Function Block Calls

Syntax: FB instance name (FB input variable := value, FB output variable => value,... More FB input and output variables);

Example: After you call an instance of the function block with the maximum value evaluated (MAXFB), load input parameters D0 and D1 and the output parameter D2, and execute the function, the result is assigned to the variable maxVar.

MYFB(VAR1 := D0,VAR2 := D1,RESULT => D2);

maxVar := MYFB.RESULT;

---

***Note***

myFB is the functional block instance of MAXFB.

---

#### 4.1.7.4 IF

IF instructions are used to execute relevant statements according to the calculation result of condition expressions.

In IF select statements, only the statements where the condition expression value is boolean 1(TRUE) can be executed. If the condition is set to 0(FALSE), no statement is executed or the statements in the ELSE (or ELSIF) keyword conditions are executed.

1. ELSIF is not required if there is only one condition expression. In addition, ELSE is not required if the Boolean expression indicating no condition is met is not processed. For example:

```
IF condition expression THEN
        statement;
END_IF
```

2. One IF select statement can contain multiple ELSIF statements. For example:

```
IF condition expression 1 THEN
        statement;
ELSIF condition expression 2 THEN
        statement;
ELSIF condition expression 3 THEN
        statement;
ELSIF condition expression 4 THEN
        statement;
ELSE
        statement;
```

```
END_IF
```

3. IF select statements can be nested. Statement 11 is executed when the condition expressions 1 and 11 are TRUE.

```
IF condition expression 1 THEN
IF condition expression 11 THEN
        statement 11;
ELSIF condition expression 12 THEN
        statement 12;
ELSE
        statement 13;
END_IF
ELSIF condition expression 2 THEN
        statement 2;
ELSE
        statement 3;
END_IF
```

## Example

```
IF score <60 THEN
        bPass := FALSE;
ELSE
        bPass := TRUE;
END_IF
```

In the example, if the score is less than 60, the test fails. Otherwise, the test passes.

## Precautions

- An IF select statement consists of one IF, one THEN, and one END_IF at least.
- The keyword must be ELSIF rather then ELSEIF.
- In a condition expression, the keyword THEN is used to determine whether the expression ends.

### 4.1.7.5 CASE

## Functions and instructions

Statements to be executed are selected from multiple statements based on the value of the specified integral expression. An integral expression can be the return value of an INT variable, a DINT variable, an expression, or a function.

CASE integral expression OF

```
   Value 1: statement 1;
   Value 2: statement 2;
   Value 3, value 4: statement 3;
   Value 5, value 6: statement 4;
         :
   ELSE
statement 5;
END_CASE;
```

Like the program expressed by LiteST, CASE instructions can be processed as follows:

- If the value of an integral expression is value 1, statement 1 is executed;
- If the value of an integral expression is value 2, statement 2 is executed;
- If the value of an integral expression is value 3 or value 4, statement 3 is executed;
- If the value of an integral expression is value 5 or value 6, statement 4 is executed;
- Otherwise, statement 5 is executed.

CASE select statements can be nested. Statement 12 is executed when the value of integral expression 1 is value 1 and the value of integral expression 11 is value 2.

```
CASE integral expression 1 OF
    1 :
   CASE integral expression 11 OF
           1 : statement 11;
           2 : statement 12;
           ELSE
           statement 1m;
   END_CASE;
    2 : statement 2;
    3 : statement 3;
    ELSE
   statement n;
END_CASE;
```

## Example

```
CASE ERROR_CODE OF
    1:ERR_MSG := 'function lacking the right bracket';
    2:ERR_MSG := 'failure to process variables';
    3:ERR_MSG := 'invalid variable initial value';
```

```
    ...
    255:ERR_MSG := 'function lacking the right bracket';
    ELSE ERR_MSG := 'unknown error';
END_CASE
```

## Precautions

- In CASE statements, values of expressions must be integers.
- ELSE options are optional, and some programs can contain only the CASE...OF...END_CASE structure.

### 4.1.7.6 WHILE

## Functions and instructions

When the calculation result of a specified condition expression is TRUE, a statement is repeatedly executed.

In a sense, the WHILE loop and REPEAT loop functions are more powerful than the FOR loop function because cycle times do not need to be counted before loop execution. Therefore, only the WHILE loop and REPEAT loop are required in some cases. However, if the cycle times is clear, the FOR loop is better.

## Example

```
WHILE Counter<>0 DO
   Var1:= Var1*2;
   Counter := Counter-1;
END_WHILE
```

## Precautions

WHILE must be used with END_WHILE in pair.

### 4.1.7.7 REPEAT

## Functions and instructions

After a statement is executed once, repeat it before the value of the specified condition expression changes to TRUE. A REPEAT instruction requires statement running before condition expression evaluation. Therefore, the statement must be executed.

## Example

```
A := 1;
TOTAL := 0;
```

```
REPEAT
    TOTAL := TOTAL + A;
    A := A+ 1;
UNTIL A>10
END_REPEAT;
```

Numbers 1 to 10 are added together, and the result is used for the variable TOTAL.

## Precautions

REPEAT, UNTIL, and END_REPEAT are necessary.

### 4.1.7.8 FOR

## Functions and instructions

The FOR loop can be used to compile the iterative processing logic.

```
FOR control variable := Initial value TO Final value{BY incremental value} DO
      statement;
END_FOR;
```

In the preceding program,

Information in the braces is optional.

The control variable is the counter. The statement will be executed only if the value on the counter is not greater than the final value. Before statement execution, check this condition. If the initial value is greater than the final value, the statement will not be executed.

After the statement is executed the last time, the counter automatically increases the incremental value. An incremental value can be any integer. If the parameter is not set, the default value is 1. When the value on the counter is greater than the final value, the loop stops.

## Example

```
sumResult := 0;
factorial := 1;
FOR i :=1 TO 10 BY 1 DO
       sumResult := sumResult + i;
       factorial := factorial * i;
END_FOR;
```

In the preceding example, sumResult (result of adding 1 to 10) and the factorial result are calculated.

## Precautions

FOR must be used with END_FOR in pair.

### 4.1.7.9 EXIT

## Functions and instructions

An EXIT instruction is used to exit the FOR, WHILE, or REPEAT loop. The instruction interrupts iterative processing of the internal FOR, WHILE, or REPEAT instruction, and executes the next step of the iterative processing.

## Example

```
IF A THEN
    DATA[3] :=98;
    FOR n := 1 TO 50 BY 1 DO
        DATA[n] := DATA[n] + n;
        IF DATA[n] > 100 THEN EXIT;
        END_IF;
    END_FOR;
A :=FALSE;
END_IF;
```

In the preceding example, the variable value starts from n=1 and increases to 50 by 1 repeatedly to add n to the specified sorting variable DATA[n]. However, after the value of DATA[n] exceeds 100, the operation ends.

## Precautions

- This instruction must be used between FOR and END_FOR, WHILE and END_WHILE, or REPEAT and END_REPEAT.
- To interrupt all hierarchical iterative processing (nesting), the number of the EXIT instructions must be the same as that of hierarchies.

### 4.1.7.10 CONTINUE

## Functions and instructions

A CONTINUE instruction is used to end a FOR, WHILE, or REPEAT loop in advance and start the next loop. It is different to interrupt a loop and exit a loop. When you interrupt a loop, the loop is ignored and the next loop is executed.

## Example

```
FOR Counter:=1 TO 5 BY DO
    INT1:=INT1/2;
    IF INT1=0 THEN
        CONTINUE;
```

```
    END_IF
Var:=Var1/UBT1L
END_FOR;
```

## Precautions

This instruction must be used between FOR and END_FOR, WHILE and END_WHILE, or REPEAT and END_REPEAT.

### 4.1.7.11 RETURN

## Functions and instructions

This instruction forcibly ends main programs, subprograms, FBs, or FCs.

## Example

```
IF b=TRUE THEN
    RETURN;
END_IF;
a:=a+1;
```

If b is TRUE, the statement "a:=a+1;" will not be executed, and POU will be immediately returned.

## Precautions

If this instruction is frequently used, the process will be complex.

### 4.1.7.12 Comments

Structured text can be commented in two ways:

- Single-line comment: Start with "//", for example, "// This is a comment.".
- Multi-line comment: Start with "(*" and end with "*)", for example, "(*This is a comment.*)".

Comments can be added to the LiteST editor declaration or any part in implementation.

A comment can be nested in other comments.

## Example

```
(*
a:=inst.out; (*to be checked*)
b:=b+1;
*)
```

## 4.1.8 PLC Instructions Supported by LiteST

### 4.1.8.1 Basic Axis Control Instructions

| Instruction | Description |
|---|---|
| MC_Power | Enable |
| MC_Reset | Reset |
| MC_ReadStatus | Axis reading status |
| MC_ReadAxisError | Axis reading fault |
| MC_ReadDigitalInput | DI reading status |
| MC_ReadActualPosition | Reading the current position |
| MC_ReadActualVelocity | Reading the actual speed |
| MC_ReadActualTorque | Reading the actual torque |
| MC_SetPosition | Setting the current position |
| MC_TouchProbe | Probe |
| MC_MoveRelative | Relative positioning |
| MC_MoveAbsolute | Absolute positioning |
| MC_MoveVelocity | Speed instruction |
| MC_Jog | Jog |
| MC_TorqueControl | Torque control instruction |
| MC_Home | Homing instruction |
| MC_Stop | Stop instruction |
| MC_Halt | Pause (not recoverable) |
| MC_SetOverRide | Overshoot value reference |
| MC_MoveFeed | Interrupt positioning |
| MC_ImmediateStop | Emergency stop |
| MC_MoveVelocityCSV | CSV-based speed instruction with adjustable pulse width |
| MC_SyncMoveVelocity | CSV-based synchronous speed instruction supporting PWM |
| MC_FollowVelocity | CSP-based synchronous speed instruction |
| MC_MoveBuffer | Multi-position instruction |
| MC_MoveSuperImposed | Motion superimposition |
| MC_SyncTorqueControl | Sync torque control instruction |
| MC_SetAxisConfigPara | Setting axis parameters |
| MC_MoveLinear | Linear interpolation |
| MC_GroupStop | Stopping axis group operation |
| MC_MoveCircular | Circular interpolation |
| MC_GroupPause | Pausing axis group operation |

### 4.1.8.2 Cam and Gear Instructions

| Instruction | Description |
|---|---|
| MC_CamIn | Starting cam operation |
| MC_CamOut | Canceling cam operation |
| MC_Phasing | Master axis phase shift |
| MC_GenerateCamTable | Updating cam table |
| MC_SaveCamTable | Saving cam table |

| Instruction | Description |
| --- | --- |
| MC_GearIn | Starting gear operation |
| MC_GearOut | Canceling gear operation |
| MC_GetCamTablePhase | Obtaining cam table phase |
| MC_GetCamTableDistance | Obtaining cam table offset |
| MC_DigitalCamSwitch | Controlling electronic cam tappet |

### 4.1.8.3 Encoder Instructions

| Instruction | Description |
| --- | --- |
| HC_Counter | High-speed counter enable |
| HC_Preset | High-speed counter preset value |
| HC_TouchProbe | High-speed counter probe |
| HC_Compare | High-speed counter comparison |
| HC_ArrayCompare | High-speed counter array comparison |
| HC_StepCompare | High-speed counter equidistance comparison |
| ENC_SetUnit | Encoder axis setting gear ratio (valid only for the local encoder axis) |
| ENC_SetLineRotationMode | Encoder axis setting linearity rotation mode (valid only for the local encoder axis) |
| ENC_Counter | Encoder axis enable |
| ENC_Reset | Encoder axis fault reset (only for the bus encoder axis) |
| ENC_ResetCompare | Encoder axis reset comparison output (only for the bus encoder axis) |
| ENC_Preset | Encoder axis preset value |
| ENC_TouchProbe | Encoder axis probe |
| ENC_Compare | Encoder axis comparison output (only for the local encoder axis) |
| ENC_ArrayCompare | Encoder axis array comparison |
| ENC_StepCompare | Encoder axis step comparison |
| ENC_GroupArrayCompare | Encoder axis group array comparison (only for the bus encoder axis) |
| ENC_ReadStatus | Encoder axis read status (only for the bus encoder axis) |
| ENC_DigitalOutput | Encoder axis digital output control (only for the bus encoder axis) |

### 4.1.8.4 Communication Instructions

| Instruction | Description |
| --- | --- |
| ETC_ReadParameter_CoE | Read the SDO parameter of the ETC slave station |
| ETC_WriteParameter_CoE | Write the SDO parameter of the ETC slave station |
| ETC_RestartMaster | Restart the ETC master station |

### 4.1.8.5 Timer Instructions

| Instruction | Description |
| --- | --- |
| TPR | Pulse timer |
| TONR | Connection delay timer |

| Instruction | Description |
| --- | --- |
| TOFR | Off delay timer |
| TACR | Accumulation timer |

### 4.1.8.6 Interrupt Instructions

| Instruction | Description |
| --- | --- |
| EI | Enable interrupt |
| DI | Disable interrupt |

### 4.1.8.7 Operation Instructions

| Instruction Type | Instruction Description | Instruction Name |
| --- | --- | --- |
| Mathematical operation instruction | Modulo | MOD |
| Shift instruction | Bitwise left shift | SHL |
| | Bitwise right shift | SHR |
| Select instruction | Either one | SEL |
| | Maximum value | MAX |
| | Minimum value | MIN |
| Arithmetic operation instruction | Absolute value | ABS |
| | Square root | SQRT |
| | Natural logarithm | LN |
| | Common logarithm | LOG |
| | Power exponent | EXPT |
| | Sine function | SIN |
| | Cosine function | COS |
| | Tangent function | TAN |
| | Arcsine function | ASIN |
| | Arccosine function | ACOS |
| | Arctan function | ATAN |
| Word logic | And | AND |
| | Or | OR |
| | Not | NOT |
| | Exclusive OR | XOR |

| Instruction Type | Instruction Description | Instruction Name |
|---|---|---|
| Data type conversion | BOOL to INT | BOOL_TO_INT |
| | BOOL to DINT | BOOL_TO_DINT |
| | BOOL to REAL | BOOL_TO_REAL |
| | INT to REAL | INT_TO_REAL |
| | INT to DINT | INT_TO_DINT |
| | INT to BOOL | INT_TO_BOOL |
| | DINT to REAL | DINT_TO_REAL |
| | DINT to INT | DINT_TO_INT |
| | DINT to BOOL | DINT_TO_BOOL |
| | REAL to DINT | REAL_TO_DINT |
| | REAL to INT | REAL_TO_INT |
| | REAL to BOOL | REAL_TO_BOOL |
| | To BOOL | TO_BOOL |
| | To INT | TO_INT |
| | To DINT | TO_DINT |
| | To floating-point number | TO_REAL |

### 4.1.8.8 Other Instructions

| Instruction | Description |
|---|---|
| ZSET | Batch setting |
| ZRST | Batch reset |
| BITW | 16-Bit variable conversion to word variable |
| WBIT | Word variable conversion to 16-bit variable |
| MSET | Memory setting |
| MCPY | Member reset |
| R_TRIG | Rising edge inspection trigger |
| F_TRIG | Falling edge inspection trigger |

### 4.1.8.9 Instruction Examples

## Use examples of axis control instructions

**MC_Power use example:**

```
MC_Power(Enable := b0, //
    Axis := Axis_0, //Axis name/ID
    Status => b4, //Axis enable flag
    Busy => b6, //Busy flag
    Error => b8, //Instruction fault flag
    ErrorID => d0); //Fault code
```

**MC_Jog use example:**

```
MC_Jog(Enable := b0, //
    Axis := Axis_0, //Axis name/ID
    JogForward := b1, //Forward motion, with the valid level for rising edge trigger
```

JogBackward := b2, //Reserve motion, with the valid level for rising edge trigger

Velocity := d0:E, //Target speed

Acceleration := d2:E, //Acceleration rate

Deceleration := d4:E, //Deceleration rate

CurveType := d6, //Curve type. 0: T-type speed curve; 1: Five-segment running curve

Busy => b3, //Busy flag

CommandAborted => b4, //Execution termination

Error => b5, //Instruction fault flag

ErrorID => d8); //Fault code

### Use examples of mathematical operation functions

**Max use example**
c:=MAX(a,b);

### Use examples of other instructions

**R_TRIG (rising edge) use example**
(*If X0 changes from FALSE to TRUE, the rising edge trigger.Q is TRUE. Execute the M0 assignment statement in the if statement. Otherwise, do not execute the statement.*)

Rising edge trigger(CLK := X0,Q => );

if rising edge trigger.Q THEN

M0:=TRUE;

END_IF;

**F_TRIG (falling edge) use example**
(*If B0 changes from TRUE to FALSE, the falling edge trigger.Q is TRUE. Execute the M0 assignment statement in the if statement. Otherwise, do not execute the statement.*)

Falling edge trigger(CLK := B0,Q => );

if falling edge trigger.Q THEN

M0:=TRUE;

END_IF;

## 4.1.9 Exception Protection and Handling

### 4.1.9.1 Division-by-zero Protection

If the divisor is 0, it automatically changes to 1.

The following figure shows the details.

```
// The divisor 0 will be replaced by 1 automatically.
i_Test2 [0] :=0;
f_Test1 [10.12300] :=f_Test1 [10.12300] /i_Test2 [0] ;
```

The PLC LED alternatively flashes Er50 and Er81.

#### 4.1.9.2 Array Out-of-bounds

Array out-of-bounds is automatically checked during compilation for constants and during running for variables. Values over the upper limit are stored in the element with the maximum subscript in the array, and values below the lower limit are stored in the element with the subscript 0 in the array. BOOL arrays are not checked for out-of-bounds currently.

As shown in the following figure, an INT array is defined with up to 10 elements. In case of out-of-bounds, the software reports an error and stores the values out of the range to the element with the subscript (9) in the array.

MAIN
SBR_AxisCtrl
SBR_LogicProgram
INT_001

```
//D
//
i_Test4 [120] :=120;
f_Test2 [120.0000] :=i_Test4 [120] ;
i_Test5 [17945] :=i_Test5 [17945] +1;
// The divisor 0 is automatically replaced by 1.
i_Test2 [0] :=0;
f_Test1 [10.12300] :=f_Test1 [10.12300] /i_Test2 [0] ;

////Array out-of-bounds
FOR i [21] :=0 TO 20 BY 1 DO
    arr1[i [21] ] [NULL] :=i [21] +1;;
END_FOR;
```

Information output window

| | Element Name | Data Type | Display format | Current Value | Comment |
|---|---|---|---|---|---|
| 44 | arr1 | INT[10] | Dec | | |
| 45 | arr1[0] | INT | Dec | 1 | |
| 46 | arr1[1] | INT | Dec | 2 | |
| 47 | arr1[2] | INT | Dec | 3 | |
| 48 | arr1[3] | INT | Dec | 4 | |
| 49 | arr1[4] | INT | Dec | 5 | |
| 50 | arr1[5] | INT | Dec | 6 | |
| 51 | arr1[6] | INT | Dec | 7 | |
| 52 | arr1[7] | INT | Dec | 8 | |
| 53 | arr1[8] | INT | Dec | 9 | |
| 54 | arr1[9] | INT | Dec | 21 | |
| 55 | ... | | | | |

The PLC LED alternatively flashes Er50 and Er80.

#### 4.1.9.3 Infinite Loop

The program is automatically checked for an infinite loop. In case of an infinite loop, an error is reported, the infinite loop is automatically displayed, and the program stop running. The fault diagnosis page shows the error information and the error is located.

The PLC LED alternatively flashes Er1500 and Er5082.

In the error information, Er1500 indicates watchdog timeout and Er5082 indicates an infinite loop alarm.

#### 4.1.9.4 Array Subscript Considerations

- The subscript of a constant array cannot exceed the array size.
- The subscript of an array cannot be a soft element.
- The subscript of an array in an FB or FC cannot be a global variable.
- The subscript of an array cannot be an expression.
- A variable with a complex structure can contain up to only one variable array sub-index.

## 4.2 Programming Language (LD)

LD is a graphical programming language. Its structure is similar to that of the circuit diagram. LD contains a series of networks (also called nodes), and each network starts from the vertical line on the left (the power rail and power flow line). A network consists of points of contact, coils, arithmetic blocks (functions, function blocks, programs, execution blocks, actions, and methods), jump instructions, labels, and connecting wires.

LD mainly includes points of contact, coils, arithmetic blocks, branches, and comments. These elements are inserted, dragged, scribed, and copied and pasted to networks to form the LD execution logic.

LD provides online commissioning functions such as monitoring, written values, force values, and breakpoints.

For details about the LD programming language, see the "AutoShop.chm". To obtain the manual, you can choose "Help" > "Help Manual" in the AutoShop menu bar and double-click "AutoShop.chm" in the "Manual" folder.

## 4.3 Programming Language (SFC)

SFC is a novel graphic programming language for programming according to the process flow. The icons or menu items for all SFC elements can be found in the SFC toolbar and SFC menu. You can click a specified icon to enter the required element, and set properties of the specified SFC element in the SFC input dialog box. The SFC toolbar and menu also provide shortcuts to add connecting wires. You can establish connections between SFC elements as required.

For details about the SFC programming language, see the "AutoShop.chm". To obtain the manual, you can choose "Help" > "Help Manual" in the AutoShop menu bar and double-click "AutoShop.chm" in the "Manual" folder.

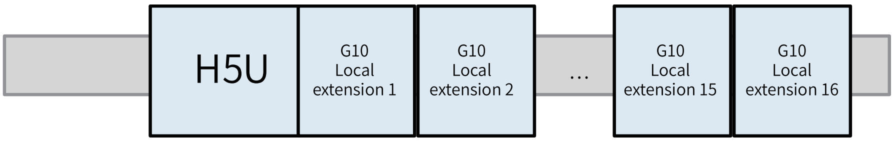
# 5 Extension Modules

## 5.1 H5U Local Extension Modules

### 5.1.1 Overview

H5U can carry up to 16 local extension modules, and can access local extension based on module configuration.

The following figure shows the hardware configuration for H5U to connect to local extension modules.



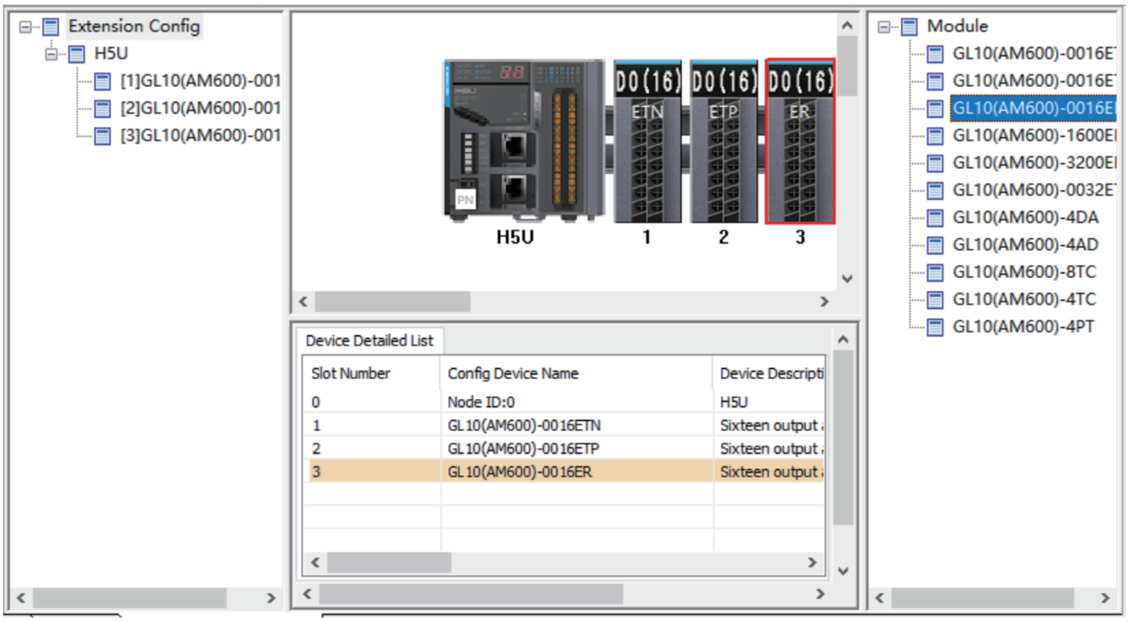

The following table lists the supported models of local extension modules.

| Product | Description |
|---|---|
| GL10-0016ETP | 16 digital output (DO) transistor module - PNP |
| GL10-0016ETN | 16 DO transistor module - NPN |
| GL10-0016ER | 16 DO relay module |
| GL10-1600END | 16 digital input (DI) module |
| GL10-3200END | 32 digital input (DI) module |
| GL10-0032ETN | 32 DO module |
| GL10-4AD | 4 analog input (AI) module |
| GL10-4DA | 4 analog output (AO) module |
| GL10-4PT | 4-in resistance temperature detector (RTD) module |
| GL10-4TC | 4-in thermocouple temperature detection (TC TEMP MEAS) module |
| GL10-8TC | 8-in TC TEMP MEAS module |

### 5.1.2 Configuring Hardware

Local extension modules are implemented by hardware configuration. To configure hardware, perform the following steps:

1. In the "Project Manager" tree, unfold "Config" and double-click "Module Config". The "Extension Config" page is displayed.



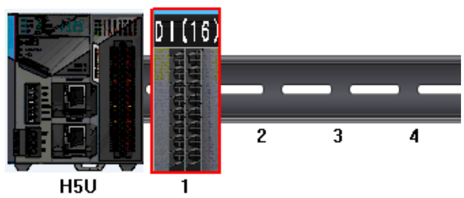

2. Click the position number of an extension module on the guide rail, double-click the module on the right or drag and move the module to the guide rail, and configure the extension module.

## 5.1.3 Configuring Extension Modules

### 5.1.3.1 DI Modules

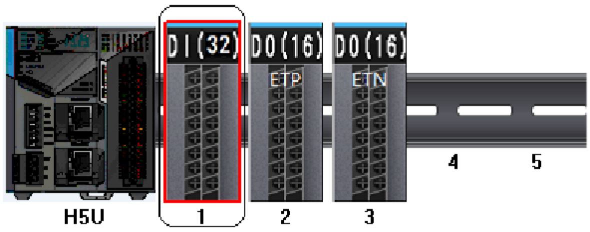
DI modules included GL10-1600END and GL10-3200END. The method of using a DI module as a local extension module is as follows:

1. In the module list, select a module to be added, and double-click the module for automatic extension on the extension rack, or drag the module to the extension rack.

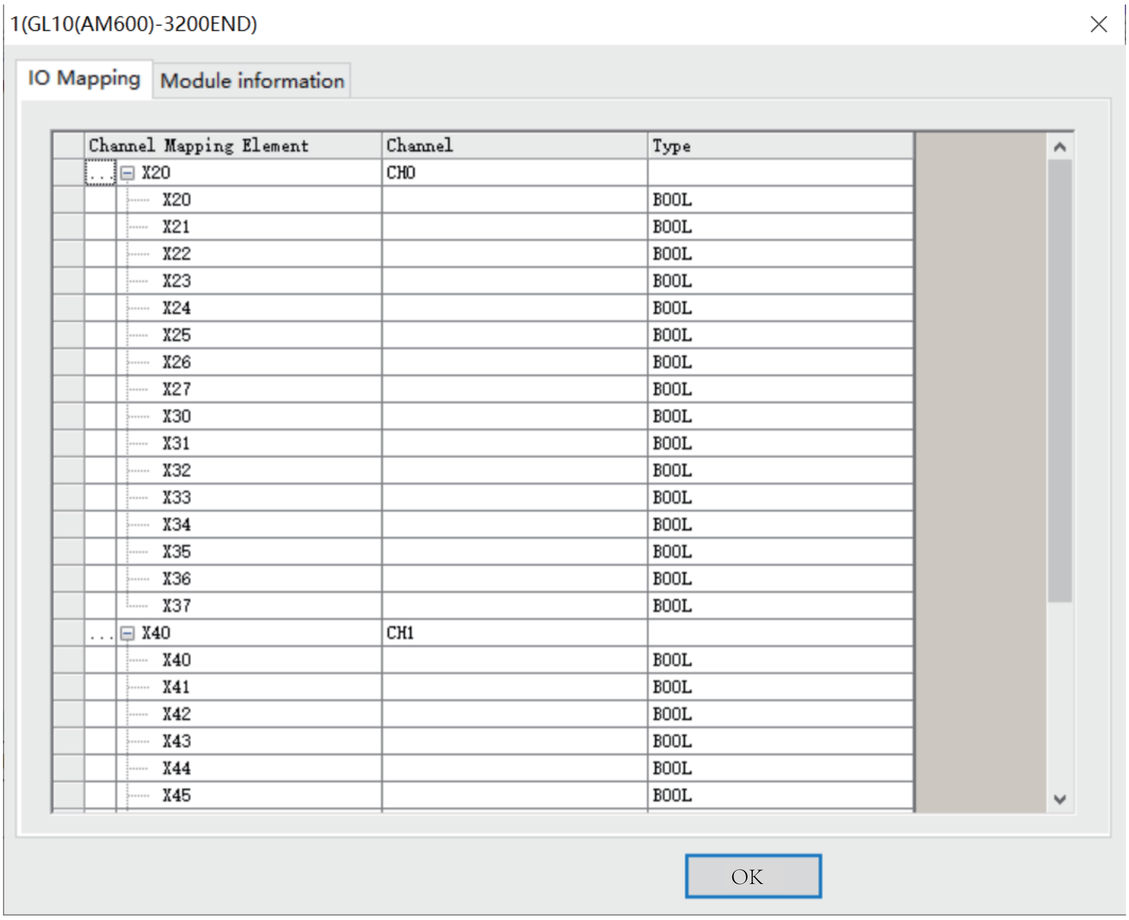



2. After local DI extension modules are connected to the master module without port configuration, numbers of input X ports on the extension modules follow the number of the input X port on the master module in sequence.
   For example, if the master module is a general H5U model, and number of the last X port on the master module is X37 after GL10-1600END connection, numbers of 16 input X ports on the extension module range from X40 to X47 and X50 to X57 during programming. This also applies to other DI extension modules by analogy.

   H5U series PLCs allow manual configuration of port numbers. You can double-click a module on the module configuration page to access the port configuration page.

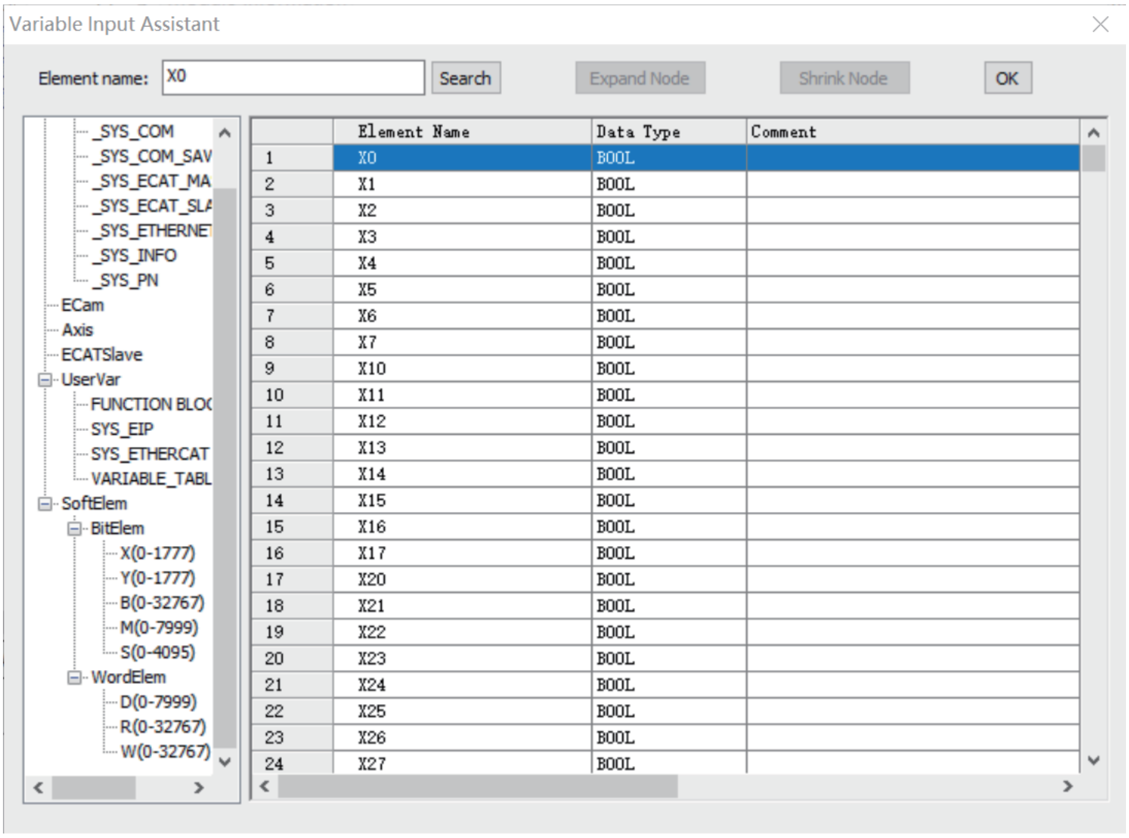



Use module 1 as an example. Double-click module 1 to access the module configuration page.




| Channel Mapping Element | Channel | Type |
|---|---|---|
| X20 | CH0 | |
| X20 | | BOOL |
| X21 | | BOOL |
| X22 | | BOOL |
| X23 | | BOOL |
| X24 | | BOOL |
| X25 | | BOOL |
| X26 | | BOOL |
| X27 | | BOOL |
| X30 | | BOOL |
| X31 | | BOOL |
| X32 | | BOOL |
| X33 | | BOOL |
| X34 | | BOOL |
| X35 | | BOOL |
| X36 | | BOOL |
| X37 | | BOOL |
| X40 | CH1 | |
| X40 | | BOOL |
| X41 | | BOOL |
| X42 | | BOOL |
| X43 | | BOOL |
| X44 | | BOOL |
| X45 | | BOOL |

Click "..." to configure the port number as required.




## *Note*

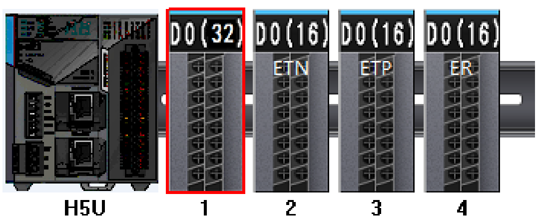
The port mapping of the H5U module is determined by the configuration. If there is no special configuration, the software arranges the port mapping in order. Even if the front-end module is deleted after the configuration is completed, the port mapping of the subsequent modules will not change.

The relay output extension module can be connected to the relay or transistor main module. Similarly, the transistor input extension module can be connected to the transistor or relay main module.

### 5.1.3.2 DO Modules

DO modules include GL10-0016ETP, GL10-0016ETN, GL10-0016ER, and GL10-0032ETN. The method of using a DO module as a local extension module is as follows:

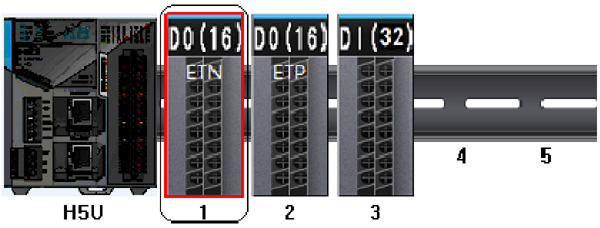
1. In the module list, select a module to be added, and double-click the module for automatic extension on the extension rack, or drag the module to the extension rack.




2. After local DO extension modules are connected to the master module, numbers of output Y ports on the extension modules follow the number of the Y port on the master module in sequence.

For example, if the master module is a general H5U model, and number of the last Y port on the master module is Y37 after GL10-0016END connection, numbers of 16 output Y ports on the extension module range from Y40 to Y47 and Y50 to Y57 during programming. This also applies to other DO extension modules by analogy.

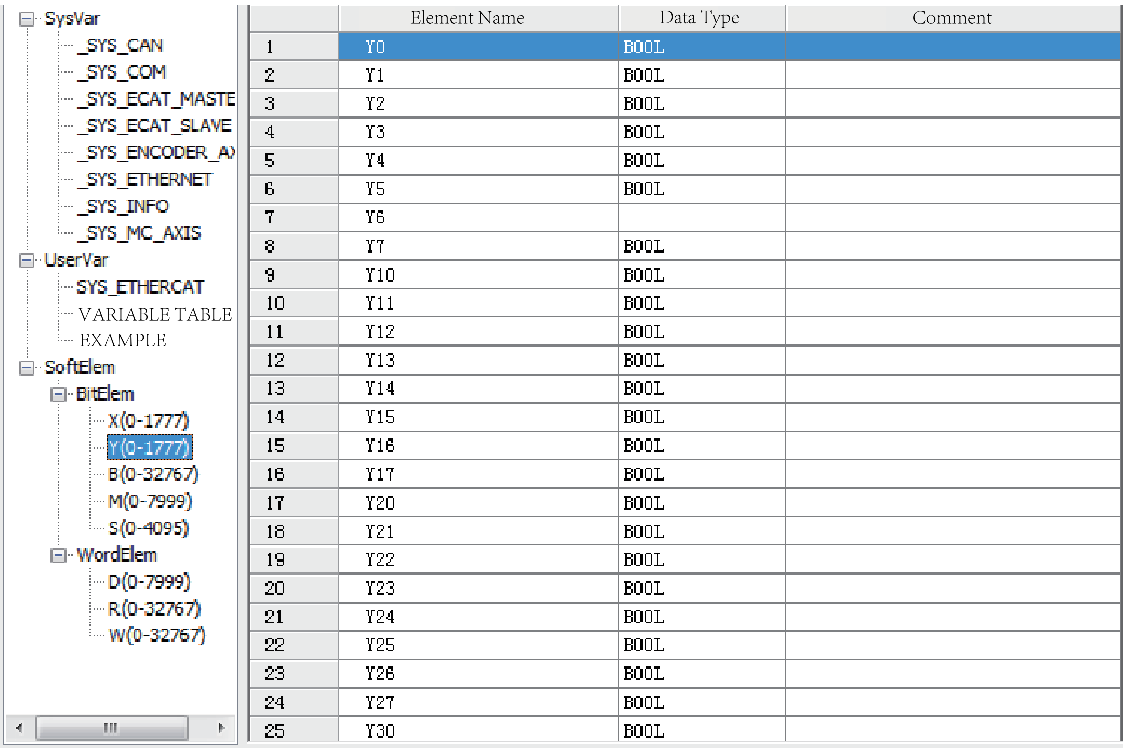
H5U series PLCs allow manual configuration of port numbers. You can double-click a module on the module configuration page to access the port configuration page.




Use module 1 as an example. Double-click module 1 to access the module configuration page.

| | | | |
|---|---|---|---|
| ... | Y20 | CH0 | BOOL |
| | Y20 | | BOOL |
| | Y21 | | BOOL |
| | Y22 | | BOOL |
| | Y23 | | BOOL |
| | Y24 | | BOOL |
| | Y25 | | BOOL |
| | Y26 | | BOOL |
| | Y27 | | BOOL |
| | Y30 | | BOOL |
| | Y31 | | BOOL |
| | Y32 | | BOOL |
| | Y33 | | BOOL |
| | Y34 | | BOOL |
| | Y35 | | BOOL |
| | Y36 | | BOOL |
| | Y37 | | BOOL |

Click "..." to configure the port number as required.




| | Element Name | Data Type | Comment |
|---|---|---|---|
| 1 | Y0 | BOOL | |
| 2 | Y1 | BOOL | |
| 3 | Y2 | BOOL | |
| 4 | Y3 | BOOL | |
| 5 | Y4 | BOOL | |
| 6 | Y5 | BOOL | |
| 7 | Y6 | | |
| 8 | Y7 | BOOL | |
| 9 | Y10 | BOOL | |
| 10 | Y11 | BOOL | |
| 11 | Y12 | BOOL | |
| 12 | Y13 | BOOL | |
| 13 | Y14 | BOOL | |
| 14 | Y15 | BOOL | |
| 15 | Y16 | BOOL | |
| 16 | Y17 | BOOL | |
| 17 | Y20 | BOOL | |
| 18 | Y21 | BOOL | |
| 19 | Y22 | BOOL | |
| 20 | Y23 | BOOL | |
| 21 | Y24 | BOOL | |
| 22 | Y25 | BOOL | |
| 23 | Y26 | BOOL | |
| 24 | Y27 | BOOL | |
| 25 | Y30 | BOOL | |

***Note***

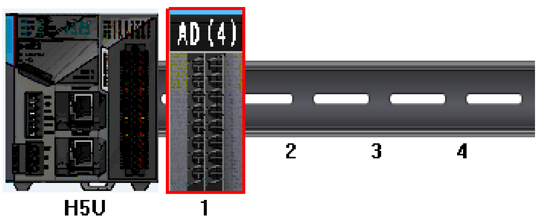
The port mapping of the H5U module is determined by the configuration. If there is no special configuration, the software arranges the port mapping in order. Even if the front-end module is deleted after the configuration is completed, the port mapping of the subsequent modules will not change.

The relay output extension module can be connected to the relay or transistor main module. Similarly, the transistor input extension module can be connected to the transistor or relay main module.

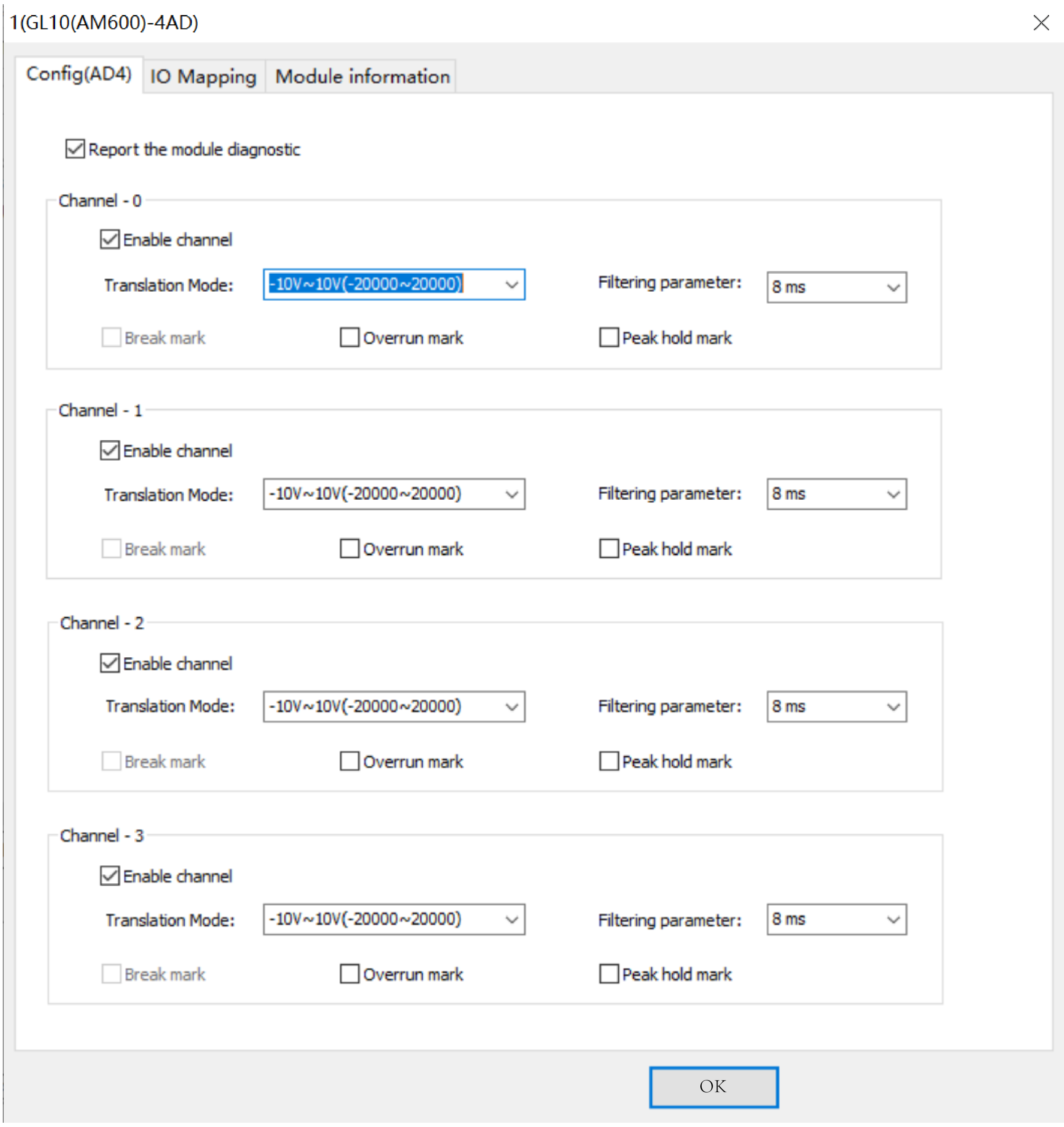
### 5.1.3.3 AI Modules

The method of using the GL10-4AD AI module as a local extension module is as follows:

1. In the module list, select a module to be added, and double-click the module for automatic extension on the extension rack, or drag the module to the extension rack.




2. Double-click the GL10-4AD module on the rack. The page shown in the following figure is displayed.



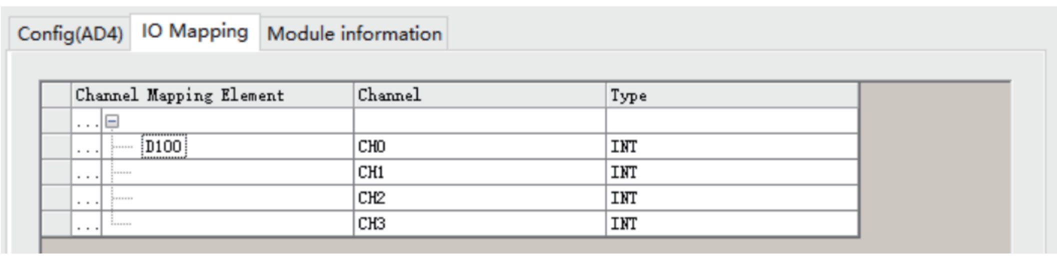

① Determine whether to select "Enable channel". If not, deselect it to save the scanning time.

② Select the corresponding span and resolution.

③ Set "Filtering parameter" to a value in the range of 1 ms to 255 ms.

④ Leave the auxiliary function items empty.

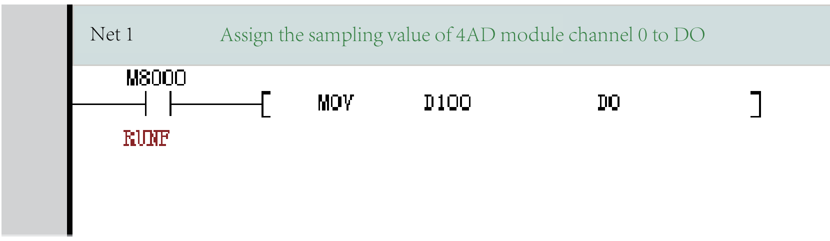
3. On the "IO Mapping" tab page, map CH0 of the 4AD module to the D element D100. In H5U, you can also map the module to a customized variable.



The following table lists the relationships between the mapped variables and actual input analog values.

| Input Type | Rated Input Range | Rated Digital Value | Input Limit Range | Digital Value Limit |
|---|---|---|---|---|
| Analog voltage input | –10 V to +10 V | –20000 to +20000 | –11 V to +11 V | –22000 to +22000 |
| | 0 V to 10 V | 0 to 20000 | –0.5 V to +10.5 V | –1000 to +21000 |
| | –5 V to +5 V | –20000 to +20000 | –5.5 V to +5.5 V | –22000 to +22000 |
| | 0 V to 5 V | 0 to 20000 | –0.25 V to +5.25 V | –1000 to +21000 |
| | 1 V to 5 V | 0 to 20000 | 0.8 V to 5.2 V | –1000 to +21000 |
| Analog current input | –20 mA to +20 mA | –20000 to +20000 | –22 mA to +22 mA | –22000 to +22000 |
| | 0 mA to 20 mA | 0 to 20000 | –1 mA to +21 mA | –1000 to +21000 |
| | 4 mA to 20 mA | 0 to 20000 | 3.2 mA to 20.8 mA | –1000 to +21000 |

4. Use the LD programming language to program AD sampling, and assign the voltage sampling value of CH0 from D100 to D0.

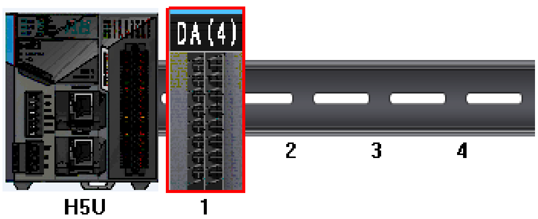



5. After compilation succeeds, download and run the project.

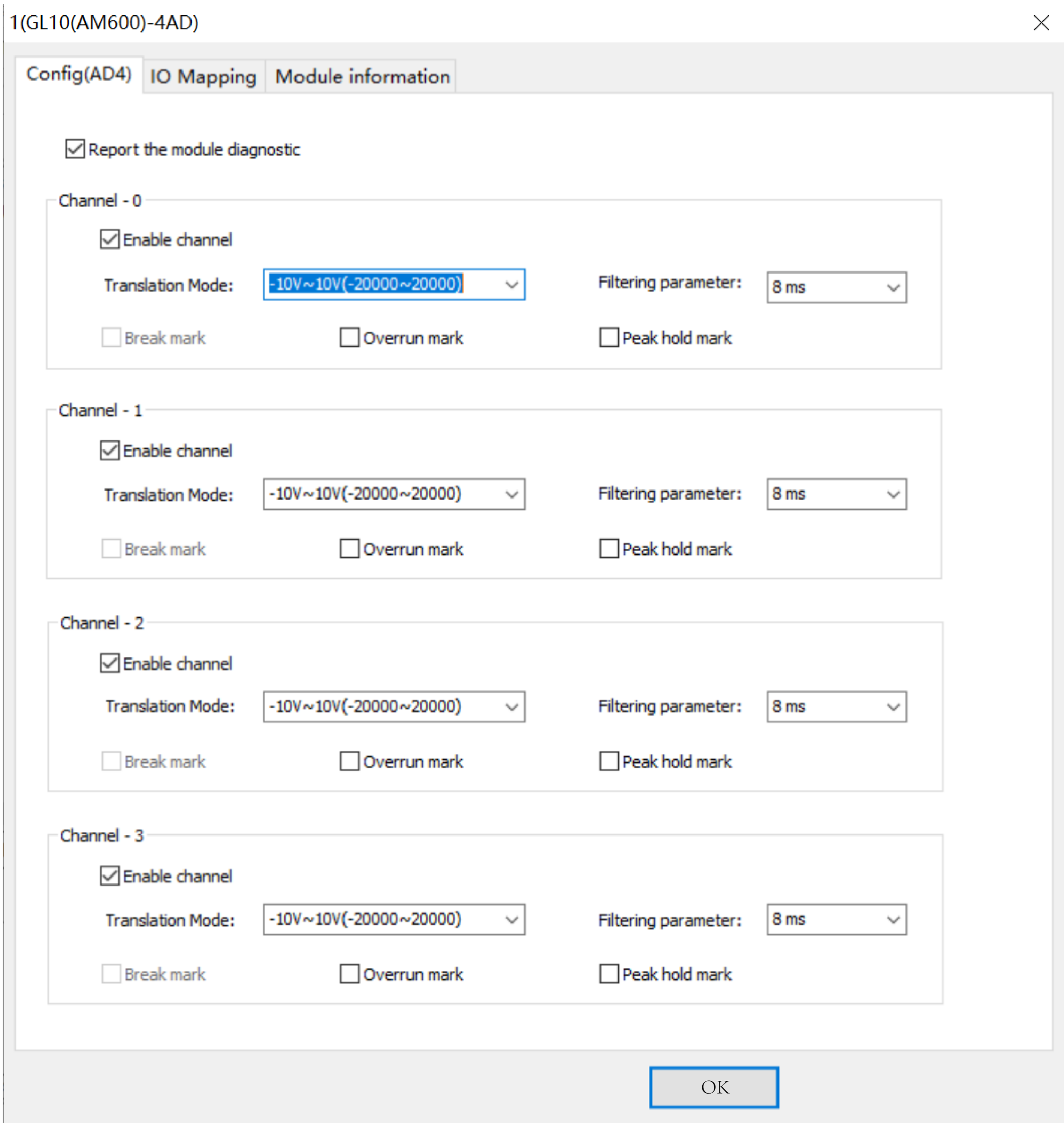
### 5.1.3.4 AO Modules

The method of using the GL10-4DA AO module as a local extension module is as follows:

1. In the module list, select a module to be added, and double-click the module for automatic extension on the extension rack, or drag the module to the extension rack.




2. Double-click the GL10-4DA module on the rack. The "Config(DA4)" tab page is displayed, as shown in the following figure.

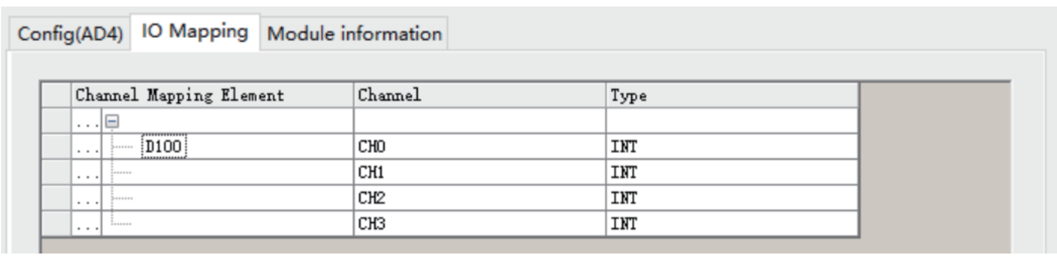



① Determine whether to select "Enable channel". If not, deselect it to save the scanning time.

② Set "Translation Mode" to select the output type and range.

③ Set "Output state after Stopping" to "Output zero", "Output Holding", or "Output preset" when the PLC is in the Stop state.

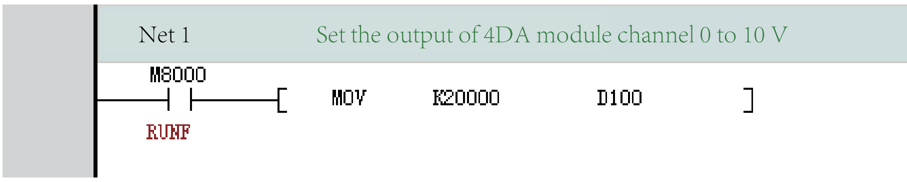
3. On the IO mapping page, map CH0 of the 4DA module to the D element D100. In H5U, you can also map the module to a customized variable.




The following table lists the relationships between the mapped variables and actual output analog values.

| Output type | Rated Output Range | Rated Digital Value | Output Limit Range | Digital Value Limit |
|---|---|---|---|---|
| Analog voltage output | –10 V to +10 V | –20000 to +20000 | –11 V to +11 V | –22000 to +22000 |
| | 0 V to 10 V | 0 to 20000 | –0.5 V to +10.5 V | –1000 to +21000 |
| | –5 V to +5 V | –20000 to +20000 | –5.5 V to +5.5 V | –22000 to +22000 |
| | 0 V to 5 V | 0 to 20000 | –0.25 V to +5.25 V | –1000 to +21000 |
| | 1 V to 5 V | 0 to 20000 | 0.8 V to 5.2 V | –1000 to +21000 |
| Analog current output | 0 mA to 20 mA | 0 to 20000 | 0 mA to 21 mA | 0 to 21000 |
| | 4 mA to 20 mA | 0 to 20000 | 3.2 mA to 20.8 mA | –1000 to +21000 |

4. Use the LD programming language to program the DA output. The digital values corresponding to –10 V to +10 V are –20000 to +20000, so the value 20000 is assigned for D0 and the output voltage of CH0 is +10 V.



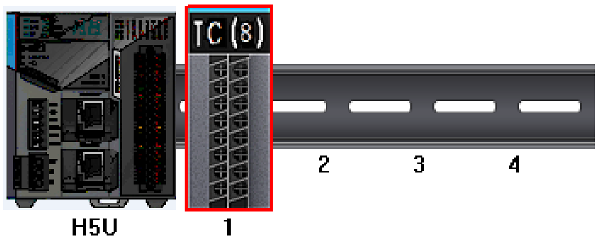

5. After compilation succeeds, download and run the project.

### 5.1.3.5 Temperature Detection Modules

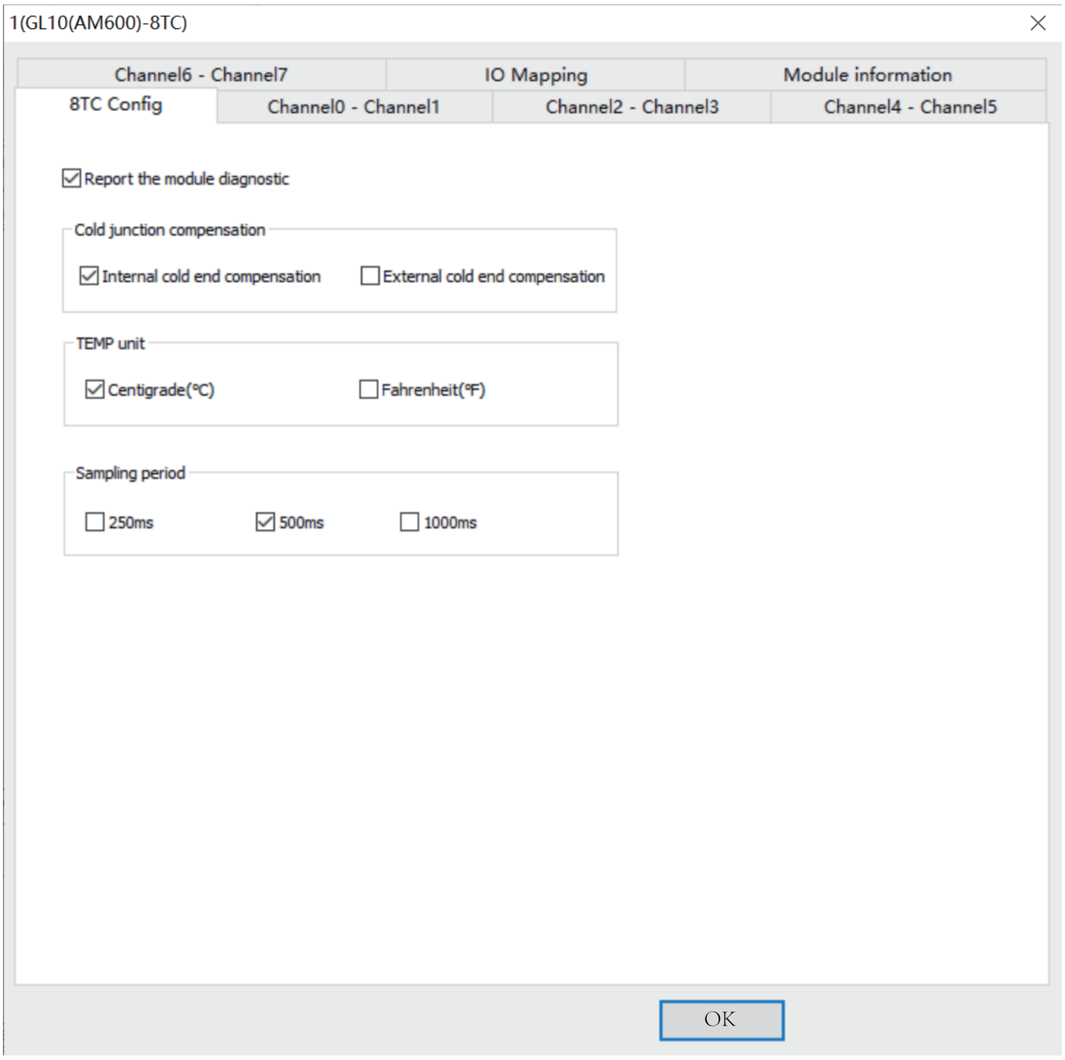
Temperature detection modules include GL10-8TC, GL10-4TC, and GL10-4PT.

Use H5U as the control master module, sample the temperature of the K thermocouple through CH0 of the GL10-8TC module, and assign the sampling value for the corresponding variable.

1. In the module list, select a module to be added, and double-click the module for automatic extension on the extension rack, or drag the module to the extension rack.




2. Double-click the GL10-8TC module on the rack. The "8TC Config" tab page is displayed, as shown in the following figure.

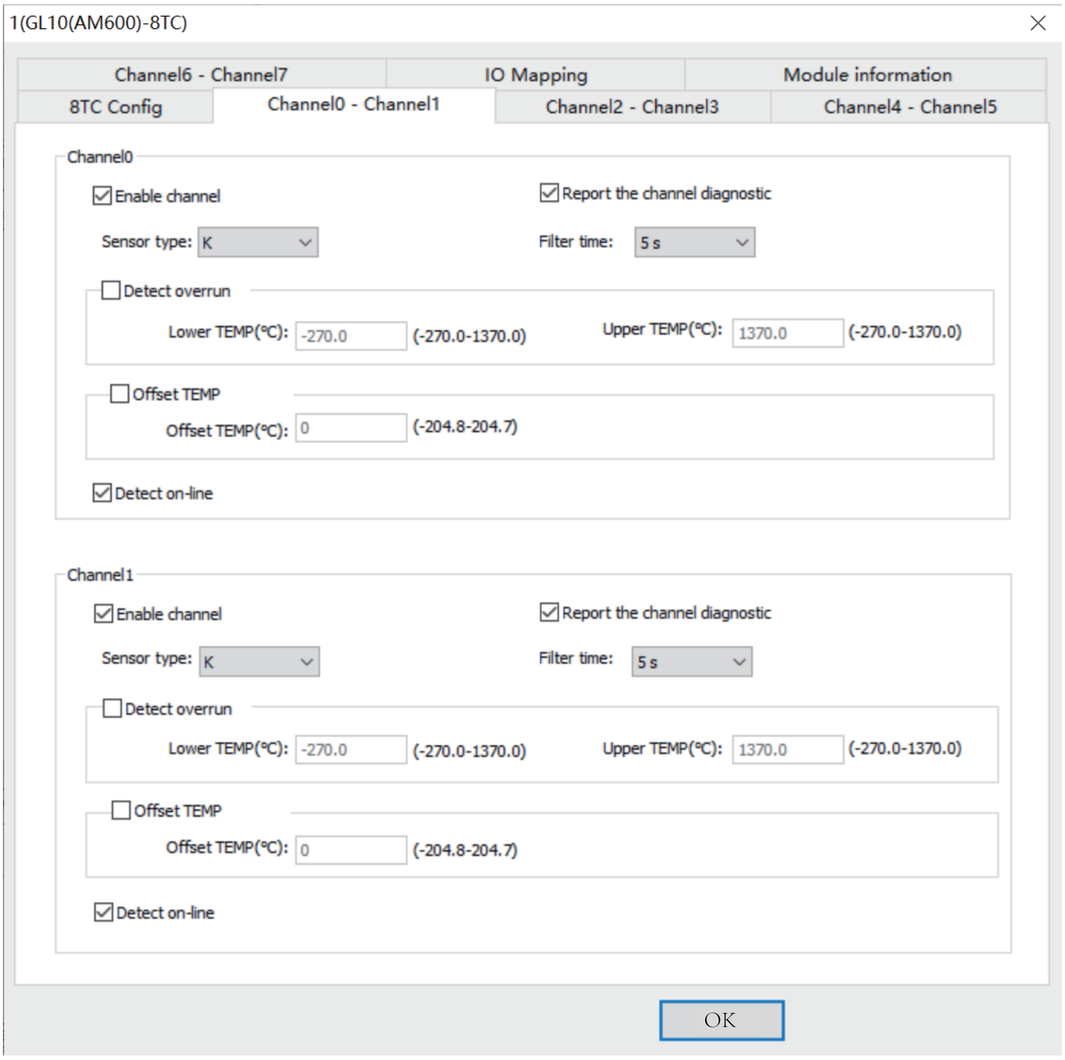



① To use external cold junction compensation, select "External cold end compensation". When external cold junction compensation is used, CH7 of the 8TC module is used for input of the external cold junction compensation sensor (PT100) but cannot be used to measure temperature for the thermocouple.

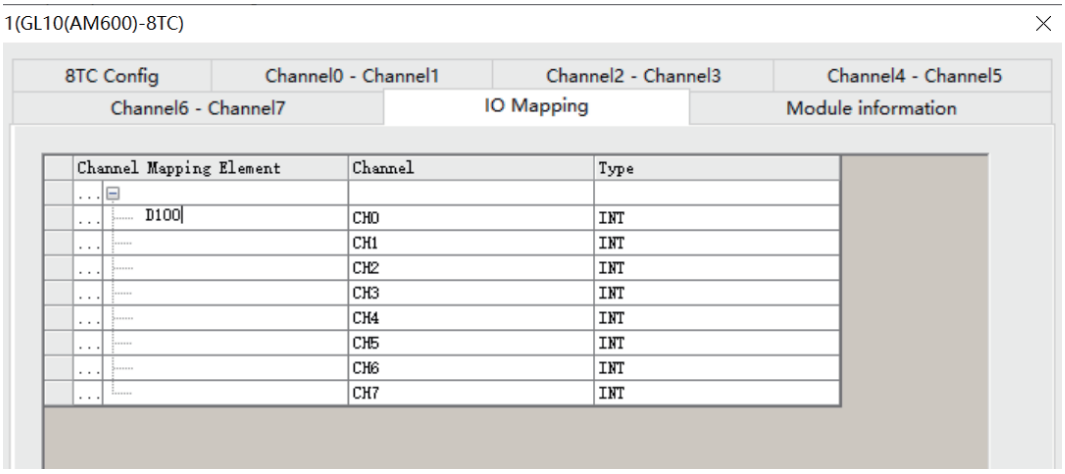
② Set "TEMP unit" to the corresponding temperature unit.

③ Set "Sampling period".

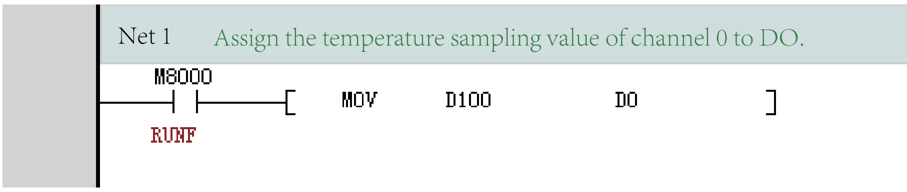
3. On the "CH0 –CH1" tab page, select "Enable channel' for CH0 and set "Sensor type" to "K".




4. On the IO mapping page, map CH0 of the 8TC module to the D element D100. In H5U, you can also map the module to a customized variable.




5. Use the LD programming language to program 8TC sampling, and assign the temperature sampling value of CH0 from D100 to D0.




6. After compilation succeeds, download and run the project.

# 5.2 Easy Local Extension Modules and Extension Cards

## 5.2.1 System Variables

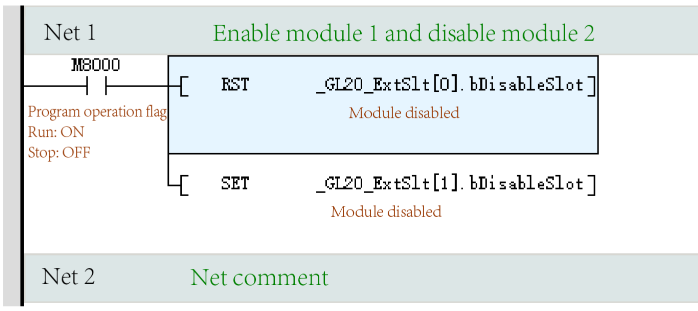
### 5.2.1.1 System Variables of Extension Modules

Information about the GL20 local module of _GL20_ExtSlt

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _GL20_ExtSlt[0].ConfigModule | DINT | Type of the configured module | R |
| _GL20_ExtSlt[0].MountedModule | DINT | Type of the installed module | R |
| _GL20_ExtSlt[0].LogicVersion | DINT | Version of the logic device | R |
| _GL20_ExtSlt[0].SWVersion | DINT | Software version | R |
| _GL20_ExtSlt[0].Error | BOOL | Error state | R |
| _GL20_ExtSlt[0].bDisableSlot | BOOL | Module disabled | R/W |

**Program example**

The program enable module 1 and disable module 2 make program compilation and download take effect.




### 5.2.1.2 System Variables of Extension Cards

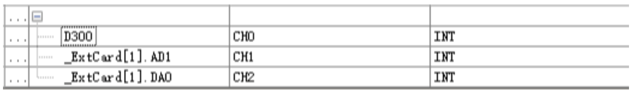
Information about the GL20 local module of _GL20_ExtSlt

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _ExtCard[0].ConfigModule | INT | Type of configured extension card | R |
| _ExtCard[0].MountedModule | INT | Type of installed extension card | R |
| _ExtCard[0].LogicVersion | INT | Version of the logic device | R |
| _ExtCard[0].SWVersion | INT | Software version | R |
| _ExtCard[0].Error | BOOL | Error state | R |

| Name | Data Type | Description | R/W |
|---|---|---|---|
| _ExtCard[0].DI0 | BOOL | DI0 bit of 4 DI extension card | R/W |
| _ExtCard[0].DI1 | BOOL | DI1 bit of 4 DI extension card | R/W |
| _ExtCard[0].DI2 | BOOL | DI2 bit of 4 DI extension card | R/W |
| _ExtCard[0].DI3 | BOOL | DI3 bit of 4 DI extension card | R/W |
| _ExtCard[0].DO0 | BOOL | DO0 bit of 4 DO extension card | R/W |
| _ExtCard[0].DO1 | BOOL | DO1 bit of 4 DO extension card | R/W |
| _ExtCard[0].DO2 | BOOL | DO2 bit of 4 DO extension card | R/W |
| _ExtCard[0].DO3 | BOOL | DO3 bit of 4 DO extension card | R/W |
| _ExtCard[0].AD0 | INT | AD0 channel of analog extension card | R/W |
| _ExtCard[0].AD1 | INT | AD1 channel of analog extension card | R/W |
| _ExtCard[0].DA0 | INT | DA0 channel of analog extension card | R/W |
| _ExtCard[0].ConfigData | INT[16] | Extension card configuration data | R |

4 DI is the default mapping address of the input extension card. 4 DO is the default mapping address of the output extension card. AD and DA are default mapping addresses of analog extension cards in the same program control way as modules.

Configure I/O mapping for GE20-2AD1DA-I, as shown in the following figure.

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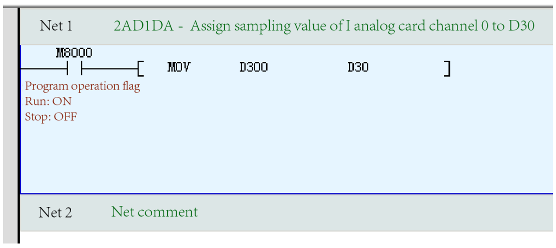
## *Note*

AutoShop earlier than version V4.8.1.0 supports modification of the GE20-2AD1DA-I/GE20-2AD1DA-V channel mapping elements. AutoShop V4.8.1.0 and later versions do not support the modification.

---

Use the LD programming language to program GE20-2AD1DA-I sampling, and assign the voltage sampling value of CH0 from D300 to D30, which can be compiled and downloaded for running, as shown in the following figure.

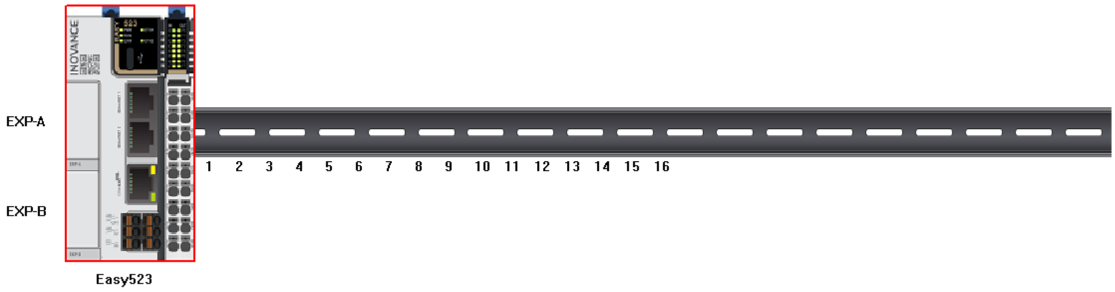



## 5.2.2 Local Extension Modules

### 5.2.2.1 Overview

An Easy series host can carry up to 16 modules to access local modules based on module configuration.

The following figure shows how to connect an Easy series host to a local module.



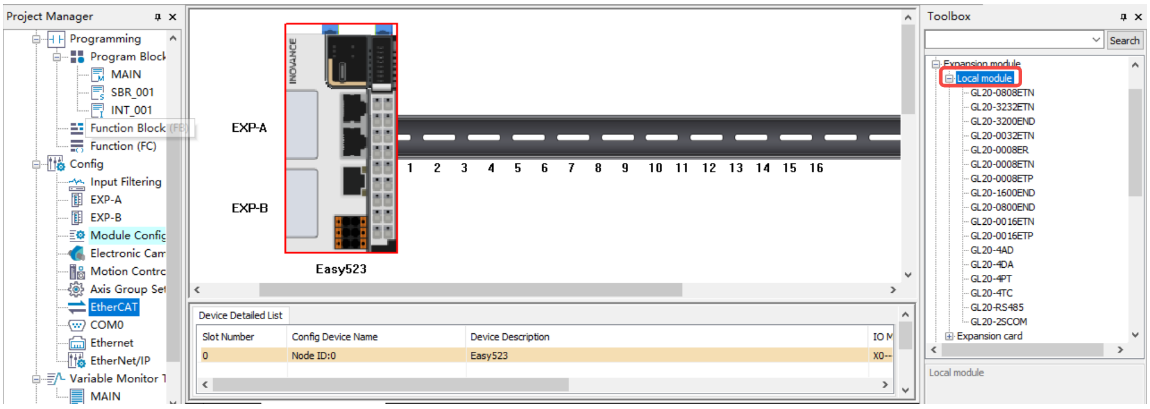

The following table lists the supported modules of local modules.

| Model | Description |
|---|---|
| GL20-1600END | 16 DI module |
| GL20-0800END | 8 DI module |
| GL20-3200END | 32 DI module |
| GL20-0016ETN | 16 DO module |
| GL20-0016ETP | 16 DO module |
| GL20-0008ETN | 8 DO module |
| GL20-0008ETP | 8 DO module |
| GL20-0008ER | 8 DO module |
| GL20-0032ETN | 32 DO module |
| GL20-0808ETN | 8 DI module and 8 DO module |
| GL20-3232ETN | 32 DI module and 32 DO module |
| GL20-4AD | 4 AI module |
| GL20-4DA | 4 AO module |
| GL20-4PT | 4-in RTD module |
| GL20-4TC | 4-in TC TEMP MEAS module |
| GL20-2SCOM | 2 serial communication module (configurable for RS232, RS422, and RS485) |
| GL20-2S485 | 2 RS485 serial communication module |

### 5.2.2.2 Configuring Hardware

Local extension modules are implemented by hardware configuration. To configure hardware, perform the following steps:

1. Double-click "Module Config" in AutoShop to access the configuration page, or unfold the extension module or local module node in the toolbox.
2. Double-click the corresponding local module. On the configuration page that is displayed, add the corresponding module.

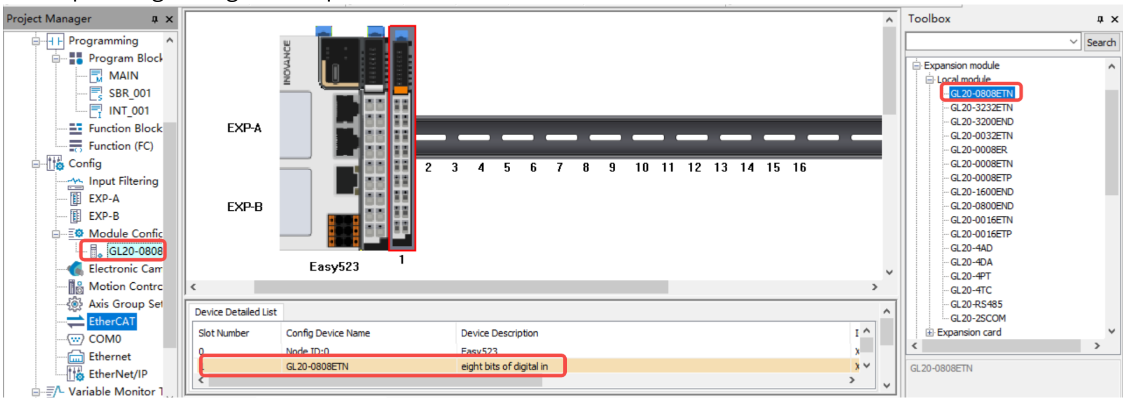



## 5.2.2.3 Configuring Extension Modules

### 5.2.2.3.1 DI Modules

DI modules include GL20-1600END, GL20-0800END, and GL20–3200END. The method of using the a DI module as a local extension module is as follows:

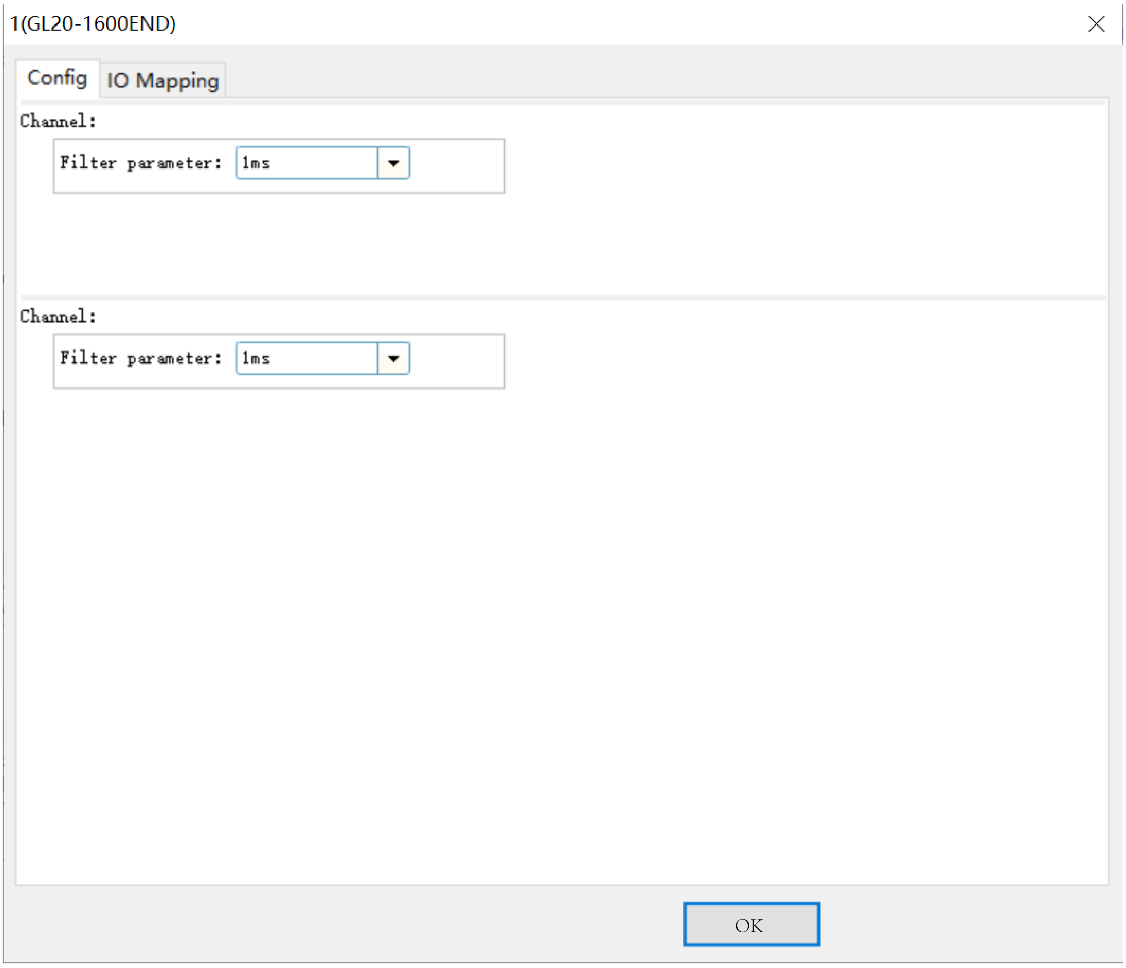
1. In the toolbox, select a module and double-click it. The module is automatically added to the corresponding configuration position.



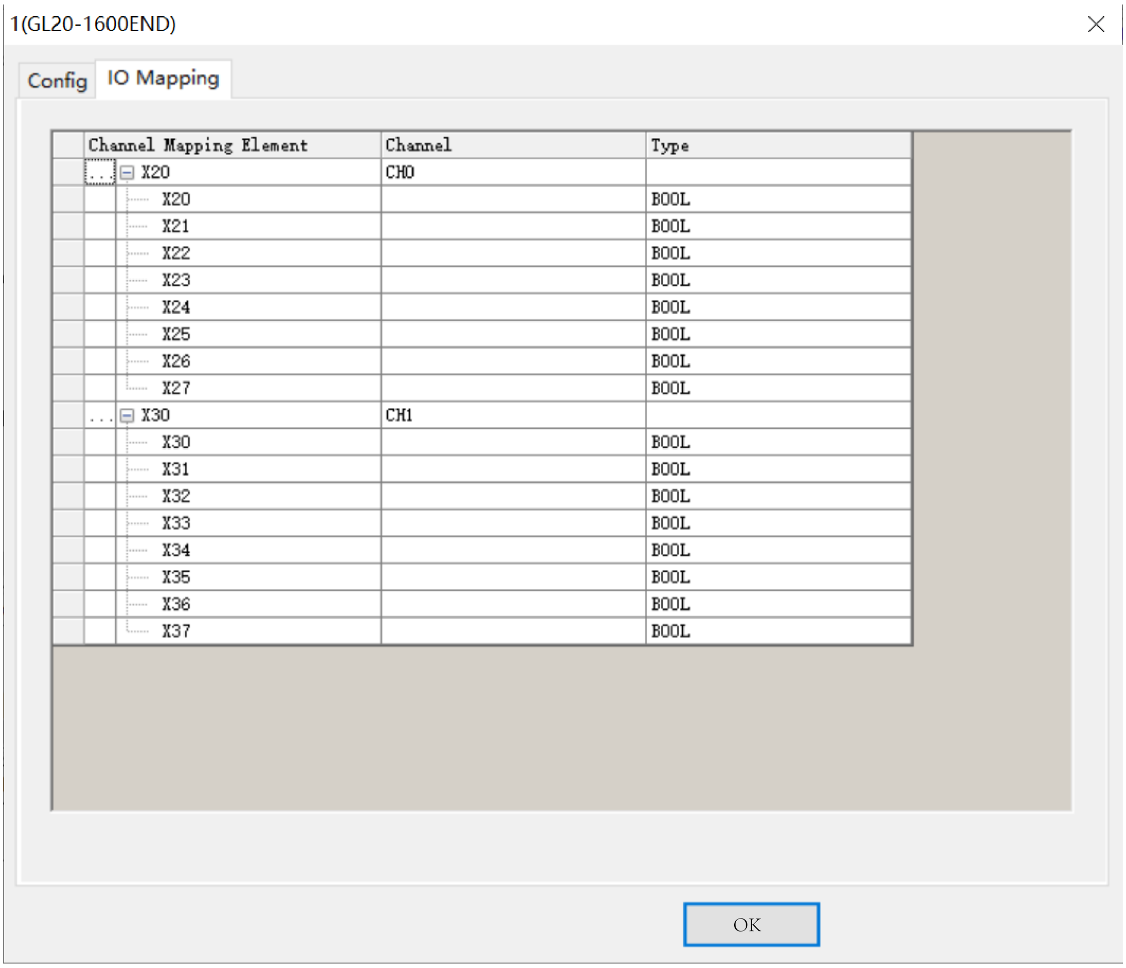

2. After local DI extension modules are connected to the master module without port configuration, numbers of input X ports on the extension modules follow the number of the input X port on the master module in sequence.
   For example, if the master module is an Easy series module, and number of the last X port on the master module is X37 after GL20-1600END connection, numbers of 16 input X ports on the extension module range from X40 to X47 and X50 to X57 during programming. This also applies to other DI extension modules by analogy. Taking GL20-1600END of module 1 as an example, access the configuration page in any of the following ways: ① Double-click the subnode under "Module Config". ② Double-click the module configuration on the configuration page. ③ Double-click an item in "Device Detailed List".

   The dialog box that is displayed contains the "Configure" tab page and "IO Mapping" tab page.

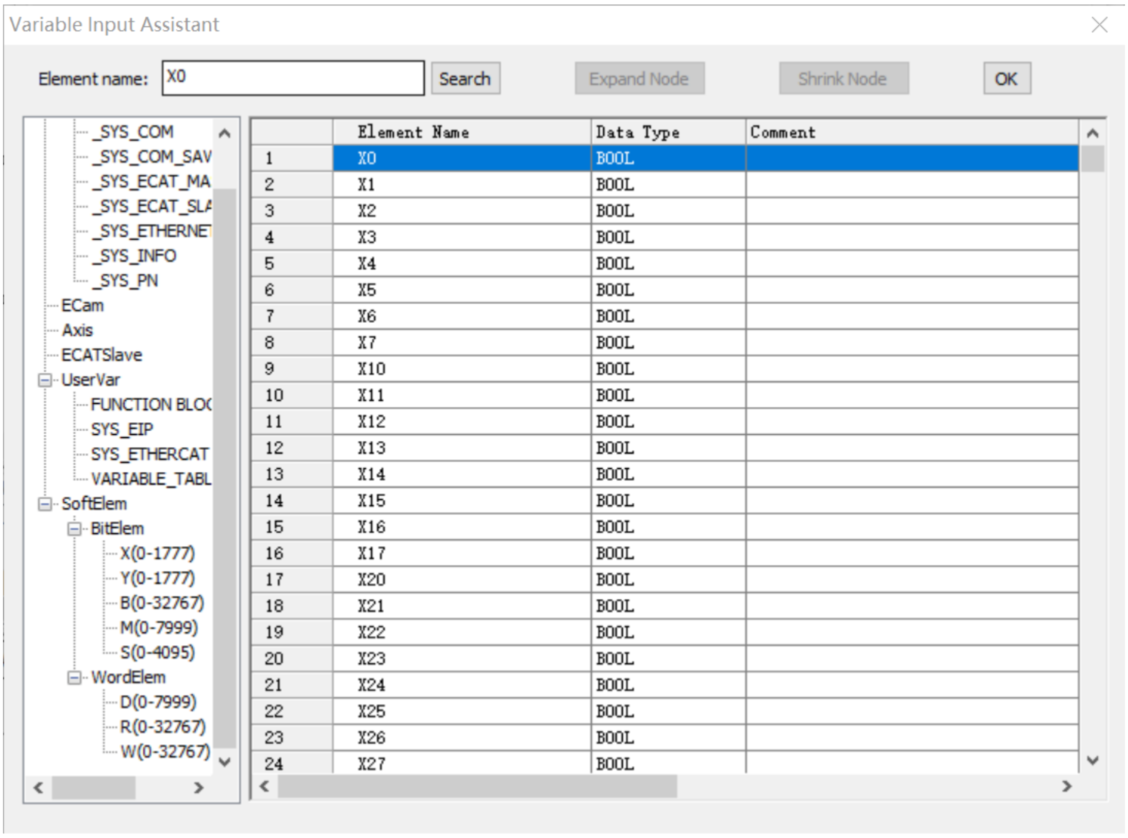
   The GL20-1600END series 16 DI module is used as an example. Two channels are provided on the "IO Mapping" tab page, each of which maps eight consecutive I/O elements. Two channels are also provided on the "Configure" tab page, each of which has a filter parameter. Set "Filtering parameter" as required, as shown in the following figure.




On the "IO Mapping" tab page, click "..." to pop up the variable assistant, or double-click the first mapped node such as X10 and X20 and enter the modified mapping element to modify the corresponding mapping, as shown in the following figure.



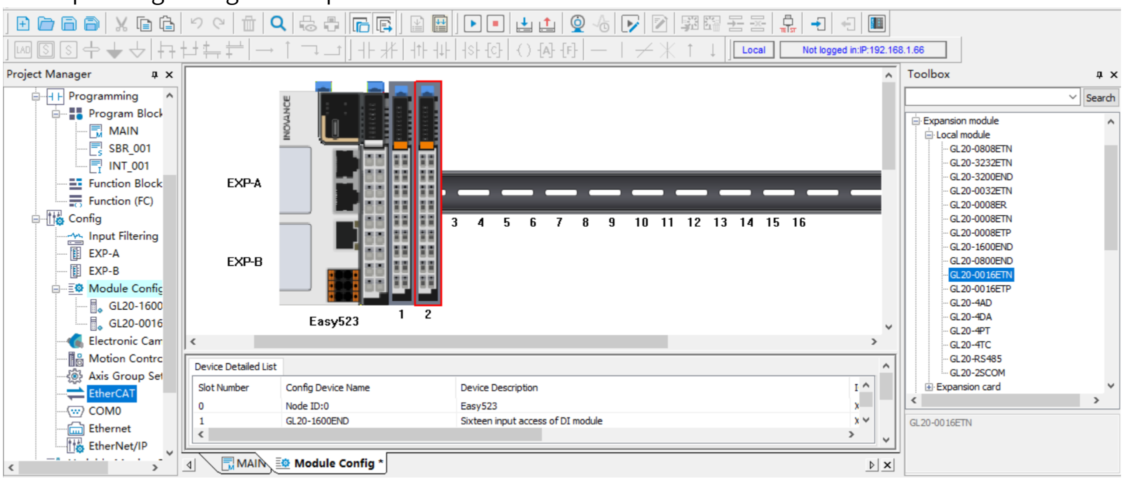

Click "..." to pop up the variable assistant and locate the corresponding element for mapping, as shown in the following figure.




5.2.2.3.2 DO Modules

DO modules include GL20-0016ETN, GL20-0016ETP, GL20-0008ETN, GL20-0008ETP, GL20-0008ER, and GL20-0032ETN. The method of using a DO module as a local extension module is as follows:

1. In the toolbox, select a module and double-click it. The module is automatically added to the corresponding configuration position.

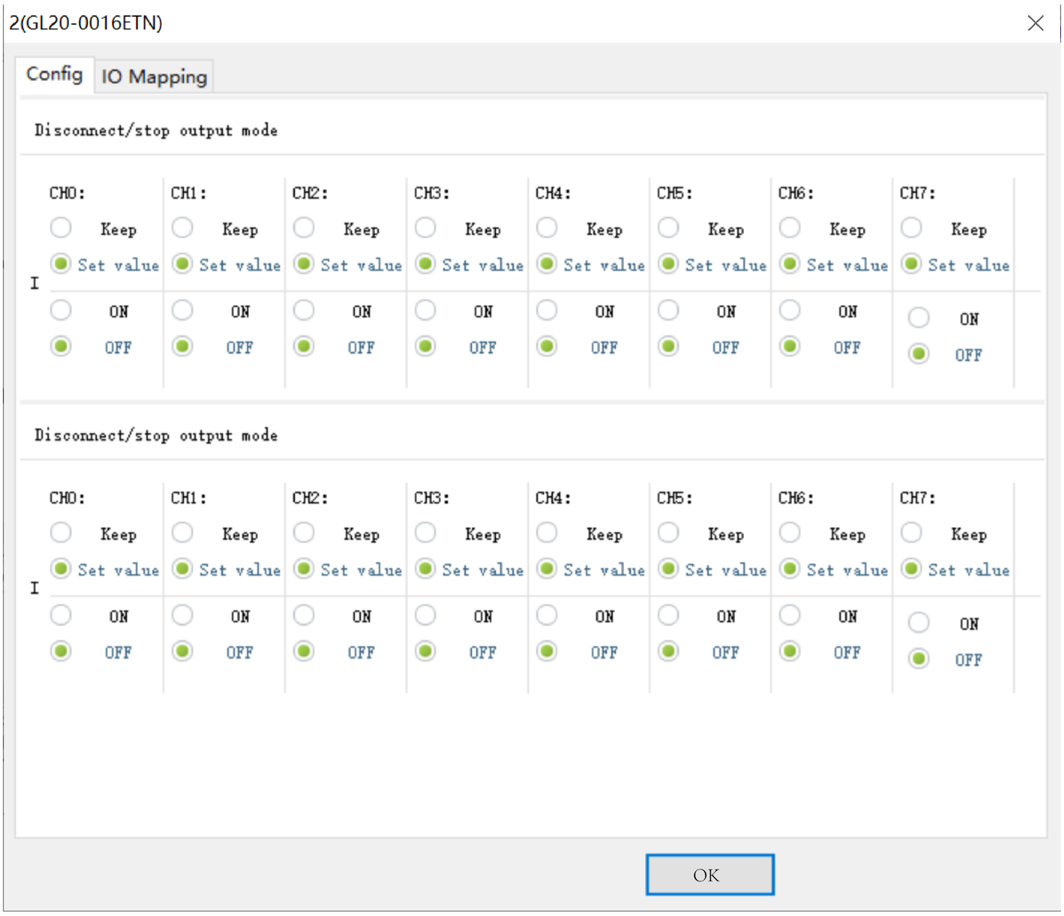



2. After local DO extension modules are connected to the master module without port configuration, numbers of input Y ports on the extension modules follow the number of the input Y port on the master module in sequence.
   For example, if the master module is an Easy series module, and number of the last Y port on the master module is Y37 after GL20-0016ETN connection, numbers of 16 input Y ports on the extension module range from Y40 to Y47 and Y50 to Y57 during programming. This also applies to other DO

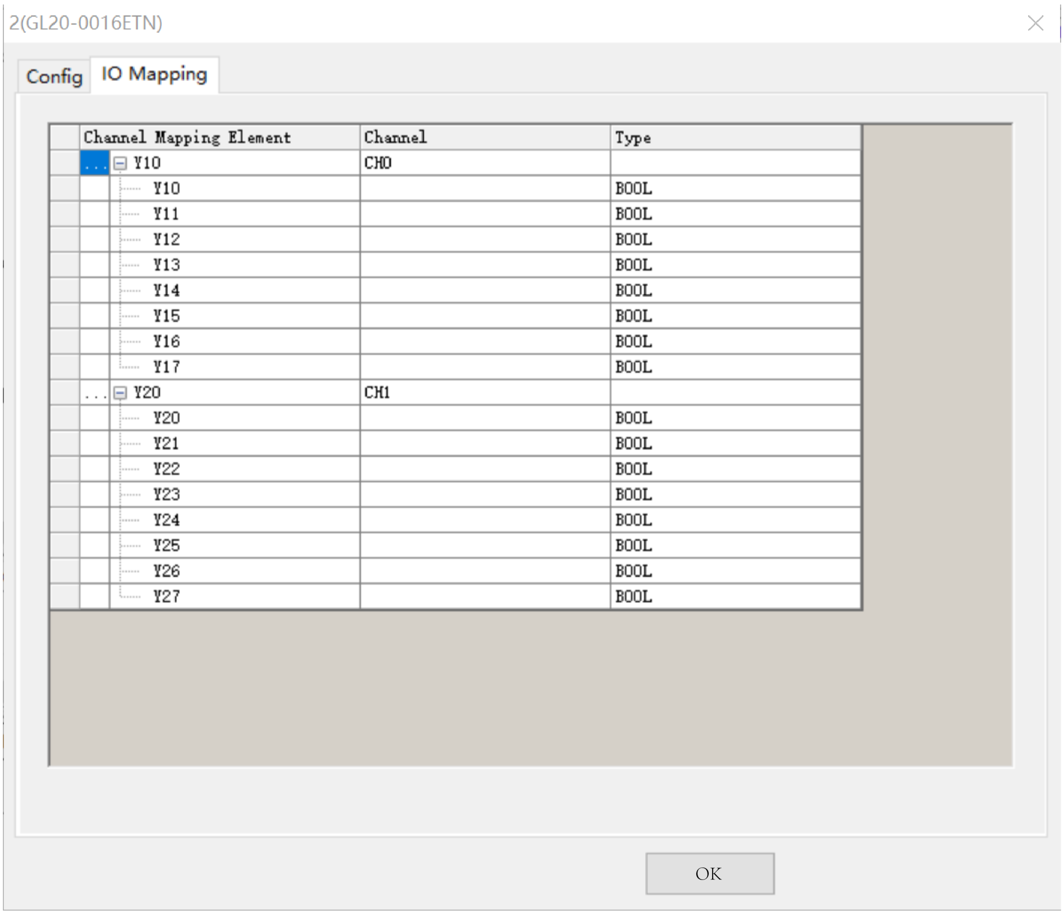
extension modules by analogy. Taking GL20-0016ETN of module 2 as an example, access the configuration page in any of the following ways: ① Double-click the subnode under "Module Config". ② Double-click the module configuration on the configuration page. ③ Double-click an item in "Device Detailed List".

The dialog box that is displayed contains the "Configure" tab page and "IO Mapping" tab page.

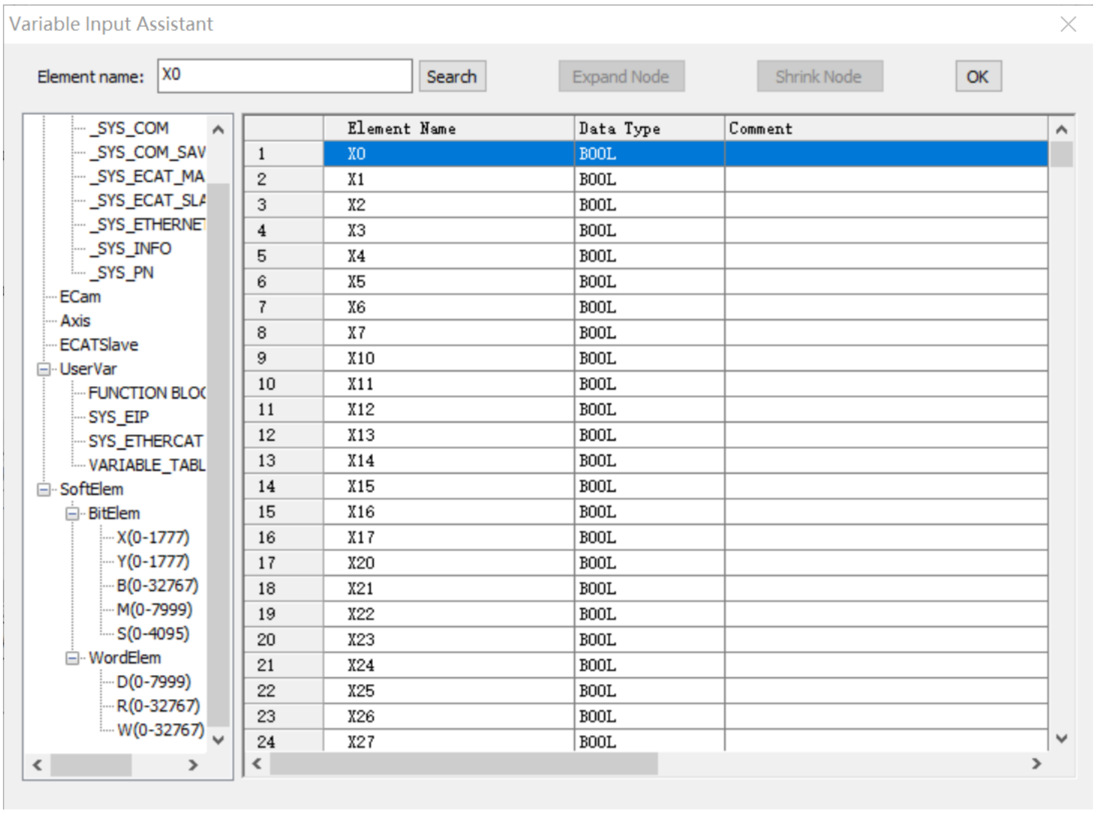
The GL20-0016ETN series 16 DO module is used as an example. Two channels are provided on the "IO Mapping" tab page, each of which maps eight consecutive I/O elements. Two channels are also provided on the "Configure" tab page, each of which is configured with the disconnection and output stop modes for eight I/O elements. You can set or retain the output values of I/O ports when the PLC is disconnected or stopped, as shown in the following figure.




On the "IO Mapping" tab page, click "..." to pop up the variable assistant, or double-click the first mapped node such as Y10 and Y20 and enter the modified mapping element to modify the corresponding mapping, as shown in the following figure.




Click "..." to pop up the variable assistant and locate the corresponding element for mapping, as shown in the following figure.



5.2.2.3.3 DI or DO Modules

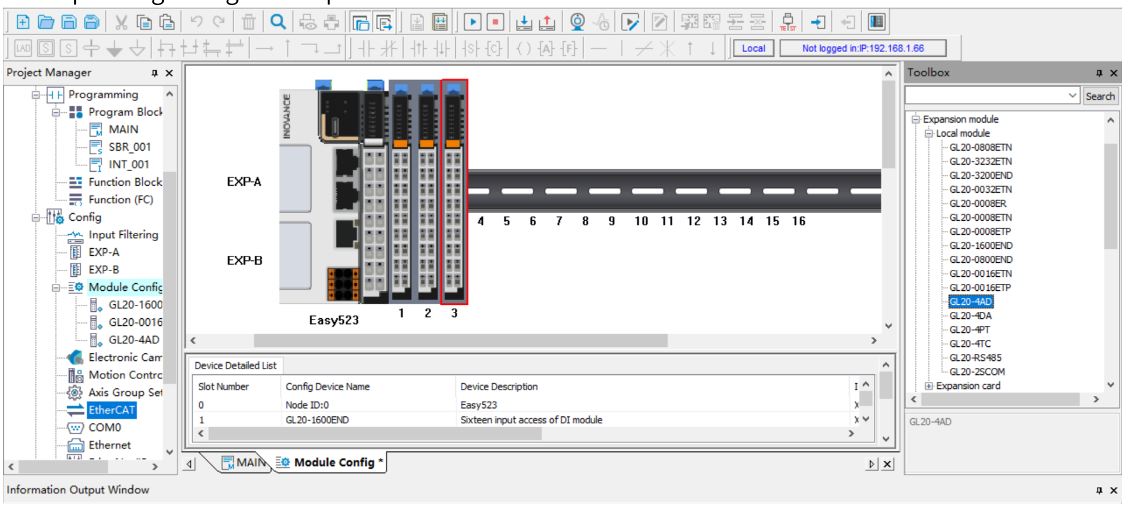
DI and DO modules include GL20-0808ETN and GL20-3232ETN. GL20-0808ETN provides two channels. One channel maps eight consecutive input I/O elements, and the other channel maps eight consecutive output I/O elements, which can be considered as combination of the DI and DO modules. This also applies to GL20-3232ETN.

For details, see the use cases of DI and DO modules.

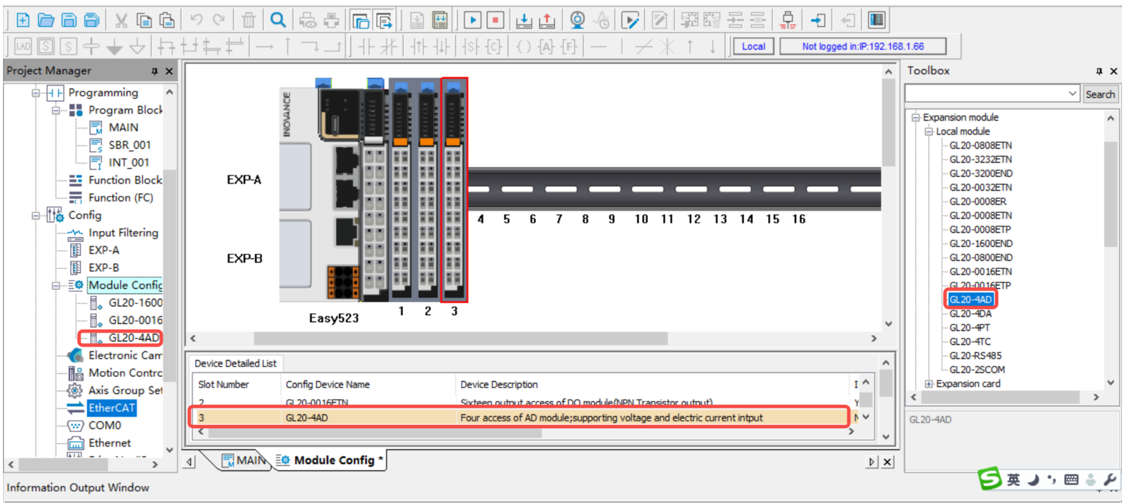
5.2.2.3.4 AI Modules

The method of using the GL20-4AD AI module as a local extension module is as follows:

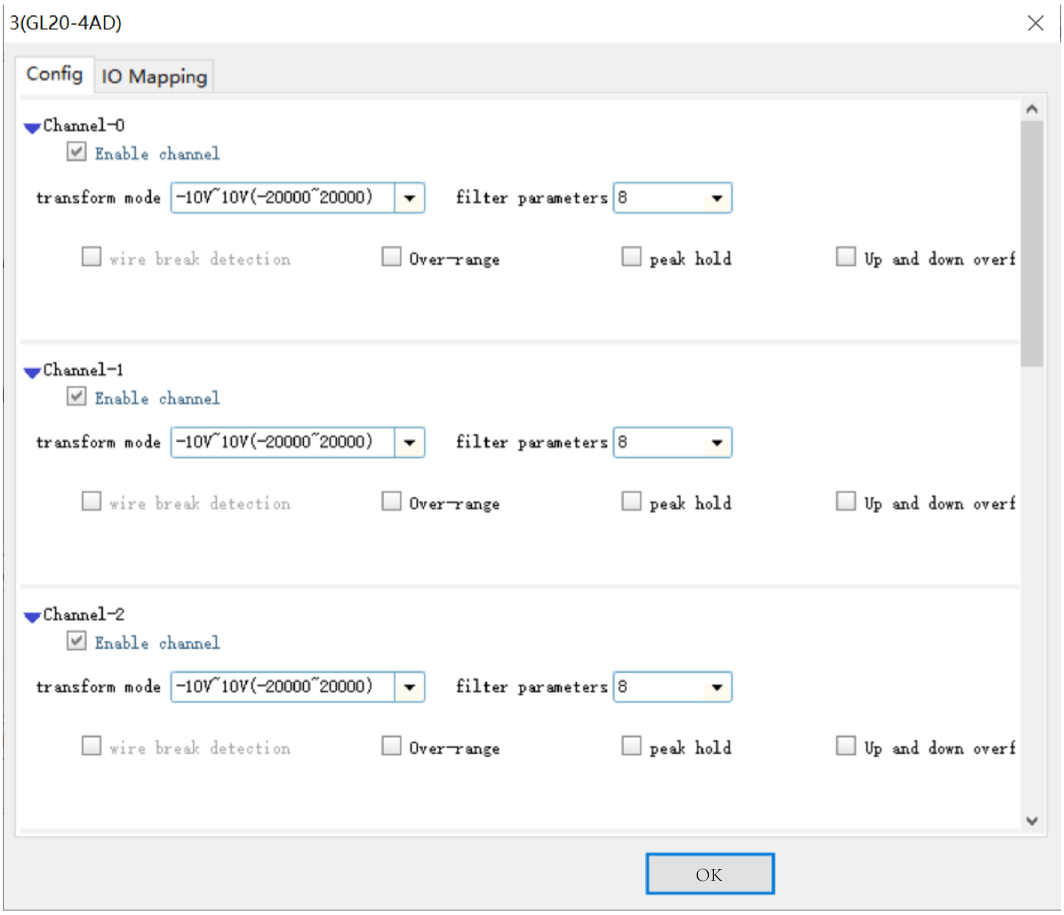
1. In the toolbox, select a module and double-click it. The module is automatically added to the corresponding configuration position.




For example, if the master module is an Easy series module, connect to the GL20-4AD extension module and then access the configuration page in any of the following ways: ① Double-click the subnode under "Module Config". ② Double-click the module configuration on the configuration page. ③ Double-click an item in "Device Detailed List".




2. Double-click GL20-4AD to access the parameter setting page of GL20-4AD.




GL20-4AD provides four channels, and the parameters for the four channels are set consistently. The parameters are defined as follows:

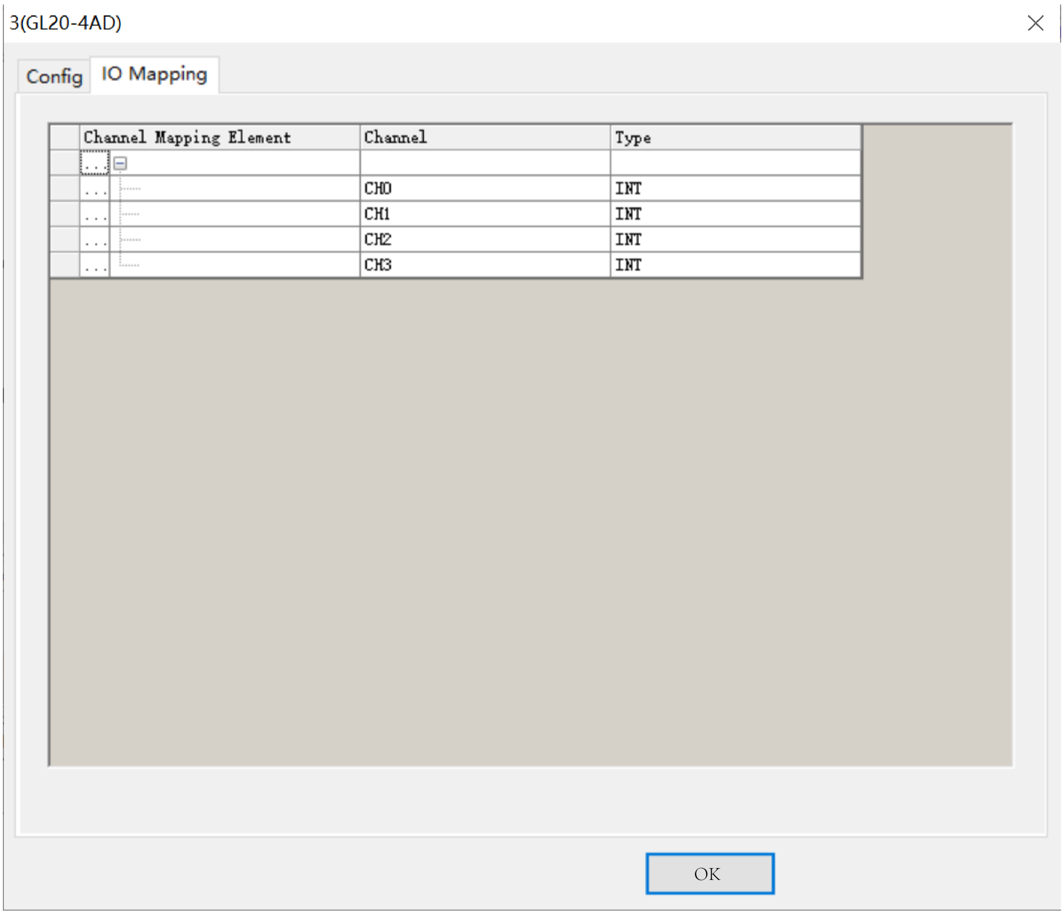
① Determine whether to select "Enable channel". If not, deselect it to save the scanning time.

② Select the corresponding span and resolution.

③ Set "Filtering parameter" to a value in the range of 1 ms to 255 ms.

④ Leave the auxiliary function items empty.

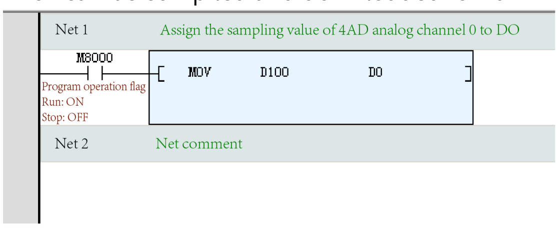
3. GL20-4AD supports consecutive I/O mapping and separate I/O mapping. Click "..." next to the parent node for consecutive mapping or double-click the node of each channel for separate mapping.




4. On the "IO Mapping" tab page, map CH0 of the 4AD module to the D element D100. In an Easy series host, you can map it to a customized variable. The following table lists the relationships between the mapped variables and actual input analog values. The EtherCAT bus coupler supports conversion of three digital spans, including –20000 to +20000, –32000 to +32000, and –27648 to +27648, while the local bus only supports conversion of the span –20000 to +20000.

| Input type | Rated Input Range | Rated Digital Value | Input Limit Range | Digital Value Limit |
|---|---|---|---|---|
| Analog voltage input | –10 V to +10 V | –20000 to +20000 | –11 V to +11 V | –22000 to +22000 |
| | 0 V to 10 V | 0 to 20000 | –0.5 V to +10.5 V | –1000 to +21000 |
| | –5 V to +5 V | –20000 to +20000 | –5.5 V to +5.5 V | –22000 to +22000 |
| | 0 V to 5 V | 0 to 20000 | –0.25 V to +5.25 V | –1000 to +21000 |
| | 1 V to 5 V | 0 to 20000 | 0.8 V to 5.2 V | –1000 to +21000 |
| Analog current input | –20 mA to +20 mA | –20000 to +20000 | –22 mA to +22 mA | –22000 to +22000 |
| | 0 mA to 20 mA | 0 to 20000 | –1 mA to +21 mA | –1000 to +21000 |
| | 4 mA to 20 mA | 0 to 20000 | 3.2 mA to 20.8 mA | –1000 to +21000 |

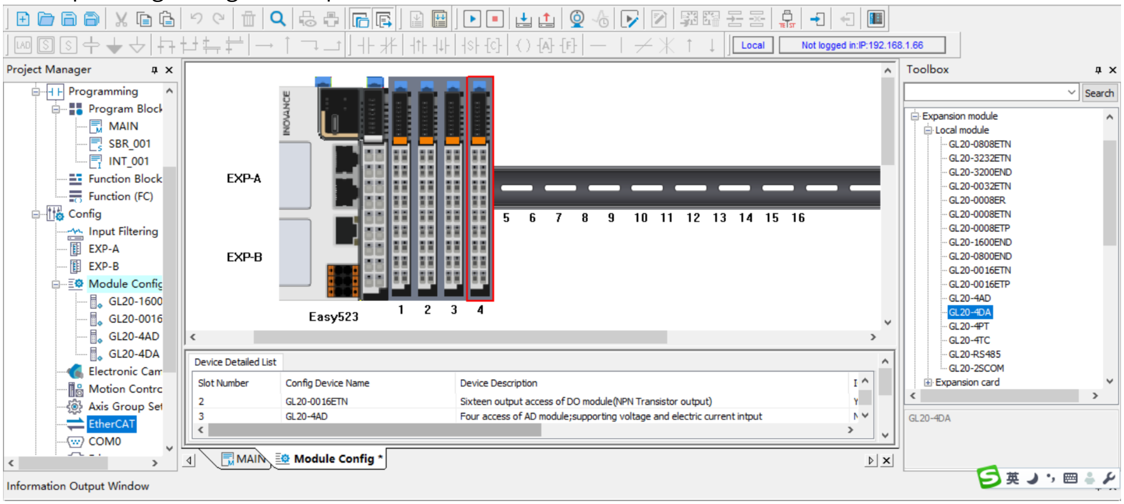
5. Use the LD programming language to program AD sampling, and assign the voltage sampling value of CH0 from D100 to D0, which can be compiled and downloaded for running.



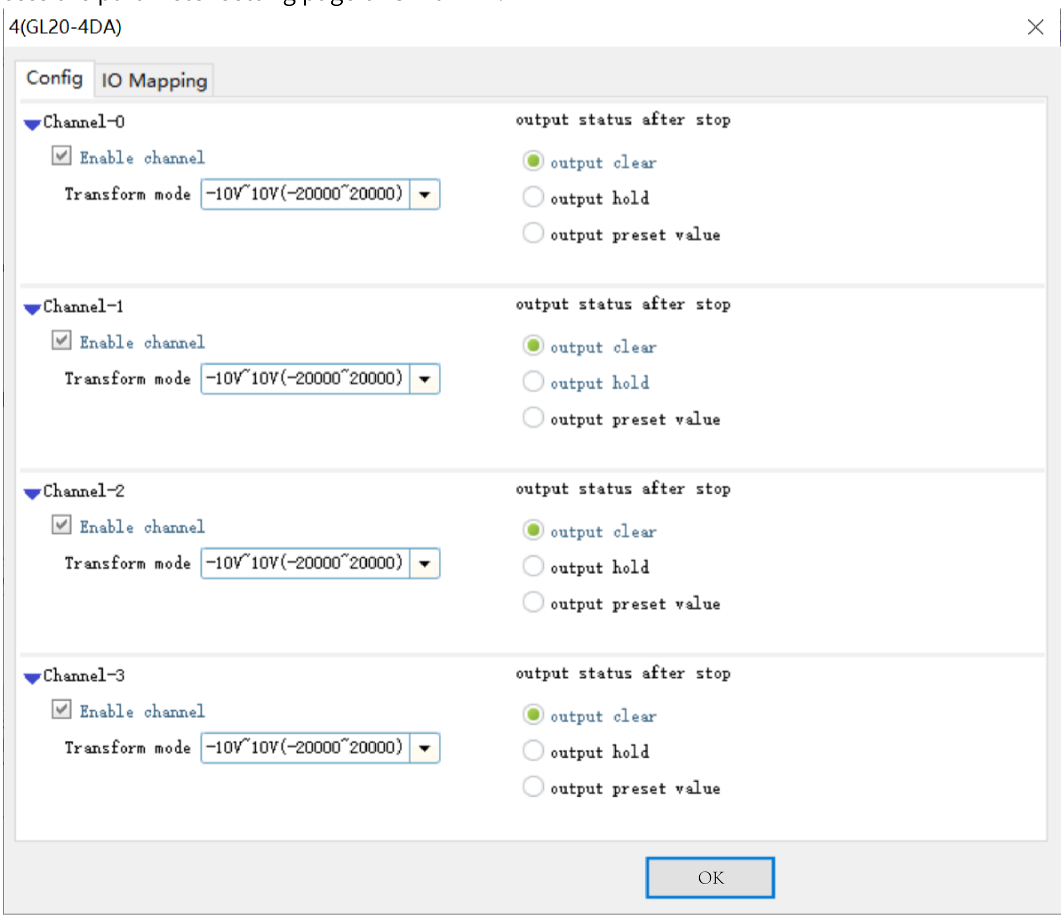
5.2.2.3.5 AO Modules

The method of using the GL20-4DA AO module as a local extension module is as follows:

1. In the toolbox, select a module and double-click it. The module is automatically added to the corresponding configuration position.




2. Access the parameter setting page of GL20-4DA.



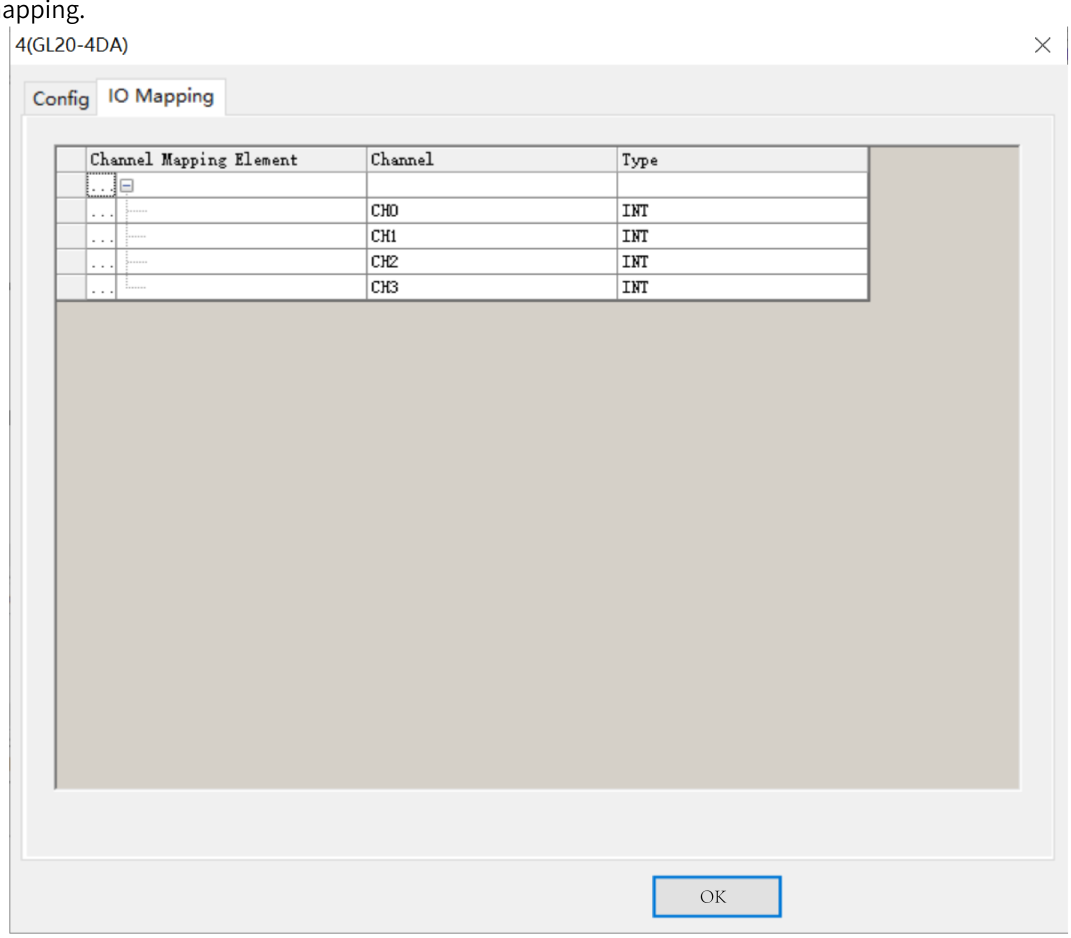

GL20-4DA provides four channels, and the parameters for the four channels are set consistently. The parameters are defined as follows:

① Determine whether to select "Enable channel". If not, deselect it to save the scanning time.

② Set "Translation Mode" to select the output type and range.

③ Set "Output state after Stopping" to "Output zero", "Output Holding", or "Output preset" for analog and digital values when the PLC is in the Stop state.

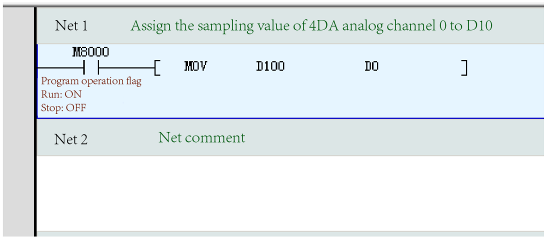
3. GL20-4DA also supports consecutive I/O mapping and separate I/O mapping. Click "..." next to the parent node for consecutive mapping or double-click the node of each channel for separate mapping.




4. On the "IO Mapping" tab page, map CH0 of the 4DA module to the D element D200. In an Easy model, you can also map it to a customized variable. The following table lists the relationships between the mapped variables and actual output analog values. The EtherCAT bus coupler supports conversion of three digital spans, including –20000 to +20000, –32000 to +32000, and –27648 to +27648, while the local bus only supports conversion of the span –20000 to +20000.

| Output type | Rated Output Range | Rated Digital Value | Output Limit Range | Digital Value Limit |
|---|---|---|---|---|
| Analog voltage output | –10 V to +10 V | –20000 to +20000 | –11 V to +11 V | –22000 to +22000 |
| | 0 V to 10 V | 0 to 20000 | –0.5 V to +10.5 V | –1000 to +21000 |
| | –5 V to +5 V | –20000 to +20000 | –5.5 V to +5.5 V | –22000 to +22000 |
| | 0 V to 5 V | 0 to 20000 | –0.25 V to +5.25 V | –1000 to +21000 |
| | 1 V to 5 V | 0 to 20000 | 0.8 V to 5.2 V | –1000 to +21000 |
| Analog current output | 0 mA to 20 mA | 0 to 20000 | 0 mA to 21 mA | 0 to 21000 |
| | 4 mA to 20 mA | 0 to 20000 | 3.2 mA to 20.8 mA | –1000 to +21000 |

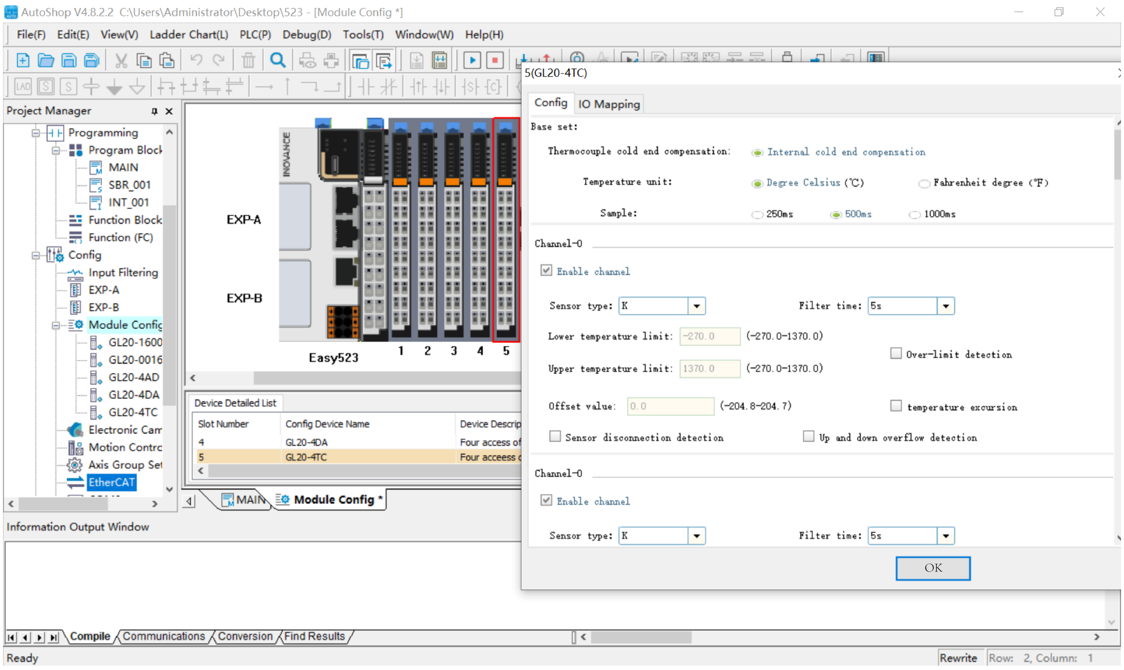
5. Use the LD programming language to program DA sampling, and assign the voltage sampling value of CH0 from D200 to D10, which can be compiled and downloaded for running.



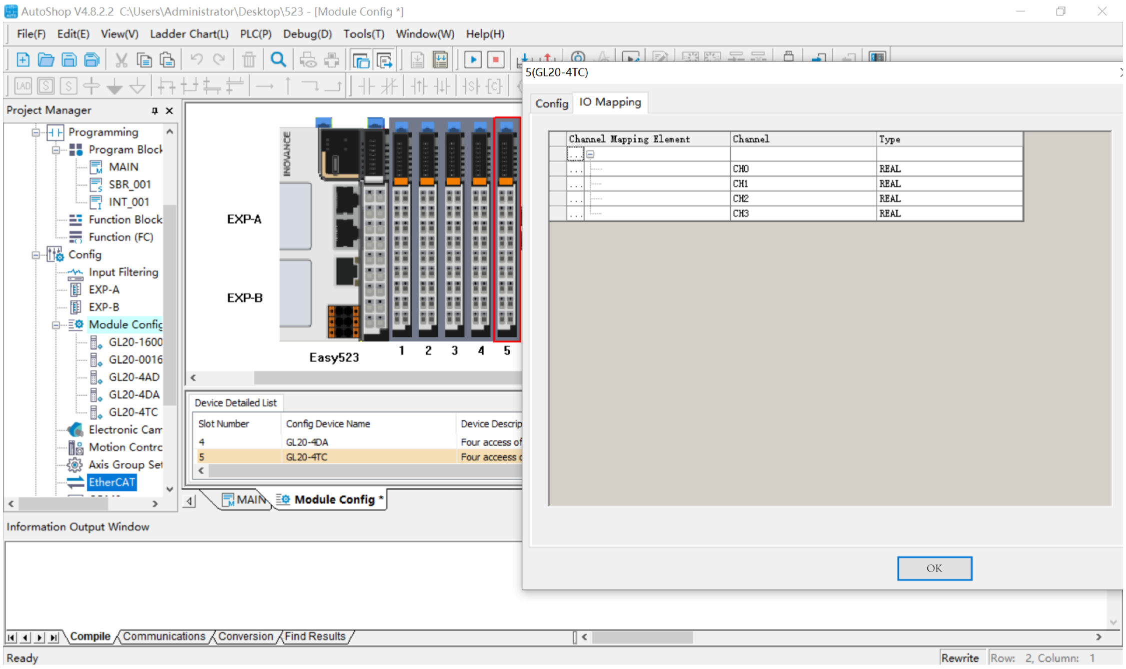

5.2.2.3.6 Temperature Detection Modules

The method of using GL20-4PT 4-in RTD module and GL20-4TC 4-in TC TEMP MEAS module as local extension modules is as follows:

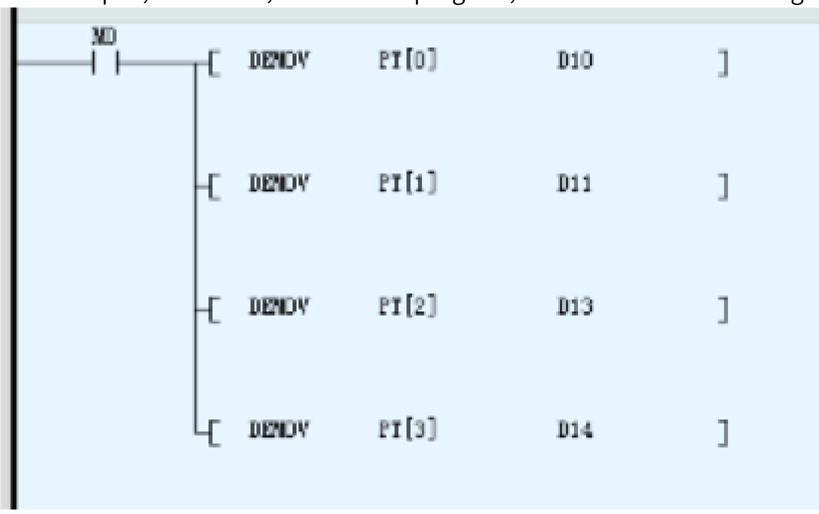
1. The add, delete, and parameter check operations on the page are similar to those of other local modules.
2. Each channel contains basic parameter settings. In the parameters, "Enable channel" indicates whether the current channel parameters are enabled; "Upper TEMP" and "Lower TEMP" can be set only when "Detect overrun" is selected; "Offset value" can be set only when "Offset TEMP" is selected.




3. GL20-4PT or GL20–4TC provides four channels, each of which can be used to map a soft element or REAL variable.



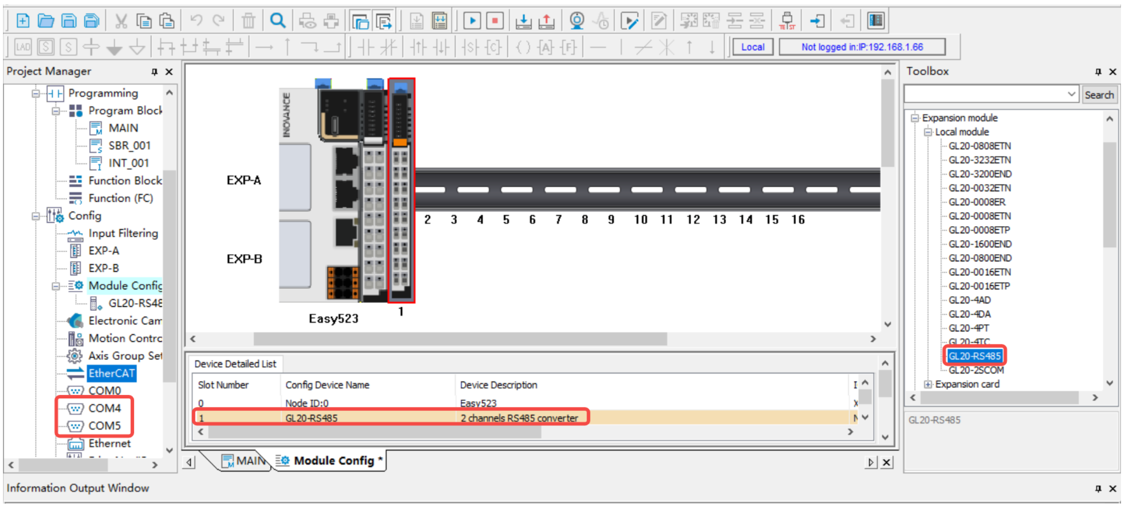

4. Use the LD programming language for sampling programming on the temperature of the GL20-4PT and GL20-4TC modules. Map CH0 to CH4 to REAL array PTs in sequence, use D10 to D14 to collect the temperature, and compile, download, and run the program, as shown in the following figure.



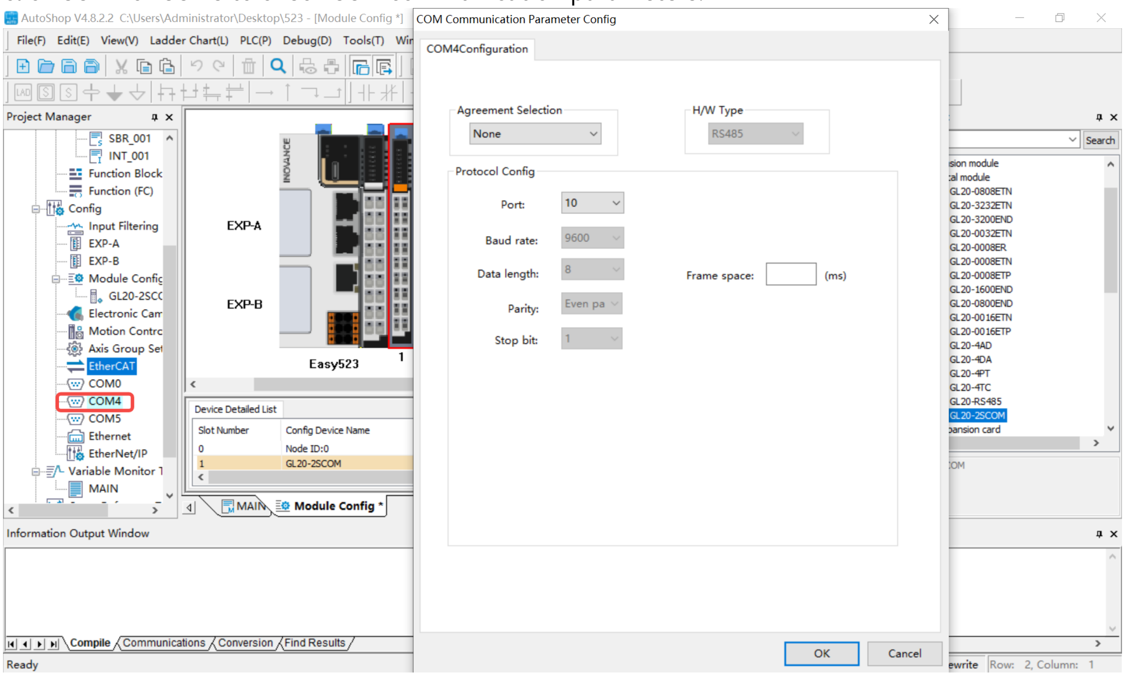

5.2.2.3.7 Communication Modules

The method of using GL20-2SCOM 2-in RS232/RS485 module, GL20-2SCOM 1-in RS422 encoder module, and GL20-2S485 2 RS485 serial communication module as local extension modules is as follows:

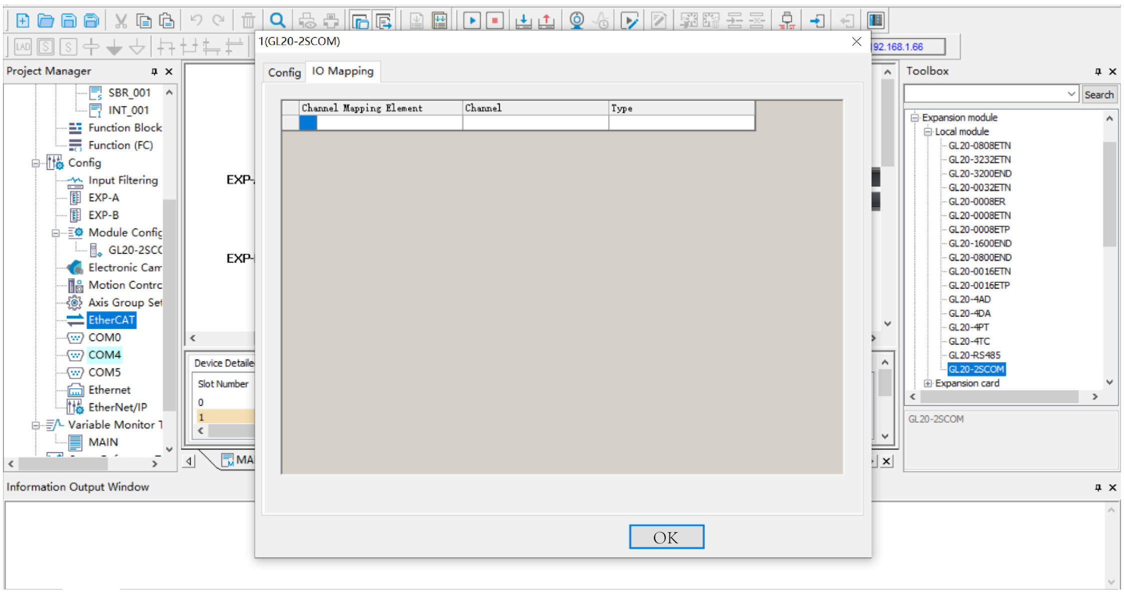
1. The add, delete, and parameter check operations on the page are similar to those of other local modules.
2. Each module provides two channels, each of which contains basic serial port parameter settings and basic data transmission settings. In the parameters, "Enable channel" indicates whether the current channel parameters are enabled; Some parameters that are unavailable, such as "Serial port NO." and "Data bit", indicate that these parameters cannot be set on the page.



3. After the GL20-2S485 and GL20-2SCOM modules are added, two COM ports are generated in the "Project Manager" tree, ranging from COM4 to COM15. As shown in the following figure, COM4 and COM5 are generated, corresponding to communication data of CH0 and CH1 of GL20-2S485. Double-click COM4 or COM5 to check COM communication parameters.

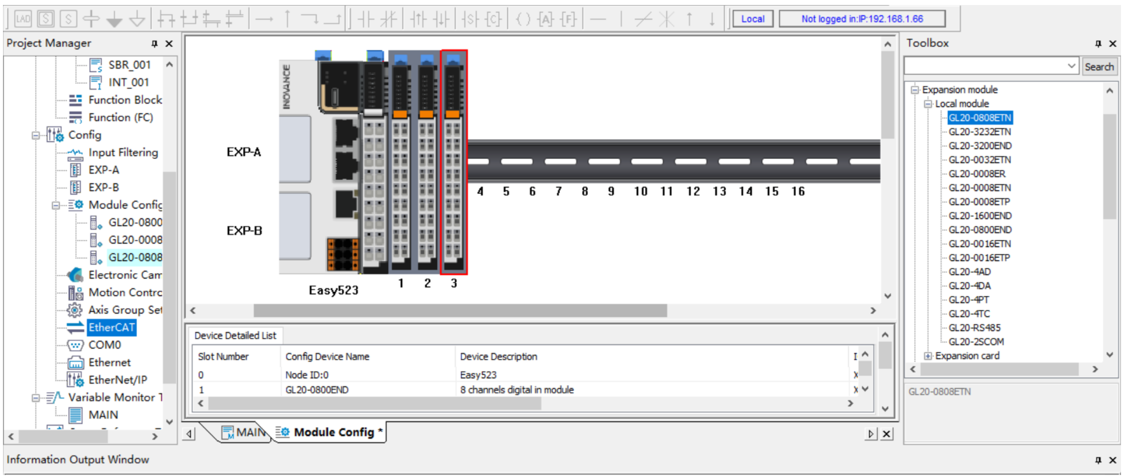


4. Select a COM port, change the COM port number, and then map corresponding data to the modified COM port. The modified parameters such as "Baud rate", "Data length", "Parity", and "Stop bit" will be synchronized to the module page shown in the preceding figure, to ensure data synchronization. After setting the corresponding COM port as the Modbus-RTU master station, right-click the port to add the Modbus configuration for Modbus communication in the same way as COM0.
If a communication module has no I/O mapping data, the module page is empty.



5.2.2.3.8 Application Examples

1. Connect the GL20-0800END, GL20-0008ETN, and GL20-0808ETN modules to the actual host as an example. In the "Project Manager" tree, right-click "Module Config" and select "Auto Scan" to start scanning. The scan result is displayed as shown in the following figure. The three modules can be manually added.
2. Click "Update Config" to add the mounted modules to the configuration. The default configuration is added for the modules by default.



3. Download the configuration and run the modules. Nodes of the modules in the "Project Manager" tree turn green and "Ok" is displayed on the configuration page, indicating that the modules are running properly.

## 5.2.3 Extension Cards

### 5.2.3.1 Overview

An Easy series host can be equipped with up to two extension cards, and nine types of extension cards are supported. Extension card slot 1 and extension card slot 2 support different types of extension cards, as listed in the following table.

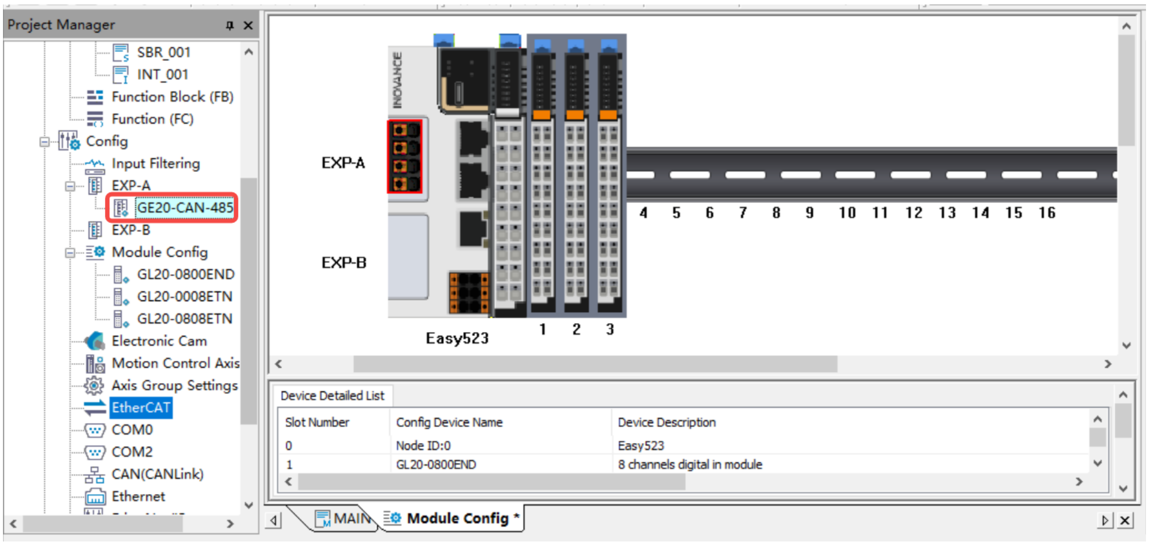
| No. | Name (Model) | Function | Extension Card Slot 1 | Extension Card Slot 2 |
|---|---|---|---|---|
| 1 | GE20-232/485-RTC | Providing either the RS232 or RS485 extension interface<br>RTC extension | Not supported | Supported |
| 2 | GE20-232/485 | Providing either the RS232 or RS485 extension interface | Supported | Supported |
| 3 | GE20-CAN-485 | Providing the CAN extension interface<br>Providing the RS485 extension interface | Supported | Not supported |
| 4 | GE20-2AD1DA-I | Providing 2-in AD and 1-out DA extension (current) | Supported | Supported |
| 5 | GE20-2AD1DA-V | Providing 2-in AD and 1-out DA extension (voltage) | Supported | Supported |
| 6 | GE20-4DI | Providing 4-in I/O extension | Supported | Supported |
| 7 | GE20-4DO-TN | Providing 4-out I/O extension | Supported | Supported |
| 8 | GE20-RTC | Providing RTC extension | Not supported | Supported |
| 9 | GE20-TF | Providing the SD extension card interface | Not supported | Supported |

### 5.2.3.2 Configuring Extension Cards

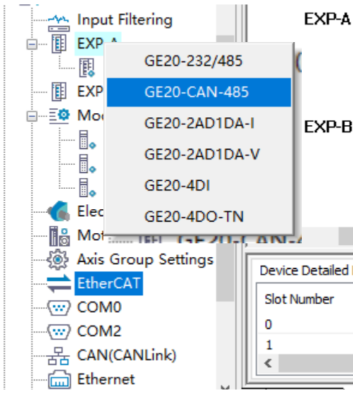
5.2.3.2.1 Adding Extension Cards

Extension cards can be added in two ways:

- Unfold the extension module or extension card node on the toolbox, and double-click to add corresponding extension cards.
- In the "Project Manager" tree, right-click EXP-A or EXP-B, and select the extension card type. On the configuration page that is displayed, add corresponding extension cards.



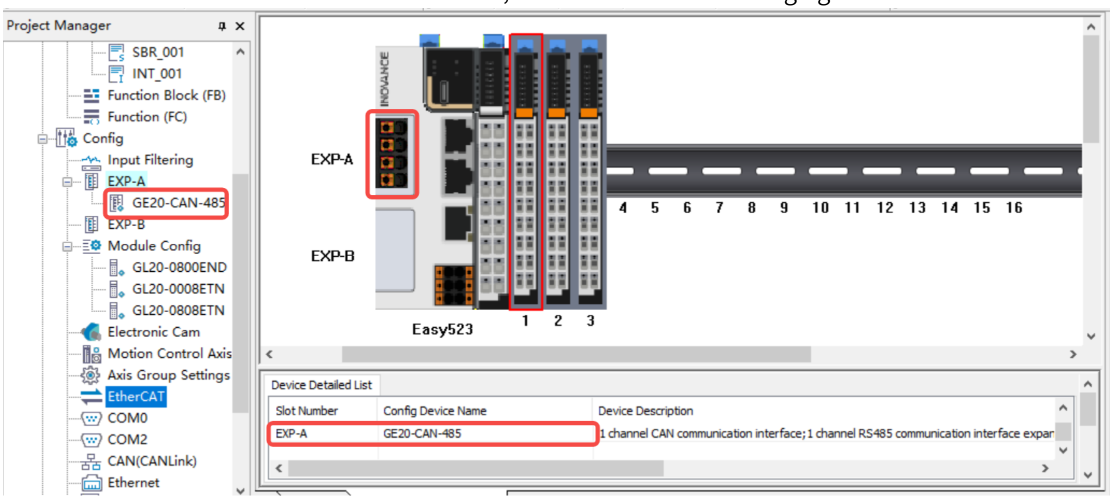

The following figure shows how to add an extension card using the shortcut menu.



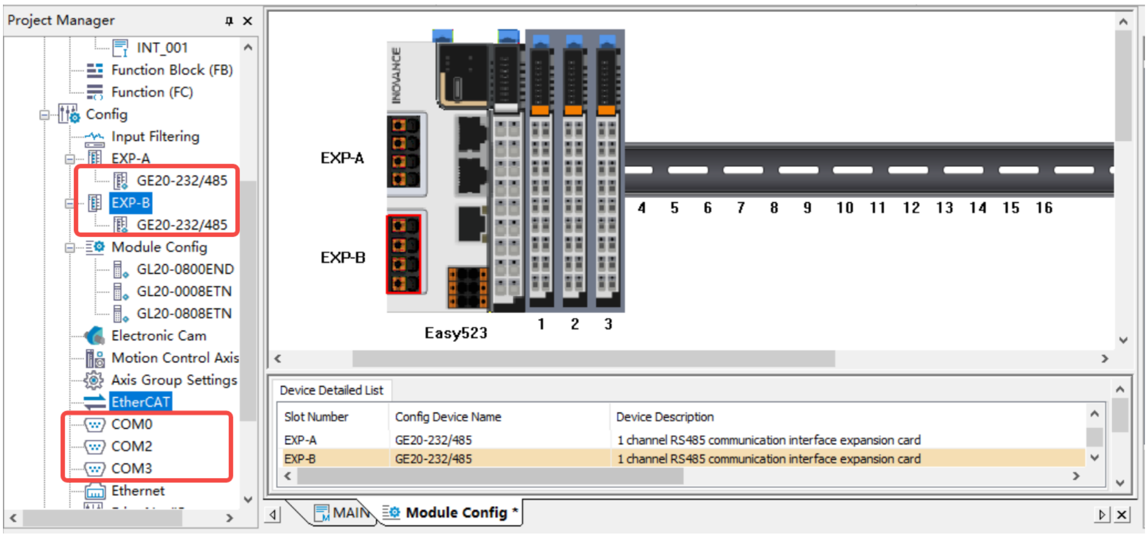

5.2.3.2.2 Configuring Extension Card Parameters

You can access the extension card configuration page in the following ways:

- Double-click a node under EXP-A or EXP-B.
- Double-click the EXP-A or EXP-B configuration on the configuration page.
- Double-click an item in "Device Detailed List", as shown in the following figure.

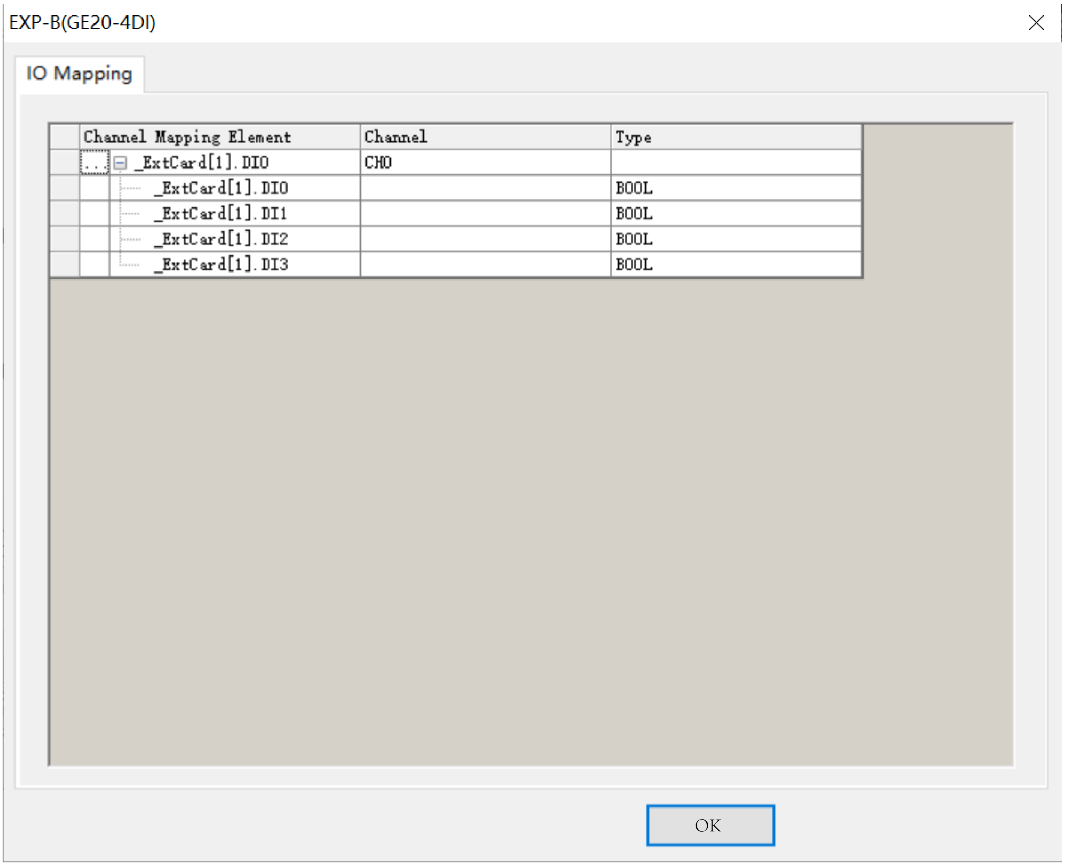


Configurable COM nodes will be generated for the cards with COM ports, such as GE20-CAN-485, GE20-232/485-RTC, and GE20-232/485. EXP-A corresponds to COM2 and EXP-B to COM3. If GE20-CAN-485 is added for EXP-A, the CAN and COM2 nodes will be generated. If GE20-232/485 is added for EXP-B, the COM3 node will be generated. You can double-click a node for parameter configuration, as shown in the following figure.



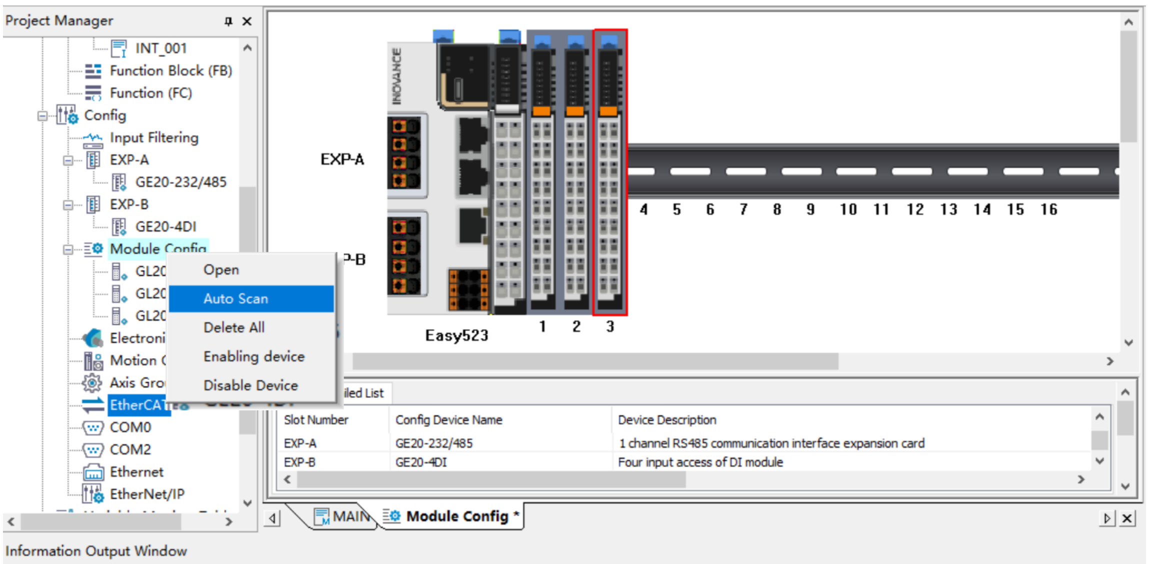

GE20-2AD1DA-I and GE20-2AD1DA-V are current-voltage hybrid extension cards. If they are added for EXP-A, the COM2 node will be generated by default. If they are added for EXP-B, the COM3 node and three Modbus instructions will be generated by default. You cannot exit COM port parameters and Modbus parameters.

GE20-4DI and GE20-4DO extension cards are used in the same way as DI and DO modules. The extension cards provide mappings to system variables by default, which can be automatically modified.




## 5.2.4 Application Examples

After installing the host and module, right-click "Module Config" in the "Project Manager" tree of the software, select "Auto Scan", and use the configuration scanning function to scan modules and extension cards, as shown in the following figure.




On the "Auto Scan" page, click "Update Config" to add the scanned configuration to default configurations, compile and download it, and check the operation status.

# 5.3 GL20-RTU-ECT Local Extension Module

## 5.3.1 Overview

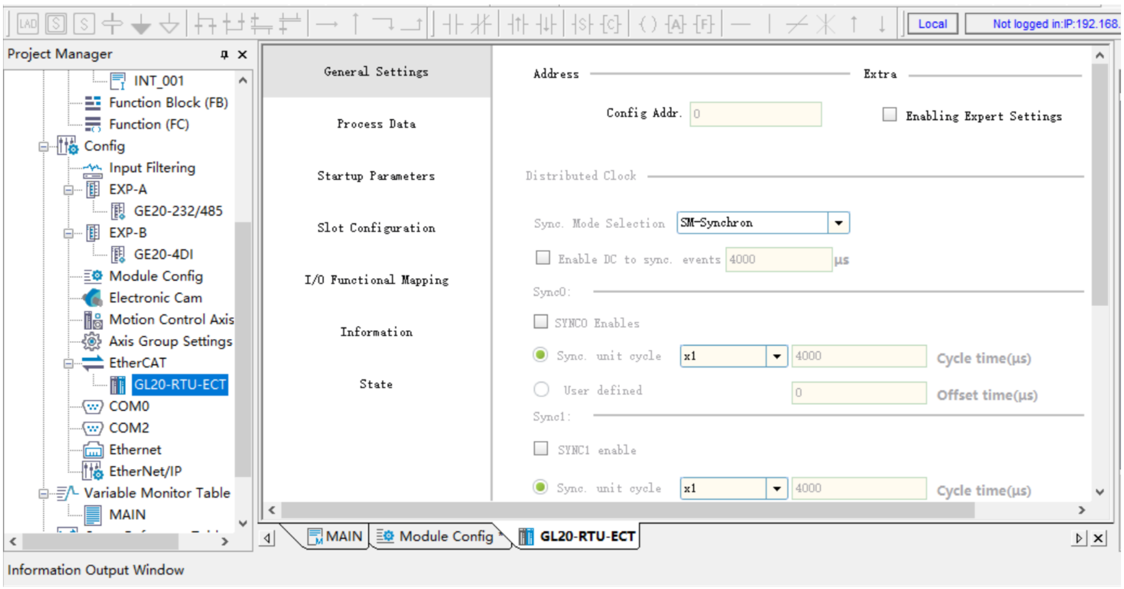
The GL20-RTU-ECT communication port module also supports the following six models.

| Model | Description |
|---|---|
| GL20-0808ETN | 8 DI module and 8 DO module |
| GL20-0008ETN | 8 DO module |
| GL20-0008ETP | 8 DO module |
| GL20-0008ER | 8 DO module |
| GL20-0800END | 8 DI module |
| GL20-4PT | 4-in RTD module |

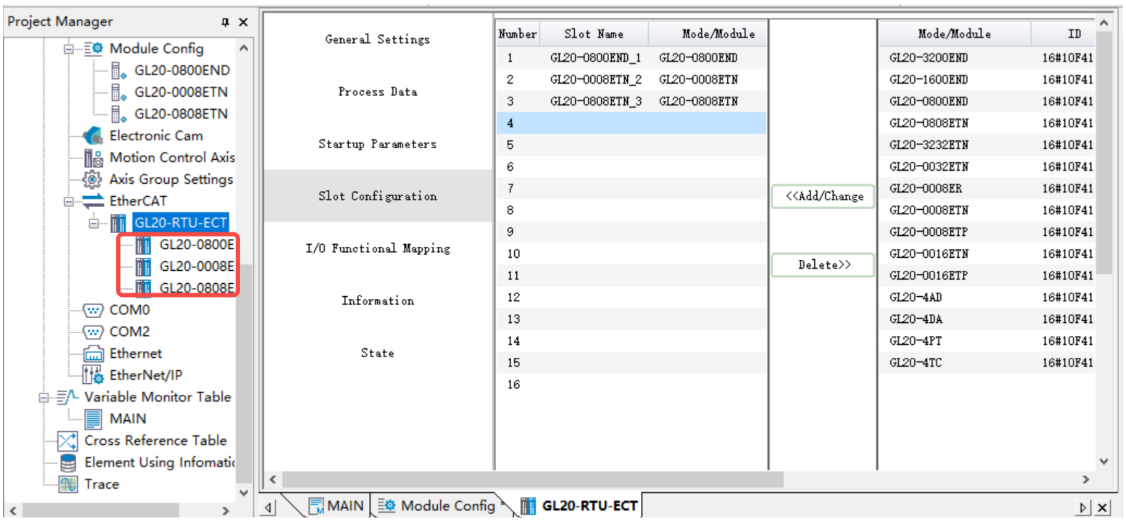
## 5.3.2 Configuring Extension Modules

The GL20-RTU-ECT coupler is mainly mounted by using the EtherCAT bus to add corresponding modules. The procedure is as follows:

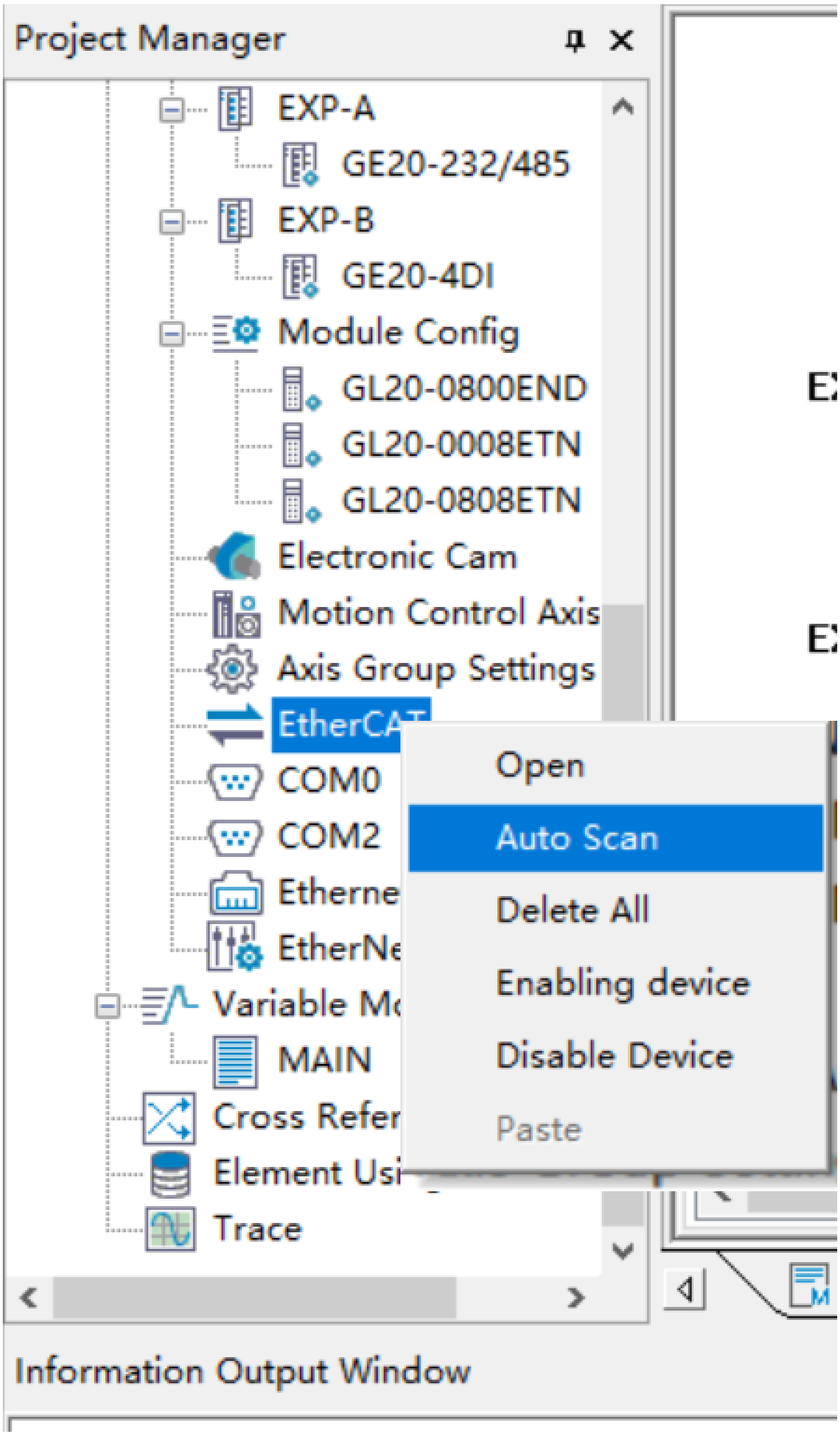
1. In the toolbox, choose "EtherCat Devices" > "Inovance Devices" > "IO coupler" and then double-click "GL20-RTU-ECT_1.2.8.0". The "GL20-RTU-ECT" slave station node is generated under "EtherCat" in the "Project Manager" tree. Double-click it to display the configuration page.



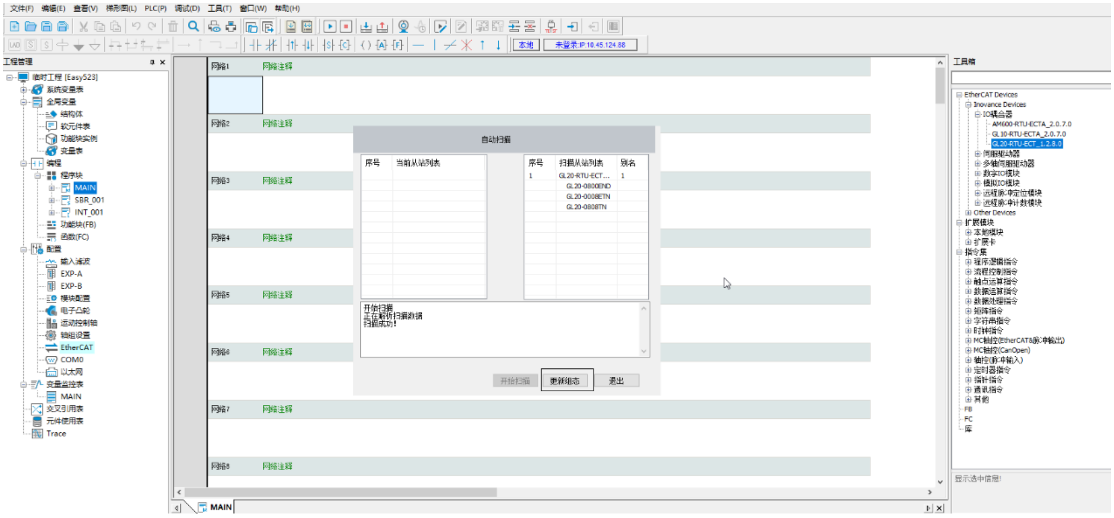

2. Click "Slot configuration" to access the slot configuration page. Select modules on the right, and click "Add/Change" or "Delete". Use the mounted modules GL20-0800END, GL20-0008ETN, and GL20-0808ETN as an example. Select the modules on the right and click "Add/Change" to add them to the left part.



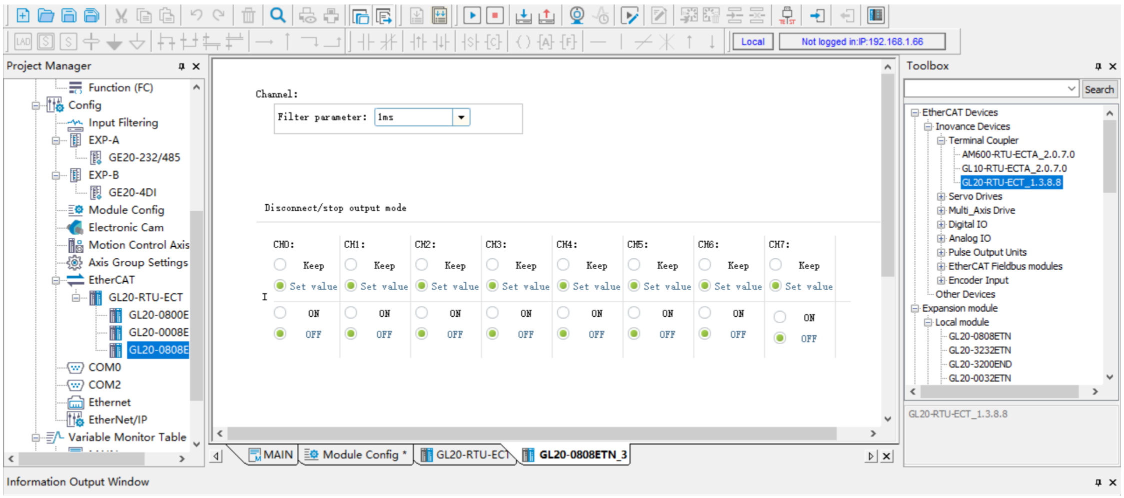

Alternatively, you can wire the modules, power on the PLC, right-click EtherCAT, and select "Auto Scan".



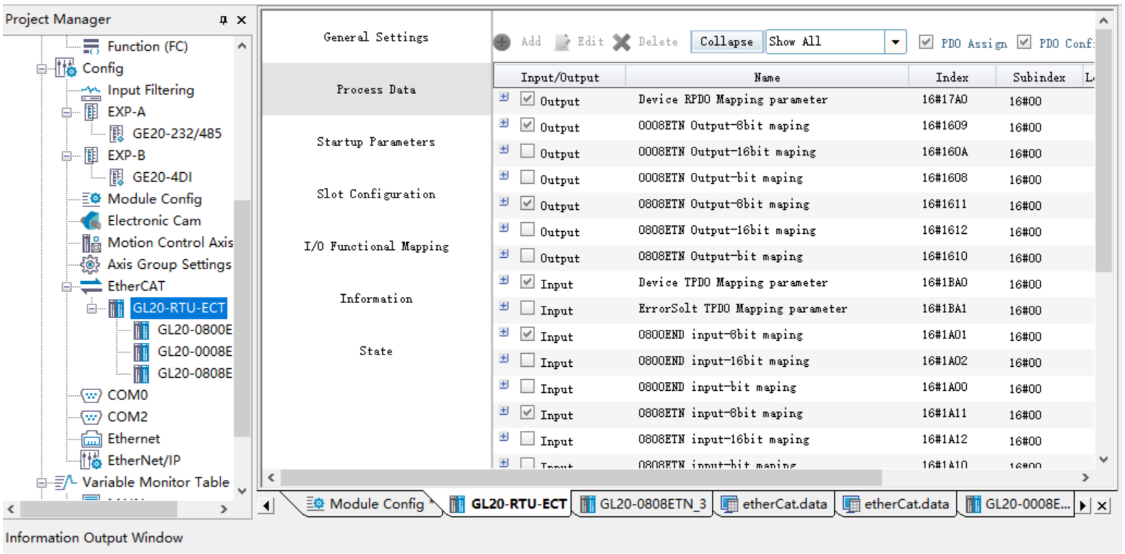

3. Click "Start Scan".



4. Click "Update Config" and select whether to retain current configurations. If so, configurations of slave stations scanned for one or more times will be added next to current configurations. If not, current configurations will be deleted and then scanned default configurations need to be added, with the same result as manual adding.
5. As shown in the following figure, three nodes are generated under GL20-RTU-ECT, indicating three modules. Double-click each node to access the corresponding module configuration page, and configure module parameters.




6. Double-click GL20-RTU_ECT and switch to the "Process data" page and the "Start parameter" page to check the generated process data and startup parameters respectively.



7. Download the generated data and run the PLC. Then, the EtherCAT and GL20-RTC-ECT icons turn green, and no PLC error is reported, indicating that the PLC is running properly.

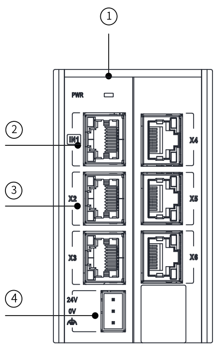
## 5.4 GR10-EC-6SW Branch Module

### 5.4.1 Overview

Caution

The GR10-EC-6SW branch module only supports use with H5U devices.

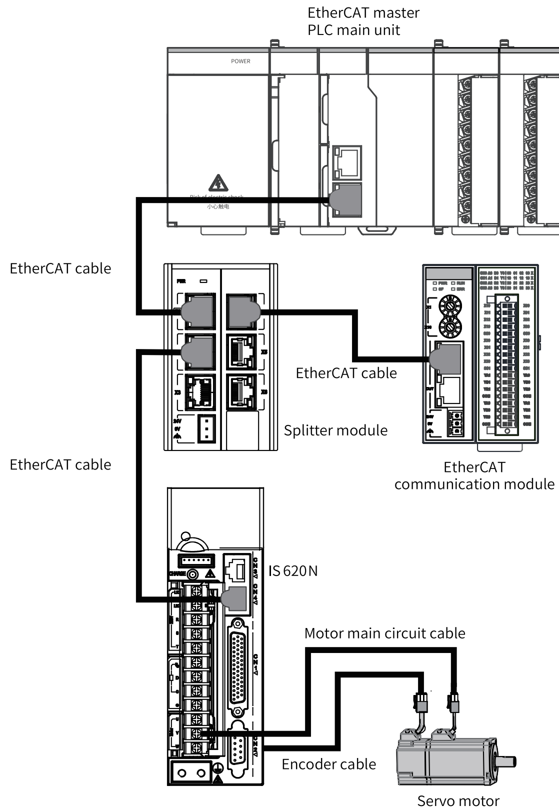
The GR10-EC-6SW branch module is used to extend Extension ports, as shown in the following figure.



| No. | Terminal Name | Definition | | |
|---|---|---|---|---|
| ① | Power indicator | PWR | Green | Turned on upon power-on |
| ② | EtherCAT input port | IN | Port1 and EtherCAT input port, connecting to the front EtherCAT master station | |

| No. | Terminal Name | Definition | |
|---|---|---|---|
| ③ | EtherCAT output port | X2 | Port2 and EtherCAT output port, connecting to the rear EtherCAT slave station |
| | | X3 | Port3 and EtherCAT output port, connecting to the rear EtherCAT slave station |
| | | X4 | Port4 and EtherCAT output port, connecting to the rear EtherCAT slave station |
| | | X5 | Port5 and EtherCAT output port, connecting to the rear EtherCAT slave station |
| | | X6 | Port6 and EtherCAT output port, connecting to the rear EtherCAT slave station |
| ④ | 24 V power input terminal | Power input for a module | |

The GR10-EC-6SW branch module can be connected to multiple EtherCAT slave devices. System wiring is shown in the following figure.



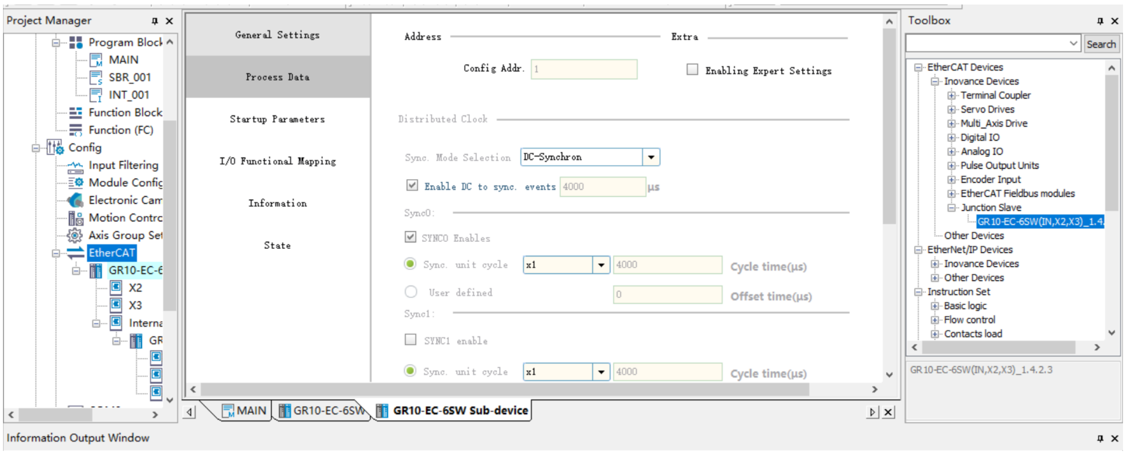

For more information about the GR10-EC-6SW branch module, see the *GR10-EC-6SW 6-EtherCAT Branch Module User Guide*.

## 5.4.2 Adding the Branch Module and Its Slave

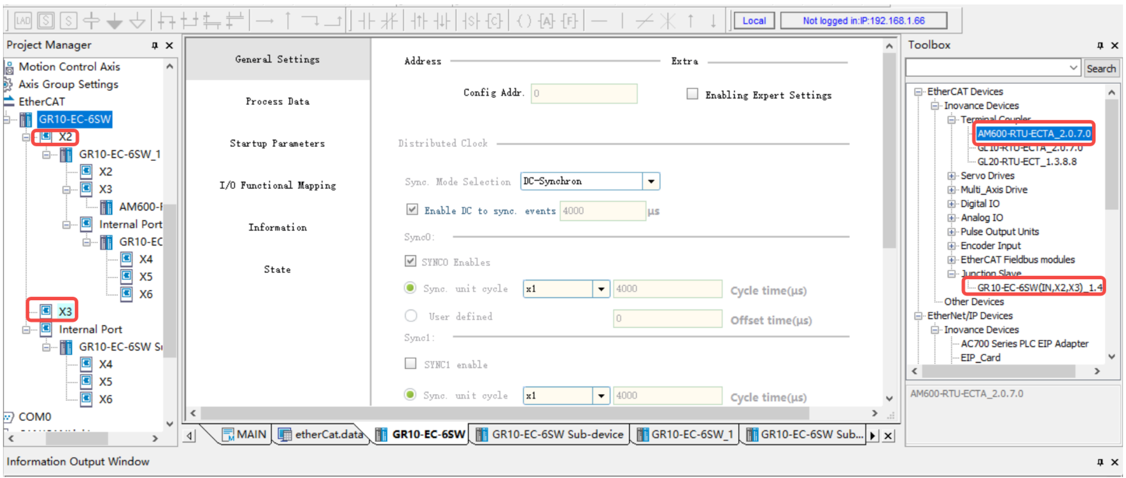
Branch modules and slave devices can be added manually or by automatic scanning.

## Manual adding

1. In the toolbox, choose "EtherCAT Devices" > "Inovance Devices" > "Branch module", and double-click GR10-EC-6SW.




2. Select the EtherCAT output port with the same physical configuration and add a branch module or slave device.
   For example, to use the X2 EtherCAT output port to add a branch module, select "X2" and double-click "GR10-EC-6SW" in the toolbox; to use the X3 EtherCAT output port to add the slave device AM600-RTU-ECTA, select "X3", choose "Inovance Devices" > "IO coupler" in the toolbox, and double-click "AM600-RTU-ECTA".




## Note

- Up to three levels of branch modules can be added.
- Multiple slaves or branch modules can be added under the EtherCAT output port of a branch module.
- If Slave-Disable is turned on for the selected node, all branch nodes under the slave are disabled. Branch nodes also support Slave-Disable. If an EtherCAT output port is disabled, all slaves under the port are disabled.
- Slaves of branch modules do not support copy and paste.

3. For details about the EtherCAT slave station configuration, see section 9.3 "Slave Configuration" in chapter 9 "EtherCAT Communication."

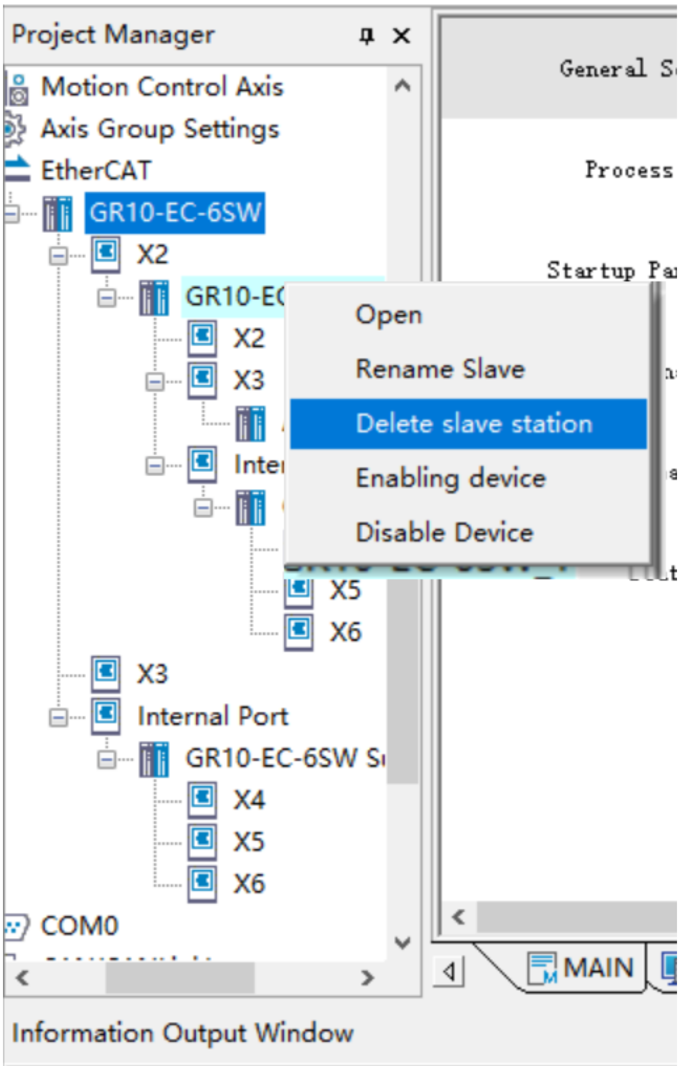
## Automatic scanning

1. In the "Project Manager" tree, right-click "EtherCAT" and select "Auto Scan". Click "Update Config", select not to retain current configurations, and add the GR10-EC-6SW branch module and its slave device.

2. For details about the EtherCAT slave station configuration, see section 9.3 "Slave Configuration" in chapter 9 "EtherCAT Communication."

### 5.4.3 Deleting the Branch Module and Its Slave

In the "Project Manager" tree on the left, right-click the branch module or slave device under "EtherCAT", and select "Delete slave station" to delete the branch module or slave device. After the slave station is deleted, data of the slave station and all its subnodes is deleted.




**Caution**

The branch modules as the X2 to X6 nodes, Internal Port, and GR10-EC-6SW Sub-device node must not be deleted.

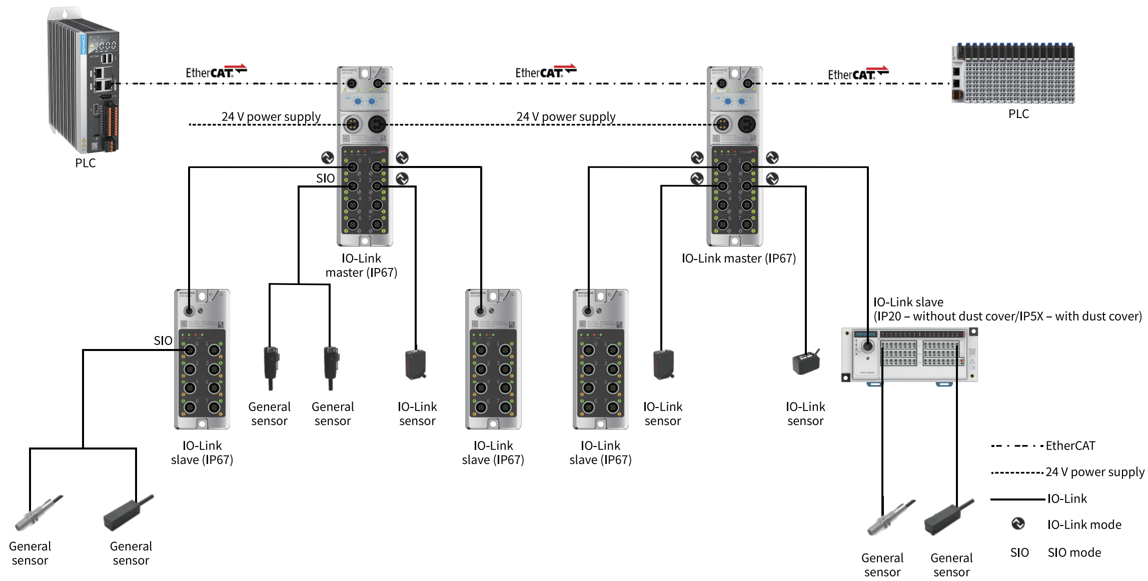
# 5.5 GS20-ECT-8L Module

## 5.5.1 Overview

The GS20-ECT-8L module is connected to the sensor or activator as an EtherCAT slave station using the IO-Link protocol.

IO-Link is a serial digital communication protocol used to integrate a smart sensor and an activator into an automation system. According to IEC 61131-9, it is the first worldwide standard I/O technology for periodic data exchange between sensors/activators and PLCs. IO-Link is an open point-to-point communication protocol but not a fieldbus protocol. The protocol features ease of use, stabilization, reliability, and plug and play and is used more and more widely with the development of industry 4.0.

The IO-Link topology consists of PLCs, IO-Link master stations (GS20-ECT-8L), IO-Link slave stations (GR20-16EMNL, GR20-16EMPL, GS20-16EMNL, or GS20-16EMPL), sensor, activator, and IO-Link cable, as shown in the following figure. IO-Link master stations are connected to each other and PLCs through EtherCAT communication. IO-Link master stations are connected to IO-Link slave stations and sensors/activators and IO-Link slave stations are connected to sensors/activators through IO-Link communication. IO-Link master stations and slave stations can supply power for sensors/activators directly.




---

### *Note*

The IO-Link ports support two working modes: IO-Link mode and Standard I/O (SIO) mode. The working mode can be set separately on any port.

---

## 5.5.2 Configuring the GS20-ECT-8L Module

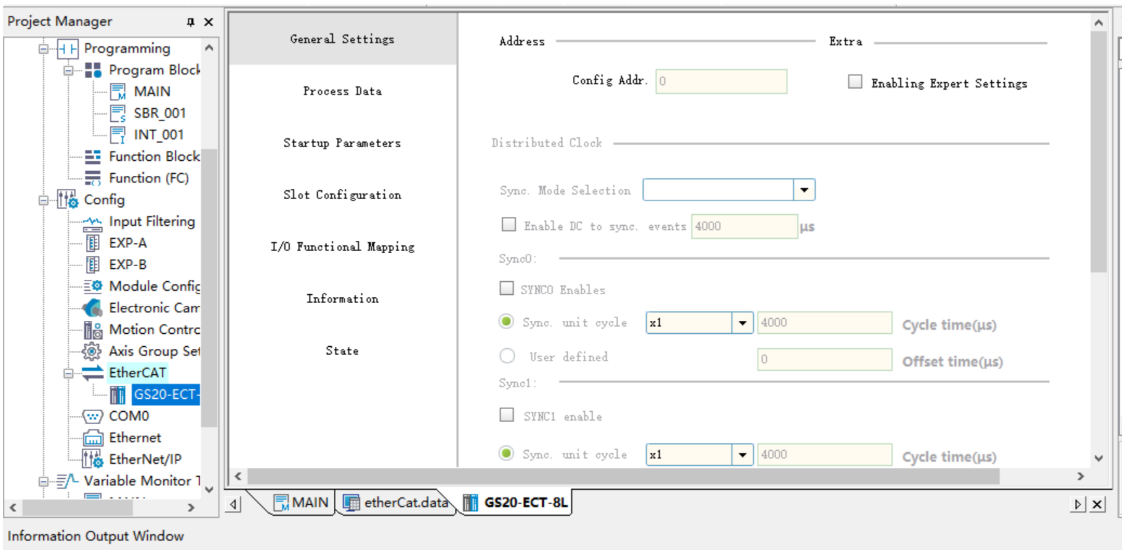
**Prerequisites:** The PLC is connected to the GS20-ECT-8L module through cables and is powered on.

1. Add the GS20-ECT-8L module.

In the toolbox, choose "EtherCAT Devices" > "Inovance Devices" > "EtherCAT Fieldbus modules", and double-click "GS20-ECT-8L" to add the GS20-ECT-8L module. Alternatively, in the "Project Manager" tree, right-click "EtherCAT" and select "Auto Scan". After successful scanning, click "Update Config" to update the device configuration and add the GS20-ECT-8L module.

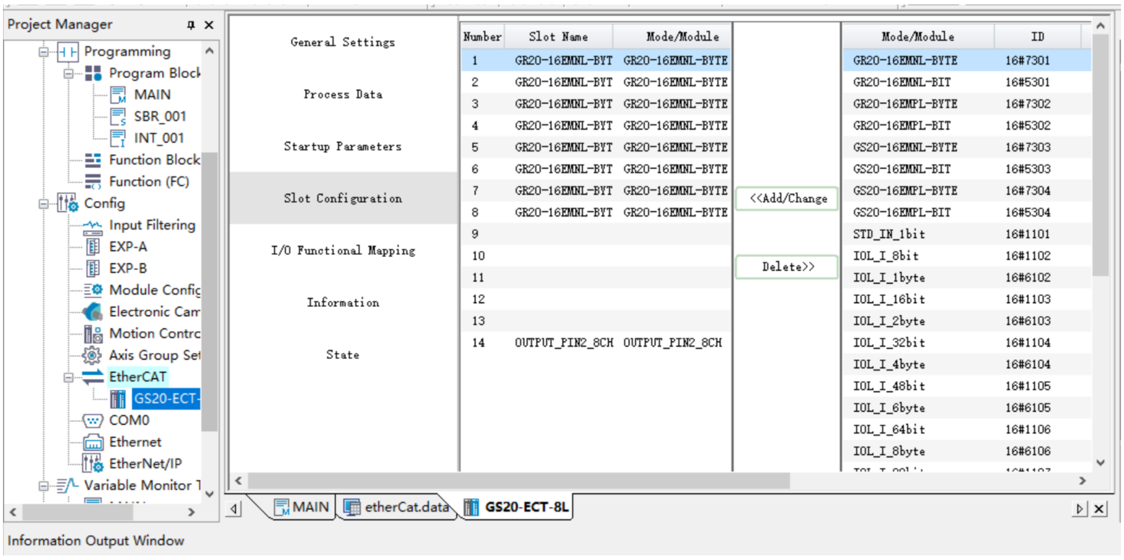
## Note

If you choose to discard the current configuration, delete all slave configurations first, and then add the scanned devices. If you choose to retain the current configuration, add the scanned slaves one by one after the existing slaves.




2. Configure slots.

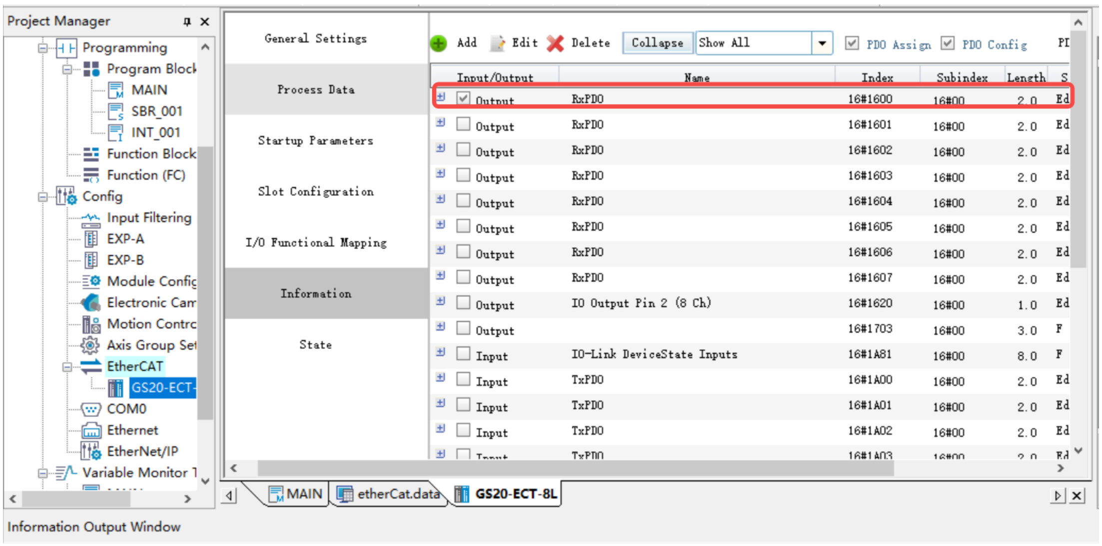
Click "Slot configuration". On the page that is displayed, select corresponding slots and click "Delete" to delete devices from the slots. When the slot area is empty, select target devices on the right and click "Add/Change" to add the selected devices to the slots. The following table lists the slot numbers, names, and description.



| No. | Slot Name | Description |
|---|---|---|
| 1 to 8 (corresponding to IO-Link physical ports 0 to 7 of the GS20-ECT-8L module) | GR20-16EMNL-BYTE, GR20-16EMNL-BIT, GR20-16EMPL-BYTE, GR20-16EMPL-BIT, GS20-16EMNL-BYTE, GS20-16EMNL-BIT, GS20-16EMPL-BYTE, GS20-16EMPL-BIT | Names of Inovance IO-Link slave station modules, where N indicates active low and P indicates active high |
| | STD_IN_1bit | Standard input |
| | STD_OUT_1bit | Standard output |
| | IOL_I_*X*byte/IOL_I_*X*bit | IO_Link input, such as IOL_I_1byte, indicating 1-byte IO-Link input |
| | IOL_O_*X*byte/IOL_O_*X*bit | IO_Link output, such as IOL_O_1byte, indicating 1-byte IO-Link output |
| | IOL_I/O_*X*/_*y*byte/IOL_I/O_*X*/_*y*bit | IO_Link I/O, such as IOL_I/O_1/_1byte, indicating 1-byte IO-Link input and 1-byte IO-Link output |
| 9 | INPUT_PIN2_8CH | PIN2 input |
| 10 | ACTOR_SHORTCIRCUIT_PIN2_8CH | PIN2 short circuit monitoring |
| 11 | ACTOR_SHORTCIRCUIT_PIN4_8CH | PIN4 short circuit monitoring |
| 12 | SENSOR_SUPPLY_SHORTCIRCUIT_8CH | PIN1 short circuit monitoring |
| 13 | SYSTEM_HARDWARE_MONITOR | Hardware status monitoring |
| 14 | OUTPUT_PIN2_8CH | PIN2 output |

3. Configure process data and I/O function mapping.

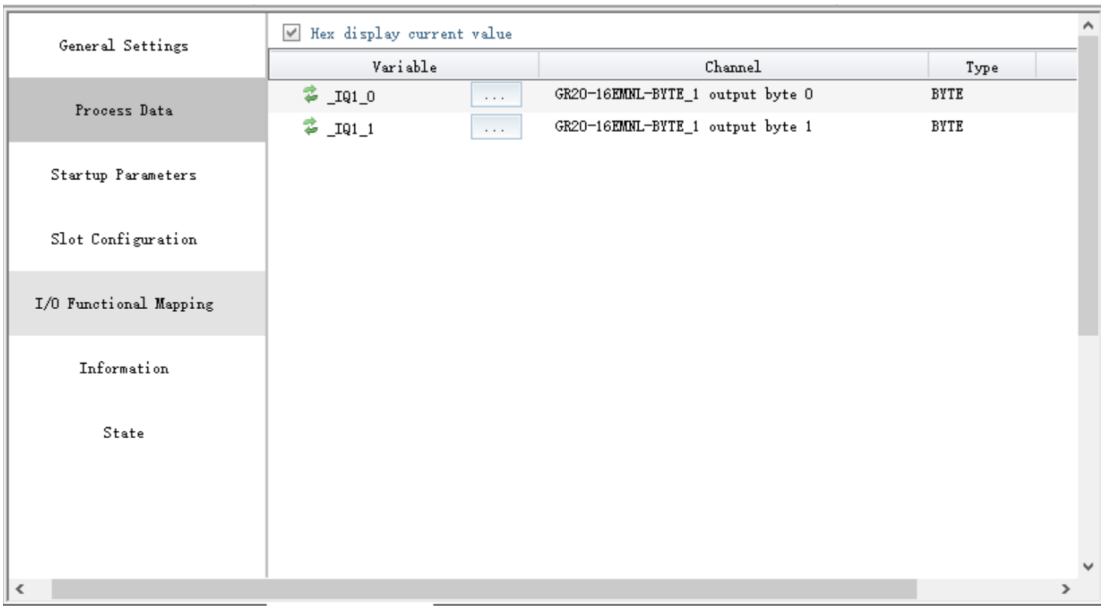
   a. Click "Process data" and select corresponding I/O PDOs as required. The corresponding I/O mapping data is generated on the "I/O function mapping" page. The PDO index 16#1600 is output as an example.




## *Note*

- The background DINT is of the signed 32-bit type, so an error occurs when UDINT data is read. If there is no signed number with more than 32 bits, test whether the value read is correct. If decimal display is incomplete, use hexadecimal display. In hexadecimal display, unsigned 32-bit numbers are displayed. Device IDs and other UDINT type data can be viewed in hexadecimal display.
- The BITARR8 type of PDO data is mapped to the BYTE type by default, and can be operated bitwise according to the BYTE type, or mapped to a BOOL array for reading and writing.

Then, channel mappings for "GR20-16EMNL-BYTE_1 output byte 0" and "GR20-16EMNL-BYTE_1 output byte 1" are generated by default.

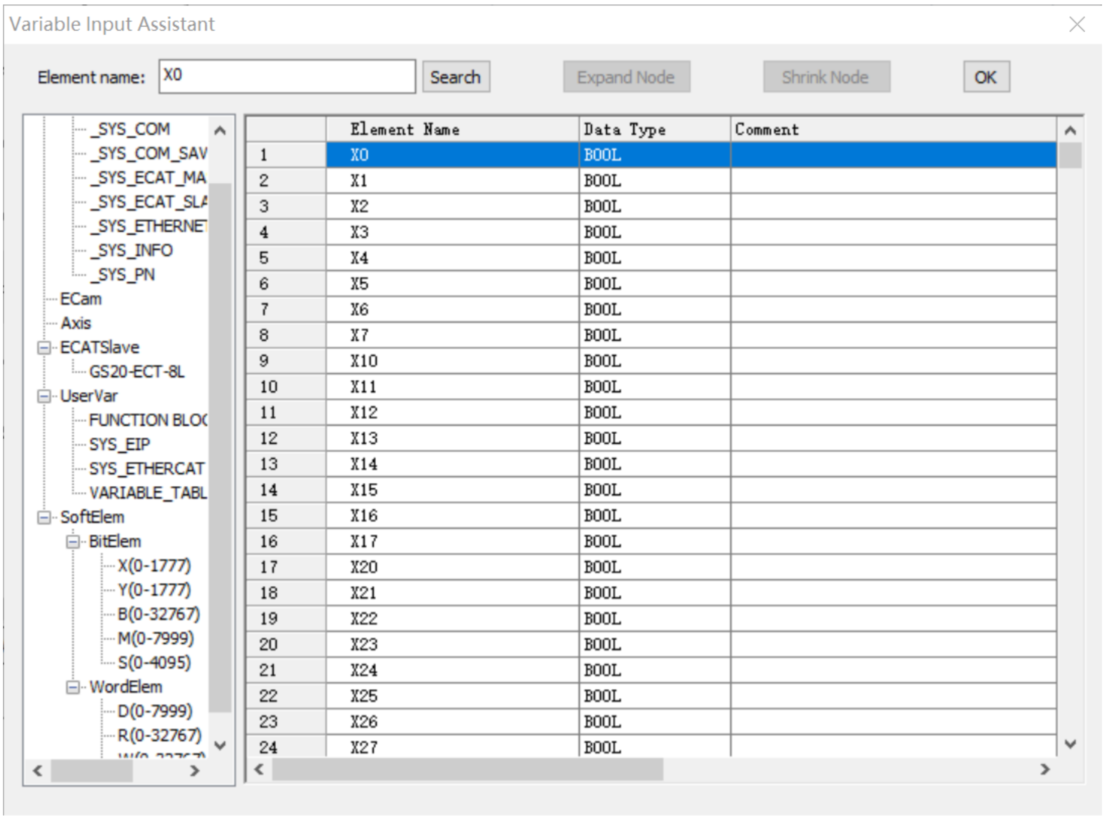



b. (Optional) Set a customized variable.

Click or . In the dialog box that is displayed, select a customized variable and click "OK".

## Note

To use the default mapping variables, skip this step.



c. For example, configure the GR20_16EMPL byte operation through CH0 and the GR20_16EMPL bit operation through CH1 to map the corresponding input and output variables respectively. Set Output_pin2_chn of the corresponding port if the slave station is configured with output data.

d. Download and run the program.

The RUN indicator of the IO-Link master station flashes green and then turns steady green. The "0" indicators of the ports configured to the IO-Link mode flash green.

e. Connect the IO-Link slave station of the GR20-16EMPL model to port 0 and port 1.

The "0" indicators on port 0 and port 1 turn steady green. The "1" indicators on port 0 and port 1 are steady yellow, for example, Output_pin2_chn. At the slave station, the US indicator is steady green and the COM indicator flashes green.

4. Configure parameters of the IO-Link slave station.

Basic parameters of the IO-Link slave station can be configured by index 0x40n0 (n = 0 to 7). For details about indexes, see *"5.5.4.4 IO-Link Slave Configuration Data" on page 229*. I/O port information of the IO-Link slave station is configured as an example as follows:

a. Run the ETC_ReadParameter and ETC_Write_Parameter instructions to set corresponding pin parameters to read and write corresponding indexes. This section describes operations of the ETC_Write_Parameter instruction, which are the same of the ETC_ReadParameter instruction.

## Note

- The string type does not support reading or writing.
- The background DINT is of the signed 32-bit type, so an error occurs when UDINT data is read. If there is no signed number with more than 32 bits, test whether the value read is correct. If decimal display is incomplete, use hexadecimal display. In hexadecimal display, unsigned 32-bit numbers are displayed. Device IDs and other UDINT type data can be viewed in hexadecimal display.
- The ETC_ReadParameter and ETC_Write_Parameter instructions support reading and writing DINT type data, and do not support reading and writing 32-bit BYTE arrays (BYTE[32]).

b. (Optional) Read the I/O port configuration information of the IO-Link slave station.

1). Set "Index" to "0X41" (hexadecimal) or "65" (decimal). The default value of "Subindex" of Inovance IO-Link slave station is 0, which does not need to be changed.

```
ETC_WriteParameter_CoE(Execute := M0,
                       SlaveID := K0,
                       Index := H4000,
                       SubIndex := K3,
                       DstLength := K4,
                       Data := H41,
                       Done => ,
                       Busy => ,
                       AbortCode => ,
                       Error => Error,
                       ErrorID => ErrorID);

ETC_WriteParameter_CoE(Execute := M0,
                       SlaveID := K0,
                       Index := H4000,
                       SubIndex := K4,
                       DstLength := K4,
                       Data := K0,
                       Done => ,
                       Busy => ,
                       AbortCode => ,
                       Error => Error1,
                       ErrorID => ErrorID1);
```

2). Set "Length" based on the index length of the IO-Link slave station in bytes, for example, 2 bytes. For details, see the "Object List" section in the IO-Link Slave Station User Guide.

```
ETC_WriteParameter_CoE(Execute := M0,
                       SlaveID := K0,
                       Index := H4000,
                       SubIndex := K5,
                       DstLength := K2,
                       Data := K2,
                       Done => ,
                       Busy => ,
                       AbortCode => ,
                       Error => Error2,
                       ErrorID => ErrorID2);
```

3). Set "Control" to 0 and then to 3 to read the I/O port configuration information of the IO-Link slave station.

```
ETC_WriteParameter_CoE(Execute := M0,
                       SlaveID := K0,
                       Index := H4000,
                       SubIndex := K1,
                       DstLength := K2,
                       Data := K0,
                       Done => ,
                       Busy => ,
                       AbortCode => ,
                       Error => Error3,
                       ErrorID => ErrorID3);

ETC_WriteParameter_CoE(Execute := M0,
                       SlaveID := K0,
                       Index := H4000,
                       SubIndex := K1,
                       DstLength := K2,
                       Data := K3,
                       Done => ,
                       Busy => ,
                       AbortCode => ,
                       Error => Error4,
                       ErrorID => ErrorID4);
```

c. Configure the I/O port information of the IO-Link slave station.

1). Set "Index" to "0X41" (hexadecimal) or "65" (decimal). The default value of "Subindex" of Inovance IO-Link slave station is 0, which does not need to be changed.

```
ETC_WriteParameter_CoE(Execute := M0,
                       SlaveID := K0,
                       Index := H4000,
                       SubIndex := K3,
                       DstLength := K4,
                       Data := H41,
                       Done => ,
                       Busy => ,
                       AbortCode => ,
                       Error => Error,
                       ErrorID => ErrorID);

ETC_WriteParameter_CoE(Execute := M0,
                       SlaveID := K0,
                       Index := H4000,
                       SubIndex := K4,
                       DstLength := K4,
                       Data := K0,
                       Done => ,
                       Busy => ,
                       AbortCode => ,
                       Error => Error1,
                       ErrorID => ErrorID1);
```

2). Set "Length" based on the index length of the IO-Link slave station in bytes. For details, see the "Object List" section in the IO-Link Slave Station User Guide.

```
ETC_WriteParameter_CoE(Execute := M0,
                       SlaveID := K0,
                       Index := H4000,
                       SubIndex := K5,
                       DstLength := K2,
                       Data := K2,
                       Done => ,
                       Busy => ,
                       AbortCode => ,
                       Error => Error2,
                       ErrorID => ErrorID2);
```

3). Set "Data". Value 1 indicates output and value 0 indicates input. For example, configure the low-order 8 bits of the IO-Link slave station as output and the high-order 8 bits as input, and set "Data[0]" to 255 and "Data[1]" to 0.

```
ETC_WriteParameter_CoE(Execute := M0,
                       SlaveID := K0,
                       Index := H4000,
                       SubIndex := K6,
                       DstLength := K2,
                       Data := HFF,
                       Done => ,
                       Busy => ,
                       AbortCode => ,
                       Error => Error5,
                       ErrorID => ErrorID5);
```

4). Set "Control" to 0 and then to 2 to configure the I/O port information of the IO-Link slave station.

```
ETC_WriteParameter_CoE(Execute := M0,
                       SlaveID := K0,
                       Index := H4000,
                       SubIndex := K1,
                       DstLength := K2,
                       Data := K0,
                       Done => ,
                       Busy => ,
                       AbortCode => ,
                       Error => Error6,
                       ErrorID => ErrorID6);

ETC_WriteParameter_CoE(Execute := M0,
                       SlaveID := K0,
                       Index := H4000,
                       SubIndex := K1,
                       DstLength := K2,
                       Data := K2,
                       Done => ,
                       Busy => ,
                       AbortCode => ,
                       Error => Error7,
                       ErrorID => ErrorID7);
```

5. Verify the configuration correctness.

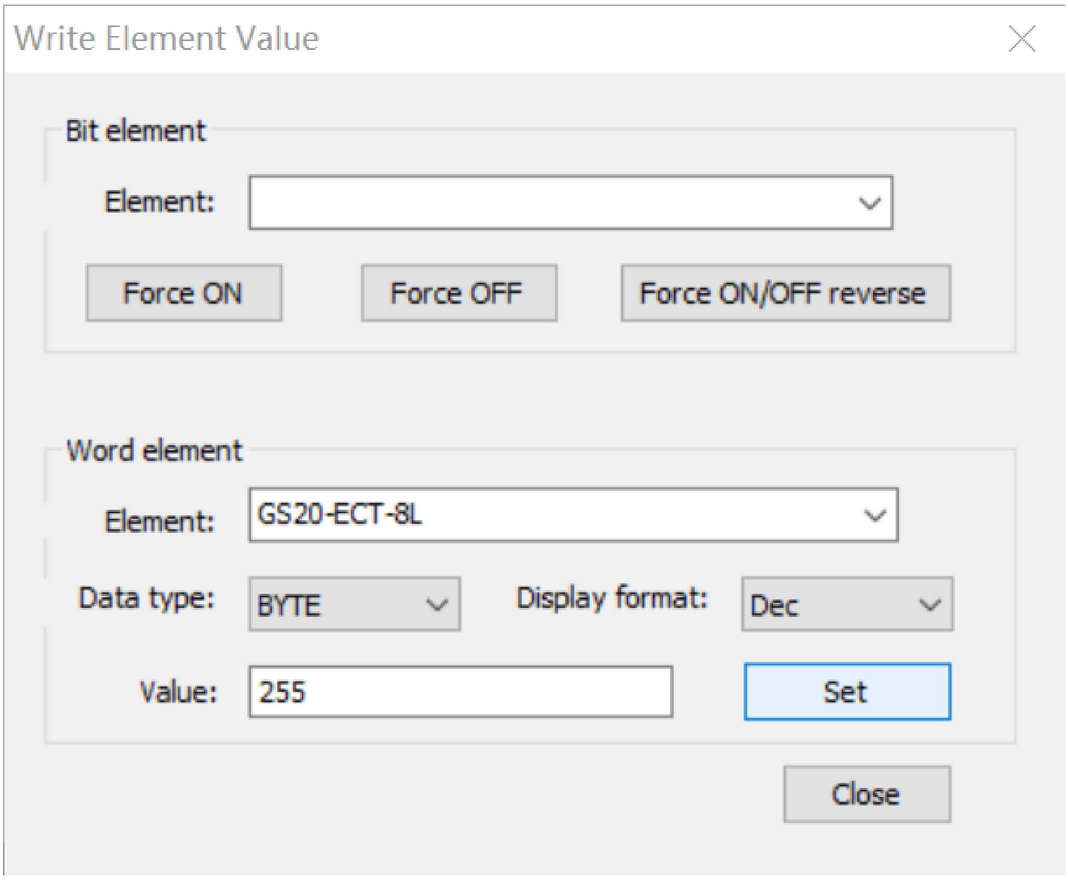
After the configuration is completed, verify whether the configuration is correct. This section verifies whether port 0 and port 1 of GS20-ECT-8L are correctly configured based on the short connection between the low-order 8 bits (configured to output) and high-order 8 bits (configured to input) of GR20-16EMPL of the IO-Link slave station.

a. Use an I/O cable for short connection between the low-order 8 bits and high-order 8 bits of GR20-16EMPL.

b. Verify whether port 0 of GS20-ECT-8L is correctly configured.

1). Use an IO-Link communication cable to connect the IO-Link port of GR20-16EMPL to port 0 of GS20-ECT-8L.

2). Make the system enter the monitoring mode, and double-click "GS20-ECT-8L". On the page that is displayed, click "I/O function mapping", and double-click the low-order 8 bit output data of port 0 of GS20-ECT-8L. In the dialog box that is displayed, set "Value" to 255 to output signal 1 for the eight input ports of the IO-Link slave station of GR20-16EMPL.



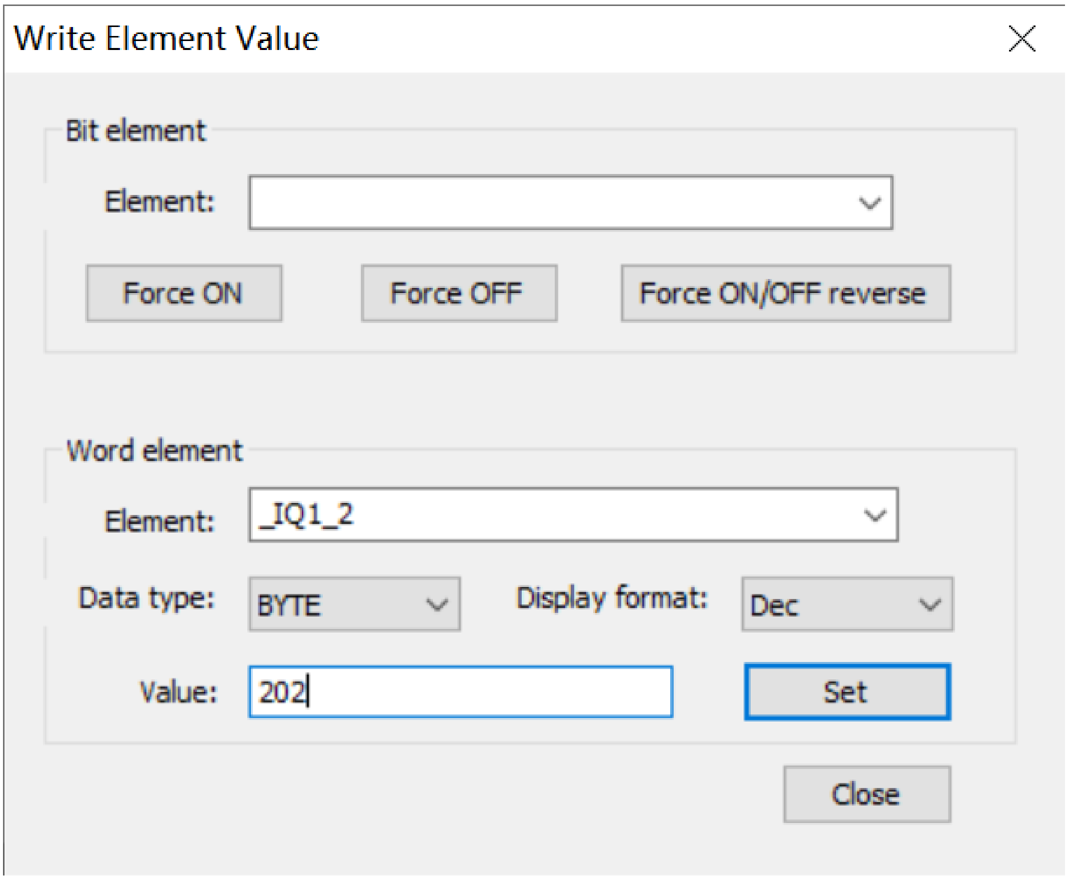

3). Check the high-order 8 bit input data of port 0 of GS20-ECT-8L and the status of I/O indicators on the IO-Link slave station of GR20-16EMPL.

If the high-order 8 bit input data of port 0 of GS20-ECT-8L is 255 and all the I/O indicators on the IO-Link slave station of GR20-16EMPL are turned on, the configuration is correct. Otherwise, the configuration is incorrect. Contact our technical support personnel for help.

c. Verify whether port 1 of GS20-ECT-8L is correctly configured.

1). Use an IO-Link communication cable to connect the IO-Link port of GR20-16EMPL to port 1 of GS20-ECT-8L.

2). Double-click "GS20-ECT-8L". On the page that is displayed, click "I/O function mapping", and double-click the low-order 8 bit output data of port 1 of GS20-ECT-8L. In the dialog box that is displayed, set "Value" to 202 as an example to output the "TRUE" or "FALSE" signal for the eight input ports of the IO-Link slave station of GR20-16EMPL. By default, BYTE variables are mapped, and the binary code of 202 is 11001010, indicating that the first, third, sixth, and seventh bits are set to TRUE and other bits are set to FALSE.




3). Check the high-order 8 bit input data of port 1 of GS20-ECT-8L and the status of I/O indicators on the IO-Link slave station of GR20-16EMPL.

If the high-order 8 bit input data of port 1 of GS20-ECT-8L is the same as the low-order 8 bit output data, and the I/O indicators on the IO-Link slave station of GR20-16EMPL are displayed accordingly, the configuration is correct. Otherwise, the configuration is incorrect. Contact our technical support personnel for help.

## 5.5.3 Fault Diagnosis

### 5.5.3.1 EtherCAT Diagnosis

| LED Indicator | | Description | Possible Cause | Solution |
|---|---|---|---|---|
| RUN | Off | The EtherCAT slave station is in the initialization state | The EtherCAT master station is not connected to the EtherCAT slave station | • Check that the configuration and parameter distribution are correct<br>• Check that the communication address configuration is correct<br>• Check that the network cable specifications (M12 interface, with a shielded Cat5e network cable) and length (within 100 m) meet the requirements |
| | Flashing green | The EtherCAT slave station is in the pre-operational state | The EtherCAT slave station is in a non-OP state | • Check that the EtherCAT slave station configuration is correct<br>• Check that the EtherCAT slave station is faulty<br>• Check that all EtherCAT slave stations are configured |
| | Flashing green only | The EtherCAT slave station is in the safe-operational state | | |
| ERR | Flashing red | The EtherCAT communication network is abnormal | • The EtherCAT master station does not exchange data with the EtherCAT slave station<br>• EtherCAT receives status conversion instructions that cannot be executed<br>• EtherCAT synchronization fails<br>• A watchdog error occurs in EtherCAT communication | • Check that the M12 network cable plus is correctly inserted<br>• Check that the network cable is not damaged<br>• Check that the PDO configuration is correct<br>• Restart the power supply |

### 5.5.3.2 IO-Link Diagnosis

The following table lists the error codes and their definitions.

| Type | Fault Code | Description |
|---|---|---|
| System | 0x0002 | US supply overvoltage |
| | 0x0003 | US supply undervoltage |
| | 0x0004 | UA supply overvoltage |
| | 0x0005 | UA supply undervoltage |
| | 0x0006 | MCU temperature over 80°C |
| | 0x0008 | Port communication disconnection |
| | 0x000c | Pin2 short circuit |
| IO-Link master station | 0x1800 | Port connection to no device |
| | 0x1801 | Parameter loading failure |
| | 0x1802 | Invalid vendor ID |
| | 0x1803 | Invalid device ID |
| | 0x1804 | Pin4 short circuit |
| | 0x1805 | PHY chip overtemperature |
| | 0x1806 | Pin1 short circuit |
| | 0x1807 | Pin1 overcurrent |
| | 0x1808 | Slave device event overflow |
| | 0x1811 | Pin4 short circuit (DO mode) |
| | 0x1813 | Pin4 overcurrent (DO mode) |
| | 0x6000 | Invalid cycle time |
| | 0x6001 | Incorrect version for slave station |

## 5.5.4 Object List

### 5.5.4.1 Process Data

The input data of the IO-Link master station indicates TxPDO of the IO-Link slave station. If the IO-Link slave station with TxPDO is connected, the port of the IO-Link master station must be configured with input data. The following table defines TxPDO data of the IO-Link slave station. In the table, the entry names and slave implementation may be different, and n indicates the port number of the IO-Link master station.

| **Index 0xF100 CHn IO-Link Communication Status (for 0 ⩽ n ⩽ 7)** | | | | |
|---|---|---|---|---|
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0xF100:00 | Sub-index 00 | Highest sub-index supported | USINT | 0x08 (8dec) |

| | | | | |
|---|---|---|---|---|
| 0xF100:01 | Sub-index 01 | Status of communication between the master station and the slave station<br>**Bit 0 to bit 3: IO-Link status**<br>0: Port inactive<br>1: Input mode<br>2: Output mode<br>3: Communication OP<br>4: Communication failure<br>**Bit 4 to bit 7: error code**<br>00: No error<br>1: Watchdog error<br>2: Buffer overflow<br>3: Invalid device ID<br>4: Invalid vendor ID<br>5: Invalid version<br>6: Invalid frame function<br>7: Invalid cycle time<br>8: Invalid length for input process data<br>9: Invalid length for output data<br>10: Connection to no device<br>11: None | USINT | 0x00 (0dec) |
| ... | ... | | ... | ... |
| 0xF100:08 | Sub-index 08 | | USINT | 0x00 (0dec) |
| **Index 0x20n0 Ch.n Pin2 status monitoring input process data (for 0 ⩽ n ⩽ 7)** | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0x20n0:00 | Sub-index 00 | Highest sub-index supported | USINT | 0x02 (2dec) |
| 0x20n0:01 | Sub-index 01 | Pin2 input process data<br>• 0: Disable<br>• 1: Enable | USINT | 0x00 (0dec) |
| 0x20n0:02 | Sub-index 02 | Short circuit status upon Pin2 configuration as output<br>• 0: No short circuit information<br>• 1: Short circuit | USINT | 0x00 (0dec) |
| **Index 0x20n1 Ch.n Pin4 and Pin1 short circuit status monitoring (for 0 ⩽ n ⩽ 7)** | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Default** |

| | | | | |
|---|---|---|---|---|
| 0x20n1:00 | Sub-index 00 | Highest sub-index supported | USINT | 0x02 (2dec) |
| 0x20n1:01 | Sub-index 01 | Short circuit status upon Pin4 configuration as output<br>• 0: No short circuit information<br>• 1: Short circuit | USINT | 0x00 (0dec) |
| 0x20n1:02 | Sub-index 02 | Pin1 short circuit status<br>• 0: No short circuit information<br>• 1: Short circuit | USINT | 0x00 (0dec) |
| **Index 0x2A02 hardware status monitoring** | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0x2A02:00 | Sub-index 00 | Highest sub-index supported | USINT | 0x03(3dec) |
| 0x2A02:01 | Sub-index 01 | Activator power voltage detection<br>• 00: 18 < UA < 30.2<br>• 01: 11 < UA < 18<br>• 10: UA > 30.2<br>• 11: UA < 11 | USINT | 0x00 (0dec) |
| 0x2A02:02 | Sub-index 02 | System power voltage detection<br>• 00: 18 < US < 30.2<br>• 01: 11 < US < 18<br>• 10: US > 30.2<br>• 11: US < 11 | USINT | 0x00 (0dec) |
| 0x2A02:03 | Sub-index 03 | MCU internal temperature detection<br>• 00: 0 < internal temperature < 85<br>• 01: internal temperature < 0<br>• 10: internal temperature > 85<br>• 11: Reserved | USINT | 0x00 (0dec) |
| **Index 0x30n8 Ch.n Pin2 output data in DO mode (for 0 ⩽ n ⩽ 7)** | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0x30n8:00 | Sub-index 00 | Highest sub-index supported | USINT | 0x01 (1dec) |
| 0x30n8:01 | Sub-index 01 | Pin2 output data<br>• 0: Disable<br>• 1: Enable | BIT | 0 |
| **Index 0x60n0 Ch.n IO-Link input data (for 0 ⩽ n ⩽ 7)** | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0x60n0:00 | Sub-index 00 | Highest sub-index supported | USINT | 0x00 (0dec) |

| | | | | |
|---|---|---|---|---|
| 0x60n0:01 | TxPDO 01 | IO-Link input process data [00] | UDINT | 0x00 (0dec) |
| ... | ... | ... | ... | ... |
| 0x60n0:20 | TxPDO 32 | IO-Link input process data [32] | UDINT | 0x00 (0dec) |
| **Index 0x70n0 Ch.n output data (for 0 ≤ n ≤ 7)** | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0x70n0:00 | Sub-index 00 | Highest sub-index supported | USINT | 0x00 (0dec) |
| 0x70n0:01 | RxPDO 01 | IO-Link output process data [00] | UDINT | 0x00 (0dec) |
| ... | ... | ... | ... | ... |
| 0x70n0:20 | RxPDO 32 | IO-Link output process data [32] | UDINT | 0x00 (0dec) |

The following table lists configuration data of the IO-Link port.

| **Index 0x20n3 Ch.n Pin4 parameters in DO mode (for 0 ≤ n ≤ 7)** | | | | | |
|---|---|---|---|---|---|
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 0x20n3:00 | IO Settings Ch.1- 8 | Highest sub-index supported | USINT | RW | 0x1(1dec) |
| 0x20n3:01 | Pin4 safe state | Safe state preset value upon Pin4 configuration as output<br>• 0x00: Output 0 upon a communication error<br>• 0x01: Output 1 upon a communication error<br>• 0x02: Last output value upon a communication error | UDINT | RW | 0x00 (0dec) |
| **Index 0x20n2 Ch.n Pin2 parameters in DO mode (for 0 ≤ n ≤ 7)** | | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 0x20n2:00 | IO Settings Ch.1- 8 | Highest sub-index supported | USINT | RW | 0x1(1dec) |
| 0x20n2:01 | Pin2 safe state | Safe state preset value upon Pin2 configuration as output<br>• 0x00: Output 0 upon a communication error<br>• 0x01: Output 1 upon a communication error<br>• 0x02: Last output value upon a communication error | UDINT | RW | 0x00 (0dec) |

### 5.5.4.2 EtherCAT Object Dictionary Data (CoE Object)

The object dictionary of the EtherCAT IO-Link master station contains SDO-based addressing objects and the standard objects and manufacturer objects supported by the IO-Link master station. The ETG.1000.6: Application Layer protocol specification describes standard objects and ETG.5001-6220 describes the modular equipment profile objects. In addition, the manufacturer objects can be addressed by combination of indexes and sub-indexes. Sub-index 0 indicates the number of sub-indexes or highest-level sub-indexes.

| **Index 0x1000 EtherCAT slave station device type** | | | | | |
|---|---|---|---|---|---|
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |

| | | | | | |
|---|---|---|---|---|---|
| 1000:00 | Device type | Device type of the EtherCAT slave station | UDINT | RO | 0x1389 (5001dec) |
| **Index 0x1001 error register** | | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 1001:00 | Error register | Error register | USINT | RO | 0x00 |
| **Index 0x1001 EtherCAT slave station device name** | | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 1008:00 | Device name | Device name | STRING(11) | RO | GS20-ECT-8L |
| **Index 0x1008 EtherCAT slave station hardware version information** | | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 1009:00 | Hardware version | Hardware version of the EtherCAT slave station | STRING(16) | RO | A00.01 |
| **Index 0x100A EtherCAT slave station protocol stack software version information** | | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 100A:00 | Slave version | Software version of the EtherCAT slave station protocol stack | STRING(4) | RO | 5.13 |
| **Index 0x100B IO-LINK master station product-related version information** | | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 100B:00 | Software version | Highest sub-index supported | USINT | RO | 0x04 |
| 100B:01 | App version | Application software version | UDINT | RO | 0x10100000 |
| 100B:02 | FPGA version | FPGA software version | UDINT | RO | 0x10100000 |
| 100B:03 | IOLM version | Software version of the IO-Link master station | UDINT | RO | 0x0305 |
| **Index 0x1018 EtherCAT slave station identity information** | | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 1018:00 | Identity | Highest sub-index supported | USINT | RO | 0x04 (4dec) |
| 1018:01 | Vendor ID | Vendor ID of the EtherCAT slave station | UDINT | RO | 0x00100000 |
| 1018:02 | Product code | Product code of the EtherCAT slave station | UDINT | RO | 0x10F42EE1 |
| 1018:03 | Revision | Firmware version of the product application | STRING(11) | RO | 1.1.0.0 |
| 1018:04 | Serial number | Production serial number | UDINT | RO | 0x15FA66 |
| **Index 0x10F3 diagnosis history** | | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 10F3:00 | Diagnosis history | Highest sub-index supported | USINT | RO | 0x16 |

| | | | | | |
|---|---|---|---|---|---|
| 10F3:01 | Maximum message | Maximum number of diagnosis messages | USINT | RO | 0x14 (20dec) |
| 10F3:02 | Newest message | Sub-index of the latest diagnosis message | USINT | RO | 0x00000000 (0dec) |
| 10F3:03 | Newest acknowledged message | Latest acknowledged message | USINT | RW | 0x00000000 (0dec) |
| 10F3:04 | New message available | New diagnosis information | BOOL | RO | 0 |
| 10F3:05 | Flags | Setting for send and store diagnosis messages | UINT | RW | 0x00000000 (0dec) |
| 10F3:06 | Diagnosis message 01 | Diagnosis information 1 | ARRAY [0..27] OF BYTE | RO | 0x00000000 (0dec) |
| ... | ... | ... | ... | ... | ... |
| 10F3:40 | Diagnosis message 64 | Diagnosis information 64 | ARRAY [0..27] OF BYTE | RO | 0x00000000 (0dec) |
| **Index 0x3010 ESC port 0 error counter** | | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 3010:00 | Port0 error counter | Highest sub-index supported | USINT | RO | 0x04 (4dec) |
| 3010:01 | Port0 invalid frame counter | Number of invalid frames for ESC port 0 | USINT | RO | 0x00 (0dec) |
| 3010:02 | Port0 Rx error counter | Number of error frames for ESC port 0 | USINT | RO | 0x00 (0dec) |
| 3010:03 | Port0 forwarded Rx error counter | Number of error loopback frames for ESC port 0 | USINT | RO | 0x00 (0dec) |
| 3010:04 | Port0 lost link counter | Number of lost frames for ESC port 0 | USINT | RO | 0x00 (0dec) |
| **Index 0x3011 ESC port 0 error counter** | | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 3011:00 | Port1 error counter | Highest sub-index supported | USINT | RO | 0x04 (4dec) |
| 3011:01 | Port1 invalid frame counter | Number of invalid frames for ESC port 1 | USINT | RO | 0x00 (0dec) |
| 3011:02 | Port1 Rx error counter | Number of error frames for ESC port 1 | USINT | RO | 0x00 (0dec) |
| 3011:03 | Port1 forwarded Rx error counter | Number of error loopback frames for ESC port 1 | USINT | RO | 0x00 (0dec) |

| | | | | | |
|---|---|---|---|---|---|
| 3011:04 | Port1 lost link counter | Number of lost frames for ESC port 1 | USINT | RO | 0x00 (0dec) |
| **Index 0x3012 ESC error counter** | | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 3012:00 | ESC error counter | Highest sub-index supported | USINT | RO | 0x04 (4dec) |
| 3012:01 | ECAT processing unit error counter | Error counter for the ESC processing unit | USINT | RO | 0x00 (0dec) |
| 3012:02 | PDI error counter | PDI error counter | USINT | RO | 0x00 (0dec) |
| 3012:03 | Watchdog counter process data | Number of watchdogs for process data | USINT | RO | 0x00 (0dec) |
| 3012:04 | Watchdog counter PDI | Number of PDI watchdogs | USINT | RO | 0x00 (0dec) |
| **Index 0x3016 station address** | | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 3016:00 | Station address | Highest sub-index supported | USINT | RO | 0x04 (4dec) |
| 3016:01 | Rotary switch value | DIP switch value | USINT | RO | 0x00 (0dec) |
| 3016:02 | Configured station address | Configured station address | USINT | RO | 0x00 (0dec) |
| 3016:03 | Configured station alias | Configured station alias | USINT | RO | 0x00 (0dec) |
| 3016:04 | Alias in EEPROM | Alias in EEPROM | USINT | RO | 0x00 (0dec) |

The following table lists configuration data of the IO-Link port.

| **Index 0x80n0 Ch.n IO-Link port configuration data (for 0 ⩽ n ⩽ 7)** | | | | | |
|---|---|---|---|---|---|
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 0x80n0:00 | IO Settings Ch.1- 8 | Highest sub-index supported | USINT | RW | 0x28 (40dec) |
| 0x80n0:04 | Device ID | ID of the IO-Link device | UDINT | RW | 0x00000000 (0dec) |
| 0x80n0:05 | VendorID | Vendor ID of the IO-Link device | UDINT | RW | 0x00000000 (0dec) |
| 0x80n0:06 | Product ID | Product ID of the IO-Link device | USINT | RW | 0x00000000 (0dec) |
| 0x80n0:08 | Serial number | Serial number of the IO-Link device | USINT | RW | 0x00000000 (0dec) |
| 0x80n0:20 | IO-Link revision | Version of the specification for IO-Link device communication<br>• Bit 0 to bit 3: Minor version<br>• Bit 4 to bit 7: Major version | USINT | RW | 0x00 (0dec) |
| 0x80n0:21 | Frame capability | Reserved | USINT | RW | 0x00 (0dec) |

| | | | | | |
|---|---|---|---|---|---|
| 0x80n0:22 | Min cycle time | Cycle time① between the IO-Link master station and slave station, which is transmitted by IO-Link data frames of the minimum cycle<br>• Bit 6 to bit 7: Time base<br>• Bit 0 to bit 5: Ratio<br>• 0x00: The IO-Link master station automatically uses the update time of the IO-Link device | USINT | RW | 0x00 (0dec) |
| 0x80n0:23 | Offset time | Reserved | USINT | RW | 0x00 (0dec) |
| 0x80n0:24 | Process data in length | Number of bits in the input process data transmitted by IO-Link data frames, which is recorded as 255 for 256 bits | USINT | RW | 0x00 (0dec) |
| 0x80n0:25 | Process data out length | Number of bits in the output process data transmitted by IO-Link data frames, which is recorded as 255 for 256 bits | USINT | RW | 0x00 (0dec) |
| 0x80n0:26 | Compatible ID | Reserved | UINT | RW | 0x0000 (0dec) |
| 0x80n0:27 | Reserved | Reserved | UINT | RW | 0x0000 (0dec) |
| 0x80n0:28 | Master control | **Bit 0 to bit 3:**<br>0: Port not used<br>1: Port configured as DI mode<br>2: Port configured as DO mode<br>3: Port configured as the IO-Link automatic mode<br>4: Port configured as the IO-Link verification mode<br>**Bit 4 to bit 7:**<br>0: Invalid process data upon network disconnection<br>1: Output 0 upon network disconnection<br>2: Output of the last cycle upon network disconnection<br>**Bit 8 to bit 15:**<br>0: Not verifying device parameter information<br>1: Verifying vendor ID and device ID in V1.0<br>2: Verifying vendor ID and device ID in V1.1<br>3: Enabling backup and restoration of slave station configuration data<br>4: Only enabling restoration of slave station configuration data<br>* V1.0 and V1.1 indicates the versions of the IO-Link slave station protocol stack.<br>* If the modes specified by values 3 and 4 are used, the port must be configured to the verification mode. | UINT | RW | 0x0000 (0dec) |
| **Index 0x90n0 Ch.n IO-Link port configuration data (for 0 ⩽ n ⩽ 7)** | | | | | |

| Index | Name | Description | Data Type | Code | Default |
|---|---|---|---|---|---|
| 0x90n0:00 | IO Settings Ch.1- 8 | Highest sub-index supported | USINT | R | 0x28 (40dec) |
| 0x90n0:04 | Device ID | Obtained device ID of the IO-Link slave device | UDINT | R | 0x00000000 (0dec) |
| 0x90n0:05 | VendorID | Obtained vendor ID of the IO-Link slave device | UDINT | R | 0x00000000 (0dec) |
| 0x90n0:06 | Product ID | Obtained product ID of the IO-Link slave device (not supported) | USINT | R | 0x00000000 (0dec) |
| 0x90n0:08 | Serial number | Obtained serial number of the IO-Link slave device (not supported) | USINT | R | 0x00000000 (0dec) |
| 0x90n0:20 | IO-Link revision | Version of the specification for IO-Link device communication<br>• Bit 0 to bit 3: Minor version<br>• Bit 4 to bit 7: Major version | USINT | R | 0x00 (0dec) |
| 0x90n0:21 | Frame capability | Reserved | USINT | R | 0x00 (0dec) |
| 0x90n0:22 | Min cycle time | Cycle time① between the IO-Link master station and slave station, which is transmitted by IO-Link data frames of the minimum cycle<br>• Bit 6 to bit 7: Time base<br>• Bit 0 to bit 5: Ratio | USINT | R | 0x00 (0dec) |
| 0x90n0:23 | Offset time | Reserved | USINT | R | 0x00 (0dec) |
| 0x90n0:24 | Process data in length | Obtained number of bits in the input process data transmitted by IO-Link slave station data frames, which is displayed as 255 for 256 bits | USINT | R | 0x00 (0dec) |
| 0x90n0:25 | Process data out length | Obtained number of bits in the output process data transmitted by IO-Link slave station data frames, which is displayed as 255 for 256 bits | USINT | R | 0x00 (0dec) |
| 0x90n0:26 | Compatible ID | Reserved | UINT | R | 0x0000 (0dec) |
| 0x90n0:27 | Reserved | Reserved | UINT | R | 0x0000 (0dec) |

① For details about the cycle time, see the following table.

| Time Baseline Code | Time Baseline Value | Calculation Method | Cycle Time |
|---|---|---|---|
| 00 | 0.1 ms | Multiplier x Time baseline | 0.4 ms to 6.3 ms |
| 01 | 0.4 ms | 6.4 ms + Multiplier x Time baseline | 6.4 ms to 31.6 ms |
| 10 | 1.6 ms | 32.0 ms + Multiplier x Time baseline | 32.0 ms to 132.8 ms |
| 11 | Reserved | Reserved | Reserved |

### 5.5.4.3 Configuration Data for Process Data Communication

EtherCAT PDO communication is managed by PDO assignment, PDO mapping, and process data object dictionaries. PDO assignment and PDO mapping are described and sampled as follows:

## PDO assignment

PDO assignment, which is divided into two object dictionaries to receive PDO assignment and transmit PDO assignment, is used to configure PDO mapping. Indexes for the two dictionaries are respectively 0x1C12 and 0x1C13.

| **Index 0x1C12 RxPDO assignment** | | | | |
|---|---|---|---|---|
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0x1C12:00 | Sub-index 00 | Assignment of output process data | USINT | 0x08 (8dec) |
| 0x1C12:01 | Sub-index 01 | Assignment of output process data of index 1 | DT1C12ARR | 0x1600 (5632dec) |
| 0x1C12:02 | Sub-index 02 | Assignment of output process data of index 2 | DT1C12ARR | 0x1601 (5633dec) |
| 0x1C12:03 | Sub-index 03 | Assignment of output process data of index 3 | DT1C12ARR | 0x1602 (5634dec) |
| 0x1C12:04 | Sub-index 04 | Assignment of output process data of index 4 | DT1C12ARR | 0x1603 (5633dec) |
| 0x1C12:05 | Sub-index 05 | Assignment of output process data of index 5 | DT1C12ARR | 0x1604 (5634dec) |
| 0x1C12:06 | Sub-index 06 | Assignment of output process data of index 6 | DT1C12ARR | 0x1605 (5635dec) |
| 0x1C12:07 | Sub-index 07 | Assignment of output process data of index 7 | DT1C12ARR | 0x1606 (5634dec) |
| 0x1C12:08 | Sub-index 08 | Assignment of output process data of index 8 | DT1C12ARR | 0x1607 (5635dec) |
| **Index 0x1C13 TxPDO assignment** | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0x1C13:00 | Sub-index 00 | Assignment of input process data | USINT | 0x08 (8dec) |
| 0x1C13:01 | Sub-index 01 | Assignment of input process data of index 1 | DT1C13ARR | 0x1A00 (6656dec) |
| 0x1C13:02 | Sub-index 02 | Assignment of input process data of index 2 | DT1C13ARR | 0x1A01 (6657dec) |
| 0x1C13:03 | Sub-index 03 | Assignment of input process data of index 3 | DT1C13ARR | 0x1A02 (6657dec) |
| 0x1C13:04 | Sub-index 04 | Assignment of input process data of index 4 | DT1C13ARR | 0x1A03 (6658dec) |
| 0x1C13:05 | Sub-index 05 | Assignment of input process data of index 5 | DT1C13ARR | 0x1A04 (6658dec) |

| | | | | |
|---|---|---|---|---|
| 0x1C13:06 | Sub-index 06 | Assignment of input process data of index 6 | DT1C13ARR | 0x1A05 (6659dec) |
| 0x1C13:07 | Sub-index 07 | Assignment of input process data of index 7 | DT1C13ARR | 0x1A06 (6659dec) |
| 0x1C13:08 | Sub-index 08 | Assignment of input process data of index 8 | DT1C13ARR | 0x1A07 (6660dec) |

## PDO mapping

PDO mapping is used to map the process data object dictionary that requires communication. PDO mapping is divided into RxPDO mapping and TxPDO mapping, and the index ranges for them are respectively 0x1600 to 0x17FF and 0x1A00 to 0x1BFF.

The object dictionary for PDO mapping contains the values of indexes, sub-indexes, and length of process data in the object dictionary for PDO communication.

| **Bit** | 31 | ... | 16 | 15 | ... | 8 | 7 | ... | 0 |
|---|---|---|---|---|---|---|---|---|---|
| **Descrip-tion** | Index | | | Sub-index | | | Object length | | |

| **Index 0x1A0n Ch.n input process data mapping (for 0 ⩽ n ⩽ 7)** | | | | |
|---|---|---|---|---|
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0x1A0n:00 | Sub-index 00 | Input process data mapping | USINT | 0x00 (0dec) |
| 0x1A0n:01 | Sub-index 01 | 1. Input process data mapping | UDINT | 0x70n0:01,08 |
| ... | ... | ... | ... | ... |
| 0x1A0n:40 | Sub-index 64 | 64. Input process data mapping | UDINT | 0x70n0:40,08 |
| **Index 0x1A10 Pin2 input process data mapping (8 Ch)** | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0x1A10:00 | Sub-index 00 | Input process data mapping for Pin2 | USINT | 0x08 (8dec) |
| 0x1A10:01 | Sub-index 01 | Input process data mapping for Pin2 through CH0 | BIT | 0x2000:01,01 |
| 0x1A10:02 | Sub-index 02 | Input process data mapping for Pin2 through CH1 | BIT | 0x2010:01,01 |
| 0x1A10:03 | Sub-index 03 | Input process data mapping for Pin2 through CH2 | BIT | 0x2020:01,01 |
| 0x1A10:04 | Sub-index 04 | Input process data mapping for Pin2 through CH3 | BIT | 0x2030:01,01 |
| 0x1A10:05 | Sub-index 05 | Input process data mapping for Pin2 through CH4 | BIT | 0x2040:01,01 |

| | | | | |
|---|---|---|---|---|
| 0x1A10:06 | Sub-index 06 | Input process data mapping for Pin2 through CH5 | BIT | 0x2050:01,01 |
| 0x1A10:07 | Sub-index 07 | Input process data mapping for Pin2 through CH6 | BIT | 0x2060:01,01 |
| 0x1A10:08 | Sub-index 08 | Input process data mapping for Pin2 through CH7 | BIT | 0x2070:01,01 |
| **Index 0x1A13 Pin1 short circuit process data mapping (8 Ch)** | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0x1A13:00 | Sub-index 00 | Short circuit process data mapping for Pin1 | USINT | 0x08 (8dec) |
| 0x1A13:01 | Sub-index 01 | Short circuit process data mapping for Pin1 through CH0 | BIT | 0x2001:02,01 |
| 0x1A13:02 | Sub-index 02 | Short circuit process data mapping for Pin1 through CH1 | BIT | 0x2011:02,01 |
| 0x1A13:03 | Sub-index 03 | Short circuit process data mapping for Pin1 through CH2 | BIT | 0x2021:02,01 |
| 0x1A13:04 | Sub-index 04 | Short circuit process data mapping for Pin1 through CH3 | BIT | 0x2031:02,01 |
| 0x1A13:05 | Sub-index 05 | Short circuit process data mapping for Pin1 through CH4 | BIT | 0x2041:02,01 |
| 0x1A13:06 | Sub-index 06 | Short circuit process data mapping for Pin1 through CH5 | BIT | 0x2051:02,01 |
| 0x1A13:07 | Sub-index 07 | Short circuit process data mapping for Pin1 through CH6 | BIT | 0x2061:02,01 |
| 0x1A13:08 | Sub-index 08 | Short circuit process data mapping for Pin1 through CH7 | BIT | 0x2071:02,01 |
| **Index 0x1A14 system hardware status monitoring process data mapping** | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0x1A14:00 | Sub-index 00 | Process data mapping for status monitoring of system hardware | USINT | 0x03(3dec) |
| 0x1A14:01 | Sub-index 01 | Process data mapping for status monitoring of system power voltage | UDINT | 0x2A02:01,08 |
| 0x1A14:02 | Sub-index 02 | Process data mapping for status monitoring of activator power voltage | UDINT | 0x2A02:02,08 |

| | | | | |
|---|---|---|---|---|
| 0x1A14:03 | Sub-index 03 | Process data mapping for status monitoring of MCU internal temperature | UDINT | 0x2A02:03,08 |
| **Index 0x1A80 master and slave station communication status monitoring process data mapping** | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0x1A81:00 | Sub-index 00 | Process data mapping for status monitoring of master and slave station communication | USINT | 0x08 (8dec) |
| 0x1A81:01 | Sub-index 01 | Process data mapping for status monitoring of master and slave station communication through CH0 | UDINT | 0xF100:01,08 |
| 0x1A81:02 | Sub-index 02 | Process data mapping for status monitoring of master and slave station communication through CH1 | UDINT | 0xF100:02,08 |
| 0x1A81:03 | Sub-index 03 | Process data mapping for status monitoring of master and slave station communication through CH2 | UDINT | 0xF100:03,08 |
| 0x1A81:04 | Sub-index 04 | Process data mapping for status monitoring of master and slave station communication through CH3 | UDINT | 0xF100:04,08 |
| 0x1A81:05 | Sub-index 05 | Process data mapping for status monitoring of master and slave station communication through CH4 | UDINT | 0xF100:05,08 |
| 0x1A81:06 | Sub-index 06 | Process data mapping for status monitoring of master and slave station communication through CH5 | UDINT | 0xF100:06,08 |
| 0x1A81:07 | Sub-index 07 | Process data mapping for status monitoring of master and slave station communication through CH6 | UDINT | 0xF100:07,08 |

| | | | | |
|---|---|---|---|---|
| 0x1A81:08 | Sub-index 08 | Process data mapping for status monitoring of master and slave station communication through CH7 | UDINT | 0xF100:08,08 |
| **Index 0x160n Ch.n output process data mapping (for 0 ⩽ n ⩽ 7)** | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0x160n:00 | Sub-index 00 | Output process data mapping | USINT | 0x00 (0dec) |
| 0x160n:01 | Sub-index 01 | 1. Output process data mapping | UDINT | 0x60n0:01,08 |
| ... | ... | ... | ... | ... |
| 0x160n:20 | Sub-index 32 | 32. Output process data mapping | UDINT | 0x60n0:40,08 |
| **Index 0x1620 Pin2 output process data mapping (8 Ch)** | | | | |
| **Index** | **Name** | **Description** | **Data Type** | **Default** |
| 0x1620:00 | Sub-index 00 | Output process data mapping for Pin2 | USINT | 0x08 (8dec) |
| 0x1620:01 | Sub-index 01 | Output process data mapping for Pin2 through CH0 | BIT | 0x3008:01,01 |
| 0x1620:02 | Sub-index 02 | Output process data mapping for Pin2 through CH1 | BIT | 0x3018:01,01 |
| 0x1620:03 | Sub-index 03 | Output process data mapping for Pin2 through CH2 | BIT | 0x3028:01,01 |
| 0x1620:04 | Sub-index 04 | Output process data mapping for Pin2 through CH3 | BIT | 0x3038:01,01 |
| 0x1620:05 | Sub-index 05 | Output process data mapping for Pin2 through CH4 | BIT | 0x3048:01,01 |
| 0x1620:06 | Sub-index 06 | Output process data mapping for Pin2 through CH5 | BIT | 0x3058:01,01 |
| 0x1620:07 | Sub-index 07 | Output process data mapping for Pin2 through CH6 | BIT | 0x3068:01,01 |
| 0x1620:08 | Sub-index 08 | Output process data mapping for Pin2 through CH7 | BIT | 0x3078:01,01 |

### 5.5.4.4 IO-Link Slave Configuration Data

| **Index 0x40n0 Ch.n IO-Link port slave configuration parameter read/write (for 0 ⩽ n ⩽ 7)** | | | | | |
|---|---|---|---|---|---|
| **Index** | **Name** | **Description** | **Data Type** | **Code** | **Default** |
| 0x40n0:00 | subindex0 | Highest sub-index supported | USINT | RO | 0x07 (7dec) |

| | | | | | |
|---|---|---|---|---|---|
| 0x40n0:01 | Control | • 0: Disabled<br>• 0→2: Write parameter<br>• 0→3: Read parameter | UDINT | RW | 0x00 (0dec) |
| 0x40n0:02 | Status | • 0x00: No error<br>• 0x02: Read success<br>• 0x40: Error | UDINT | RW | 0x00 (0dec) |
| 0x40n0:03 | Index | Index number of the slave station | USINT | RW | 0x00 (0dec) |
| 0x40n0:04 | Subindex | Sub-index number of the slave station | USINT | RW | 0x00 (0dec) |
| 0x40n0:05 | Length | Data length, in byte | UINT | RW | 0x00 (0dec) |
| 0x40n0:06 | Data | Data | ARRAY [0..31] OF BYTE | RW | 0x00 (0dec) |
| 0x40n0:07 | Fault Code | • 0x1: Operation not supported<br>• 0x3: Device access failure<br>• 0x4: Unauthorized operation<br>• 0x5: Slave device in non-OP state<br>• 0x34: Length error<br>• 0x36: Invalid operation due to busy master station<br>• 0x39: Port disabled | UINT | RO | 0x00 (0dec) |

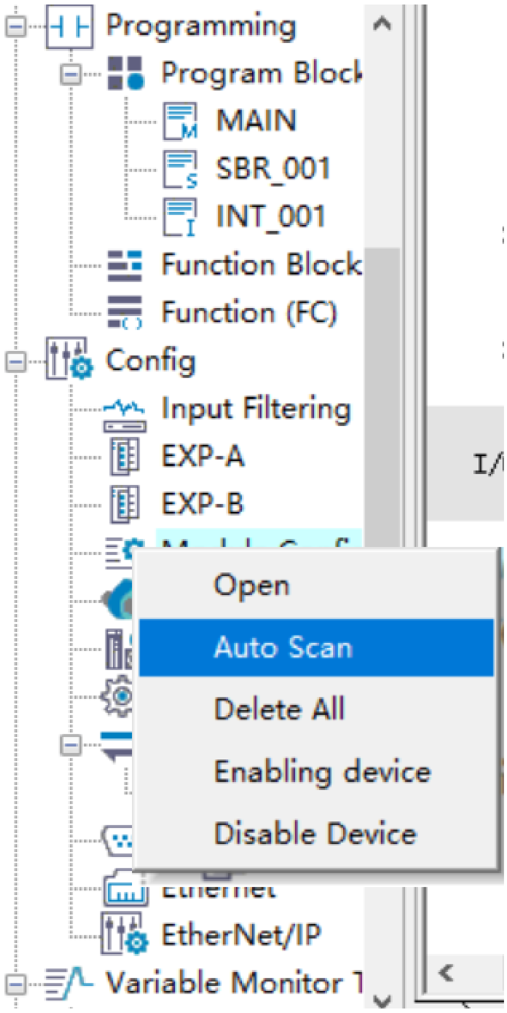
## 5.6 Basic Operations of Local Modules

### 5.6.1 Scanning Local Modules Automatically (Easy)

1. Right-click "Module Config" and select "Auto Scan".

***Note***

Both modules and extension cards are scanned and the scanning follows the same specifications.




2. In the dialog box that is displayed, click "Start Scan". If the PLC is running, click "Yes" in the popup window to switch to the stopped state.
3. Click "Start Scan". After the scanning is completed, the list of scanned modules is displayed. If the mounted modules are inconsistent with the modules configured in the background, they are marked red.
4. Click "Update Config".

   The "Save current axises." window is described as follows:

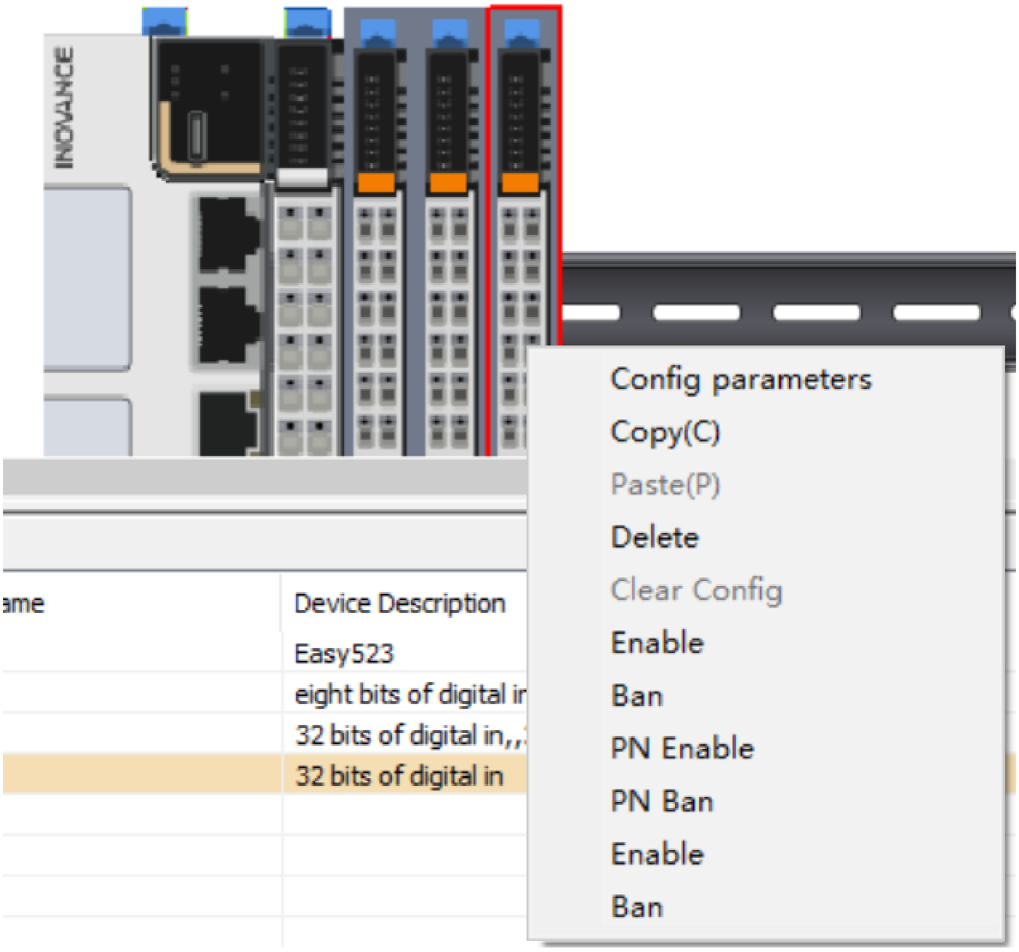
   - Deselected: All the background module configurations are deleted. The default configurations of scanned modules are added according to the scan result.
   - Selected: Compare the mounted modules with the modules configured in the background. If they are consistent, the mounted modules are not replaced or updated. If they are inconsistent, the background modules of the corresponding slots are deleted, the default configured modules are added, and the modules are compared in sequence by slot.

   Click "OK" to add the scan result.

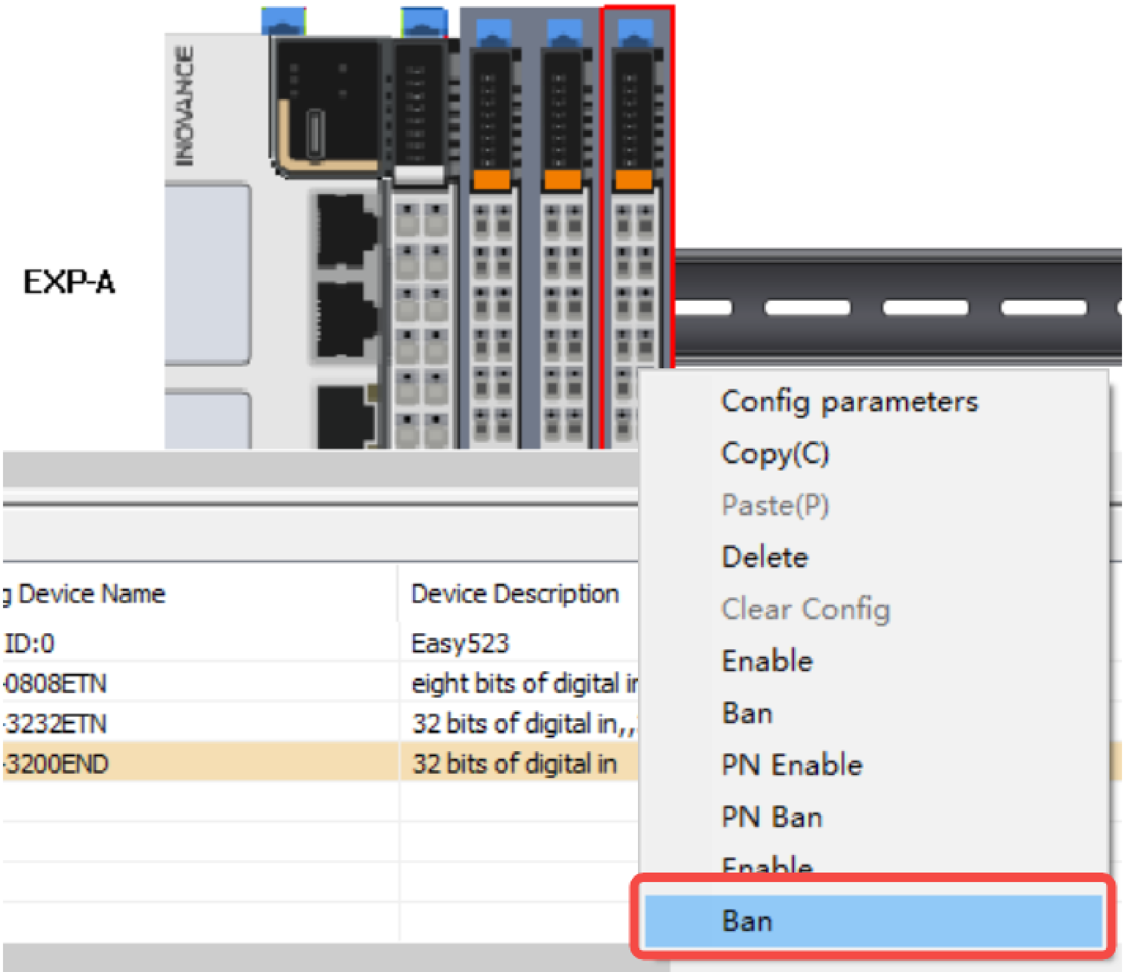
## 5.6.2 Disabling Local Modules

To use the function of disabling local extension modules, ensure that the physical extension modules removed are the same as the modules to be disabled in the module list of the software. The procedure is as follows:

1. In the module list, select a module to be disabled and right-click the module.




2. Choose "Ban" from the drop-down list, and download the program to the PLC device.

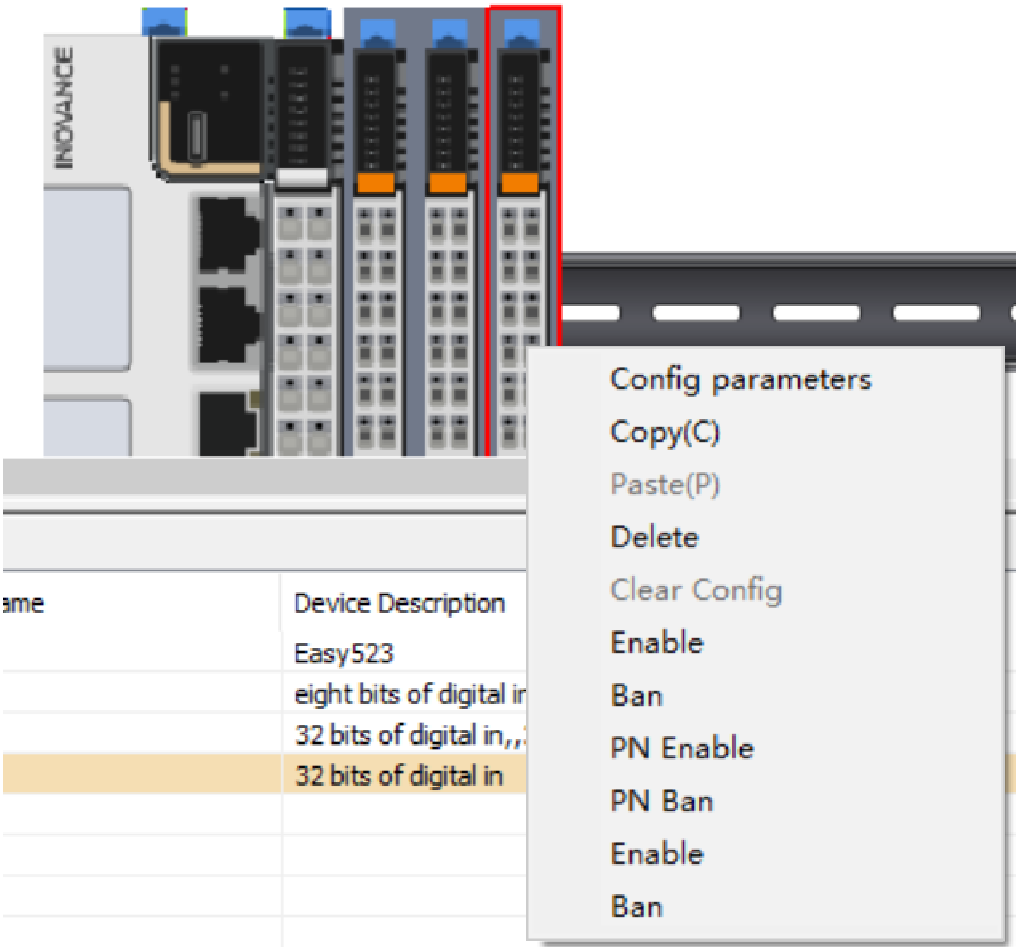



3. After downloading the program, restart the PLC device.

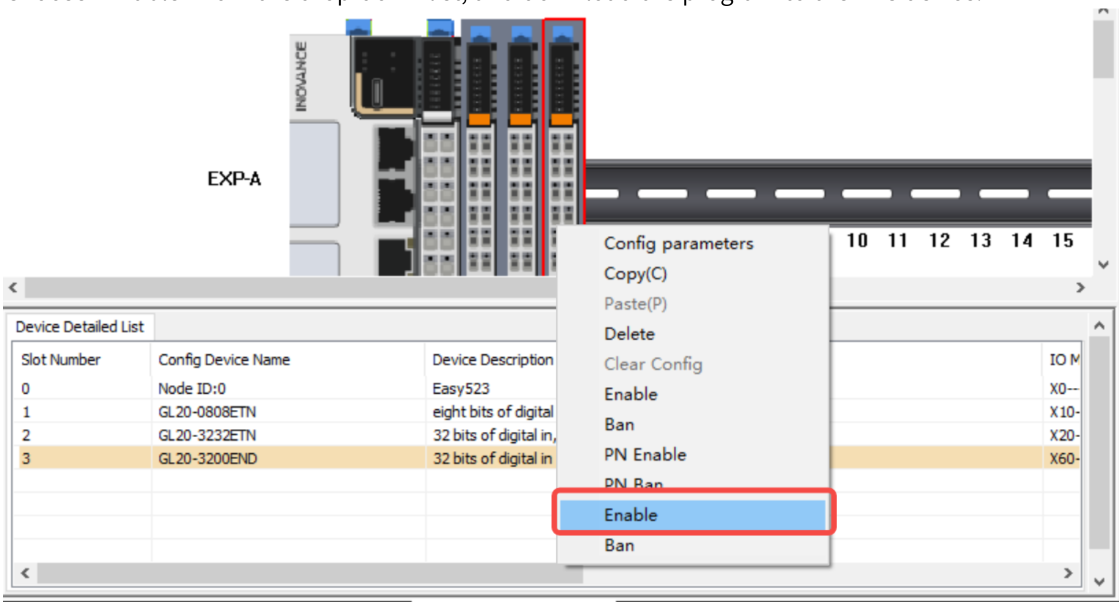
## 5.6.3 Enabling Local Modules

To use the function of enabling local extension modules, ensure that the physical extension modules installed are the same as the modules to be enabled in the module list of the software. The procedure is as follows:

1. In the module list, select a module to be enabled and right-click the module.




2. Choose "Enable" from the drop-down list, and download the program to the PLC device.




3. After downloading the program, restart the PLC device.

# 6 Serial Communication

## 6.1 Overview

H5U provides a serial communication port that supports baud rates of 9600 bps, 19200 bps, 38400 bps, 57600 bps, and 115200 bps.

Serial ports supported by the Easy series are listed in the following table.

| | Easy300 Series | | | Easy500 Series | | | | |
|---|---|---|---|---|---|---|---|---|
| | Easy301 | Easy302 | Easy320 | Easy501 | Easy502 | Eas y521 | Eas y522 | Eas y523 |
| Serial com- muni- cati- on | One RS232 port and one RS485 port, supporting free protocol for serial ports | One RS232 port and one RS485 port, scalable up to two RS485/ RS232 ports, supporting free protocol for serial ports | One RS485 port, scalable up to two RS485/RS232 ports, supporting free protocol for serial ports | One RS485 port, scalable up to two RS485/RS232 ports, supporting free protocol for serial ports | | One RS485 port, scalable up to two RS485/RS232 ports, supporting free protocol for serial ports | | |

Table 6–1 Communication protocol

| Communication Protocol | Description |
|---|---|
| Free protocol | Freely sends/receives data with the SerialRS instruction |
| Modbus-RTU master station | A standard Modbus-RTU master station that reads/writes data from/to a slave station through Modbus configuration |
| Modbus-RTU slave station | A standard Modbus-RTU slave station |
| Modbus-ASCII master station | A standard Modbus-ASCII master station that reads/writes data from/to a slave station through Modbus configuration |
| Modbus-ASCII slave station | A standard Modbus-ASCII slave station |

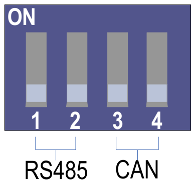
## 6.2 Serial Communication Network

You are recommended to use shielded twisted pairs for the RS485 bus and use twisted pairs to connect RS485+ and RS485–. A 120 Ω termination resistor is connected at both ends of the bus to prevent signal reflection. The reference grounds (GND) of RS485 signals on all nodes are connected together. A maximum of 31 nodes are supported and the distance between each node and the bus must be less than 3 m.

### H5U series

**Communication termination resistor DIP switch**

The communication termination resistor DIP switch is located in the battery bay. ON means the termination resistor is connected (factory default: OFF). The switch schematic diagram is as follows, in which 1 and 2 are used for RS485 communication, and 3 and 4 are used for CAN communication.



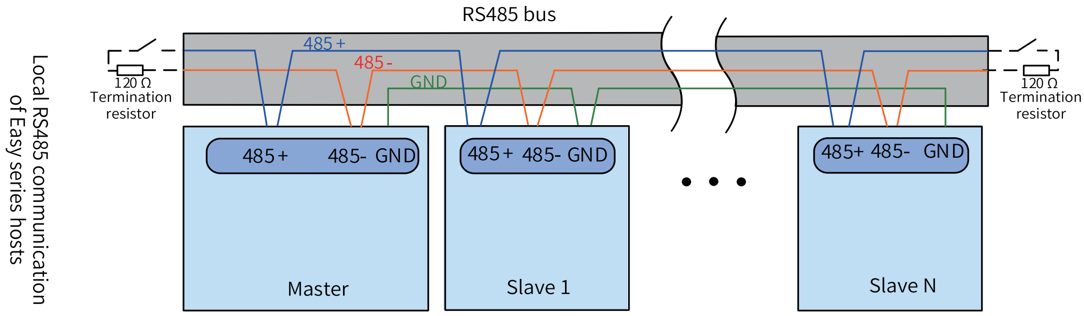

**Networking of RS485 serial communication**

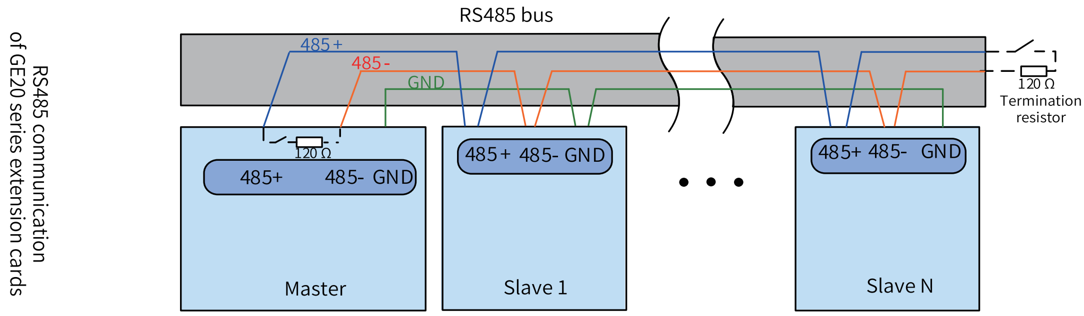
The following figure shows the RS485 bus topology.

The RS485 port of H5U has a 120 Ω termination resistor which can be turned on or off by setting the DIP switch.

## Easy series

The Easy series host has no termination resistor. An external termination resistor can be connected if necessary. The RS485 communication extension card of the GE20 series has a termination resistor. The termination resistor can be turned on or off by setting the DIP switch and the default setting is OFF. The following figure shows the RS485 bus topology.

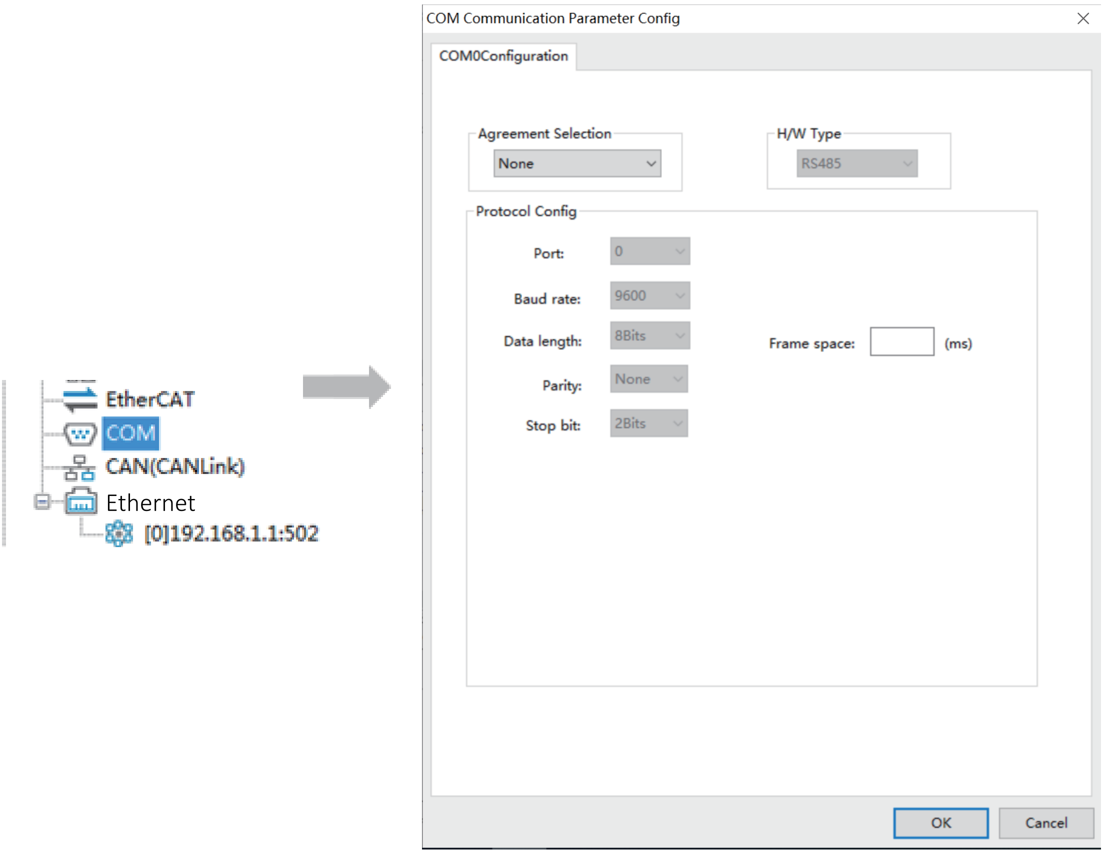



# 6.3 Free Protocol Configuration

## 6.3.1 Free Protocol Configuration

Double-click "COM". In the dialog box "COM Communication Parameter Config" displayed, select "Free Agreement", set serial port parameters, and then click "OK". Then, you can use the SerialRS instruction to send and receive data in the user program.




## 6.3.2 Free Protocol Cancellation (SerialSR Instruction)

When the free protocol is set for the COM port, you can use the SerialSR instruction to send and receive data over the free protocol, and set the system variable _SerialSR.abort to abort a free protocol send/ receive process. The modification takes effect immediately, as shown in the following figure.

| | | |
|---|---|---|
| _SerialSR | | _sSerial_SR |
| port | 0 | INT |
| states | 0 | INT |
| sent | 0 | INT |
| received | 0 | INT |
| mutexF | 0 | DINT |
| trigger | 0 | DINT |
| errorid | 0 | DINT |
| timeout | 0 | DINT |
| sendlen | 0 | DINT |
| sendbuf | | INT[256] |
| recvlen | 0 | DINT |
| recvbuf | | INT[256] |
| abort | 0 | INT |

Figure 6-1 _SerialSR structure

**Usage:**

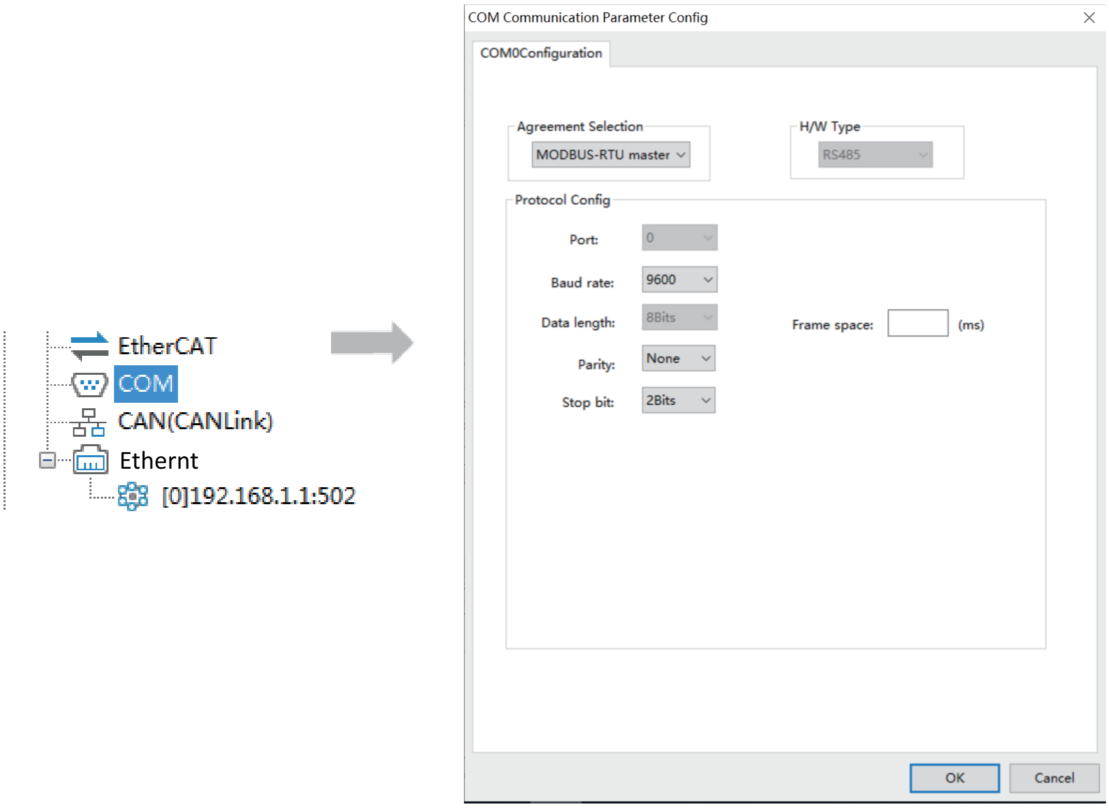
When _SerialSR.abort is set to a non-zero value, the send and receive processes can be aborted within the specified timeout period. After the processes are aborted, their states change to 16-Completed, and the DONE signal is ON.

## 6.4 Master Configuration

### 6.4.1 Modbus-RTU or Modbus-ASCII Master

#### Setting the serial port

Double-click "COM". In the dialog box "COM Communication Parameter Config" displayed, select "MODBUS-RTU master" or "MODBUS-ASC master", and set serial port parameters.




### Adding the Modbus configuration

- Timeout: Sets the period for the master station to wait for the slave station to answer, in the unit of ms.
- Enabling control element: Enables or disables the connection. Customized variables are supported. If this option is not selected, the master station is enabled by default.

### Accessing detailed configuration

Double-click "COM0 Modbus Config" to access the "Modbus Config" window. For detailed configuration, see *"6.4.2 Modbus Master Configuration Table" on page 239*

## 6.4.2 Modbus Master Configuration Table

Configure the Modbus master station.
The following describes relevant configuration items:

- Name
  The name that labels this condition configuration.
- Slave No.
  The number of the slave station you want to access. Up to 255 slave stations can be specified.
- Trigger mode and condition
  The communication modes are "Cycle" and "Trigger".

When "Cycle" is selected, the trigger condition is used to set the cycle time in ms. Then the configurations are executed according to the specified cycle.

## Note

When the set cycle is smaller than the time required for communication, the configuration is executed according to the time required for communication. For example, if the set cycle is 10 ms and the actual slave response requires 20 ms, the actual execution cycle is 20 ms.

When "Trigger" is selected, the trigger condition is used to set the trigger condition variable/ element. In this mode you can set the trigger condition to trigger a communication. If the slave station responds to the request, the trigger condition is automatically reset; otherwise, the trigger condition remains unchanged. If one trigger variable/element is used to trigger multiple configurations, the trigger condition will be automatically reset after all the triggered configurations are executed and the triggered configurations are not executed again.

- Function code

| Function Code | Definition |
|---|---|
| 0x01 (01) | Reads coils |
| 0x02 (02) | Reads discrete inputs |
| 0x03 (03) | Reads registers |
| 0x04 (04) | Reads input registers |
| 0x05 (05) | Single coil |
| 0x06 (06) | Single register |
| 0x0f (15) | Writes multiple coils |
| 0x10 (16) | Writes multiple registers |

- Slave register address
  The slave register address to be accessed.

  You can set the slave register address format to hexadecimal or decimal.

- Quantity
  The number of coils, discrete quantities, or registers to be accessed.

| Function Code | Name | Max. |
|---|---|---|
| 0x01 (01) | Reads coils | 2000 |
| 0x02 (02) | Reads discrete inputs | 2000 |
| 0x03 (03) | Reads registers | 125 |
| 0x04 (04) | Reads input registers | 125 |
| 0x05 (05) | Single coil | 1 |
| 0x06 (06) | Single register | 1 |
| 0x0f (15) | Writes multiple coils | 1968 |
| 0x10 (16) | Writes multiple registers | 123 |

- Mapped address
  The mapped address of the slave coil, discrete quantity, or register in the master station. Customized variables are supported.

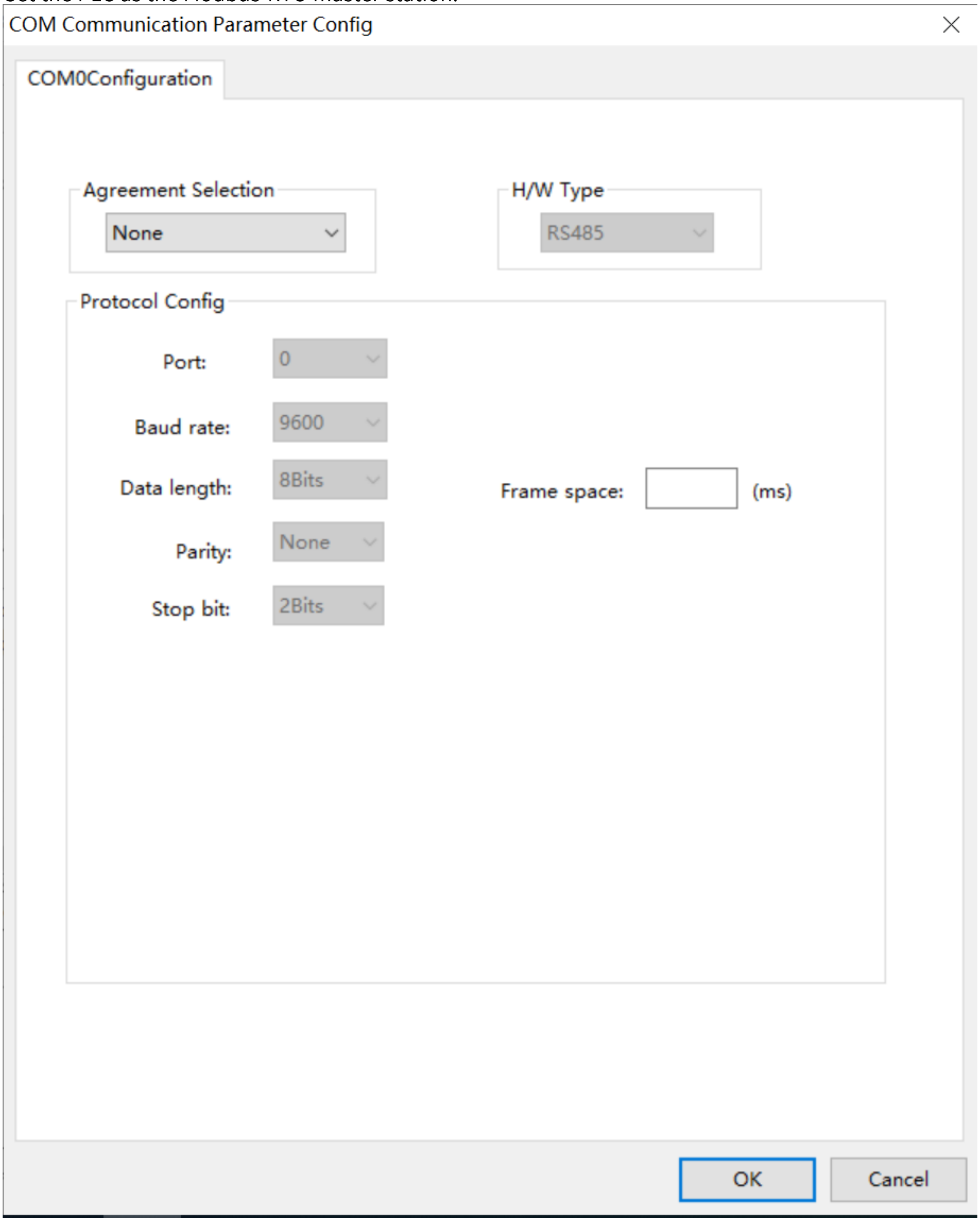
- Repeat number
  The number of retries after the slave station response times out.

### 6.4.3 Modbus-RTU Slave Disable

When the PLC serves as the Modbus-RTU master station, you can use system variables to disable a slave station.

## Configuration

1. Set the PLC as the Modbus-RTU master station.

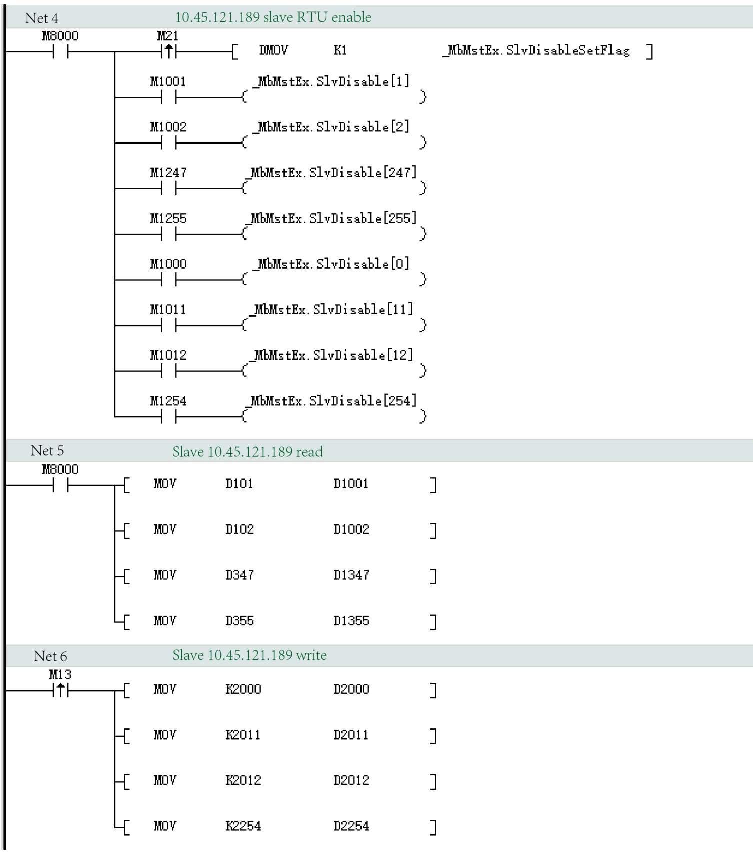



2. Add the configuration table.
3. Locate the slave station you want to disable based on the slave No. or slot No..
4. Configure the _MbMstEx structure array to disable slave stations under the corresponding host.

## Note

- The configuration corresponding to COM[N] in the _MbMstEx [N] structure array is not retentive at power failure.
- _MbMstEx.SlvDisableSetFlag is used to enable or disable the Slave Disable function. When it is non-zero, the Slave Disable function is enabled.
- In _MbMstEx.SlvDisable[M], M is the Slave Disable flag corresponding to the slave station number mentioned in step 3. It is only valid when _MbMstEx.SlvDisableSetFlag is enabled.

### Program example

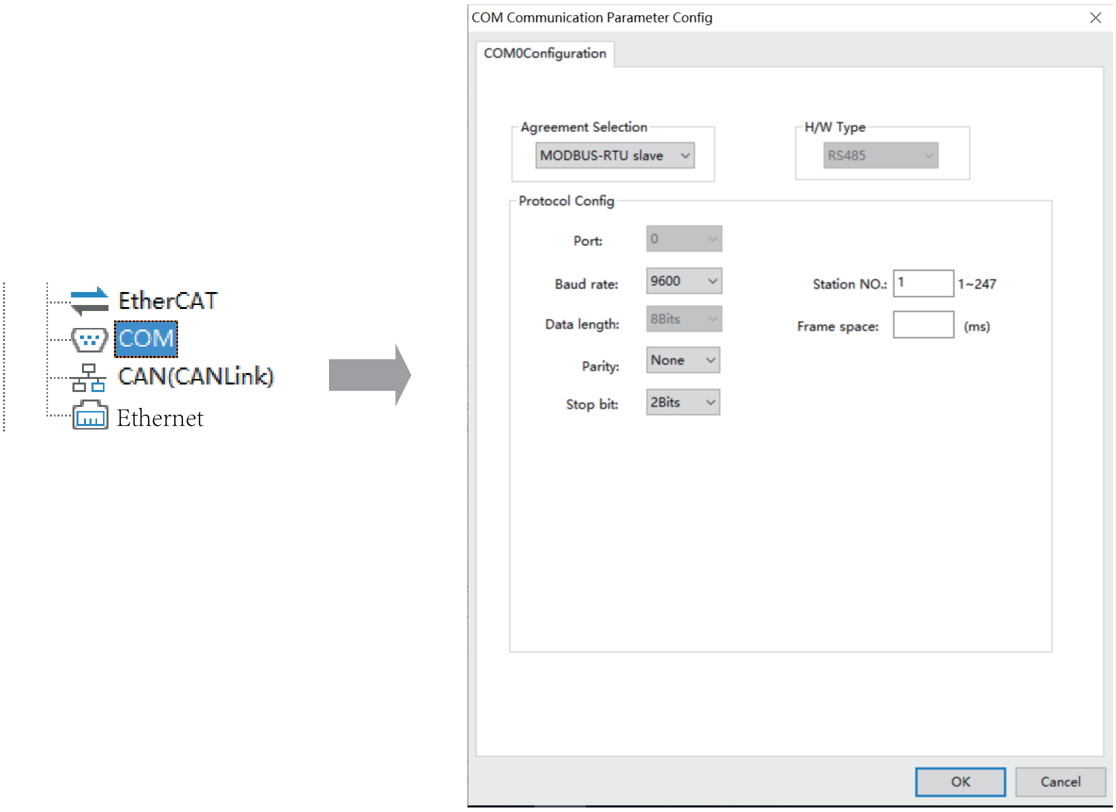



**Note**: When M1001, M1002, …, and M1254 are used to disable a single slave station, the read or write operation on this slave station is invalid.

# 6.5 Slave Configuration

## 6.5.1 Modbus-RTU or Modbus-ASCII Slave

Double-click "COM". In the dialog box "COM Communication Parameter Config" displayed, select "MODBUS-RTU slave" or "MODBUS-ASC slave", set serial port parameters and the slave No., and then click "OK". Download the project to H5U. For function codes and addresses supported when H5U is used as the Modbus slave station, see *“6.5.2 Parameters and Addresses” on page 243*.




### 6.5.2 Parameters and Addresses

- When H5U is used as the slave station, the following function codes are supported:

| Function Code | Definition |
|---|---|
| 0x01 | Reads coils |
| 0x02 | Reads discrete quantities (same as 0x01). |
| 0x03 | Reads registers |
| 0x04 | Reads input registers (same as 0x03). |
| 0x05 | Writes a single coil. |
| 0x06 | Writes a single register. |
| 0x0f | Writes multiple coils |
| 0x10 | Writes multiple registers |
| 0x80 to 0xFF | Standard Modbus fault code |

- When H5U is used as the slave station, addresses of coils that can be accessed by Modbus are listed in the following table:

| Variable | Quantity | Address Range |
|---|---|---|
| M0-M7999 | 8000 | 0x0000 to 0x1F3F (0 to 7999) |
| B0-B32767 | 32768 | 0x3000 to 0xAFFF (12288 to 45055) |
| S0-S4095 | 4096 | 0xE000 to 0xEFFF (57344 to 61439) |
| X0-X1777 (octal) | 1024 | 0xF800 to 0xFBFF (63488 to 64511) |
| Y0-Y1777 (octal) | 1024 | 0xFC00-0xFFFF (64512 to 65535) |

- When H5U is used as the slave station, addresses of registers that can be accessed by Modbus are listed in the following table:

| Variable | Quantity | Start Address |
|---|---|---|
| D0-D7999 | 8000 | 0x0000 to 0x1F3F (0 to 7999) |
| R0-R32767 | 32768 | 0x3000 to 0xAFFF (12288 to 45055) |

***Note***

W elements and Pointer variables are not supported.

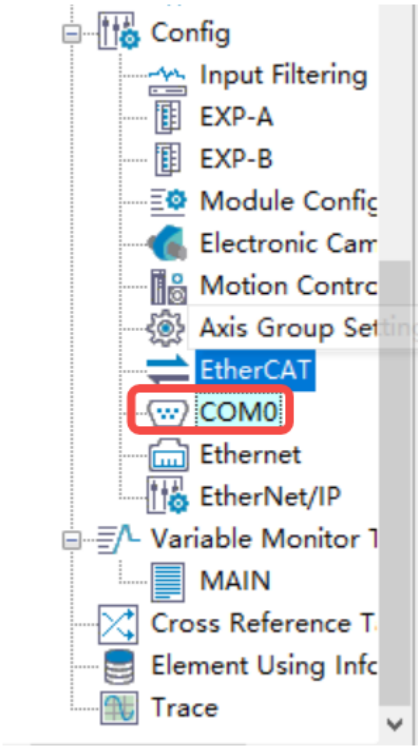
# 6.6 Example of Modbus-RTU Communication Application

## Program requirements

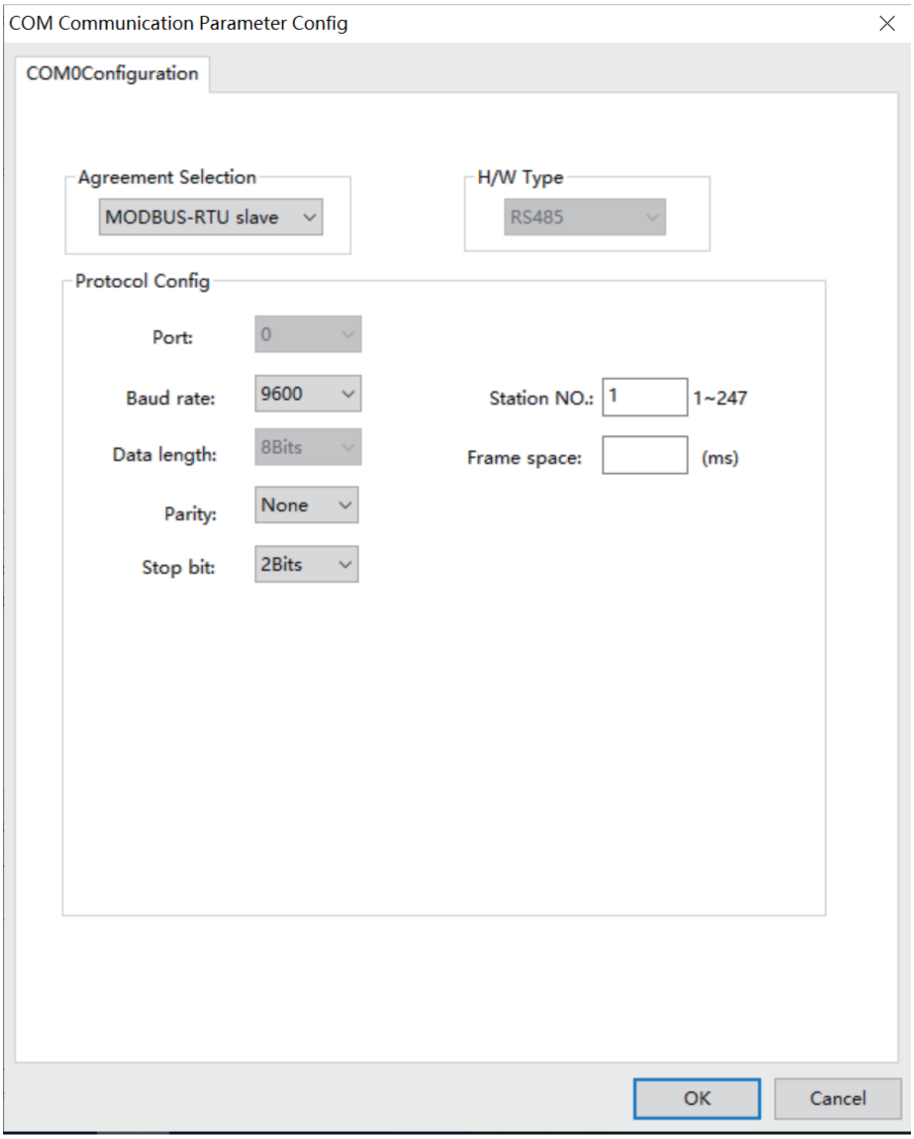
In this example, two H5Us are connected through a serial port and communicate with each other through the Modbus-RTU protocol. The master PLC reads the value in the D100 register of the slave PLC every 10 ms, and the value in D100 of the slave station is added by one every second.

## Slave configuration

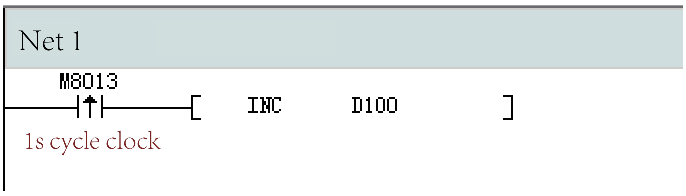
Double-click the COM icon to access the serial port configuration page.




In the window displayed, set the serial communication protocol and communication parameters. In this example, the protocol is Modbus-RTU and the communication parameter is 9600-8N2. Then, click "OK" to save the settings.



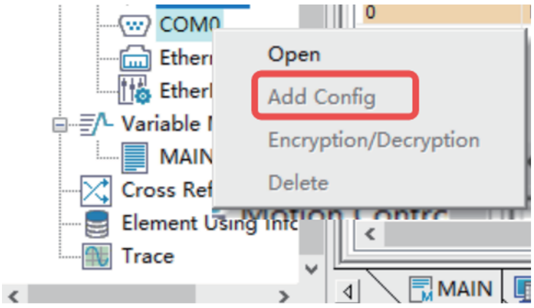

Edit the program so that the value of D100 of the slave station is added by one every second.




Then, click "Download" to download the program to the PLC.

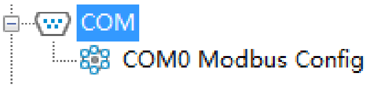
## Master configuration

Double-click the COM icon. In the window displayed, set the communication protocol to Modbus-RTU master and set the communication parameter to that of the slave station. Right-click the COM icon. In the dialog box displayed, select "Add MODBUS Config".




You can set "Timeout" and "Enabling control element" in the dialog box displayed. In this example, the default settings are used: "Timeout" is set to 500 ms, and "Enabling control element" is deselected.

Click "OK". The master configuration is generated.




Double-click "COM0 Modbus Config". On the configuration table page displayed, click "Add" to add the configuration. In this example, the value of D100 of the slave station is stored in D200 of the master station.

Then, click "Download" to download the program to the PLC.

### Effect

The value of the D100 register of the slave station can be read from the D200 register of the master station.

| | | Element Name | Data Type | Display Format | Current Value |
|---|---|---|---|---|---|
| 1 | ... | D200 | INT | Dec | 1853 |
| 2 | ... | | | | |
| 3 | ... | | | | |
| 4 | ... | | | | |
| 5 | | | | | |

## 6.7 Modifying Serial Port Parameters

### 6.7.1 Modifying COM Port Parameters

When the free protocol and Modbus-RTU/Modbus-ASC master-slave are configured for the COM port, you can set the system variable _COMSet to modify the COM port parameters. The effective _COMSet parameter is synchronized to the _COM parameter, as shown in the following figure.

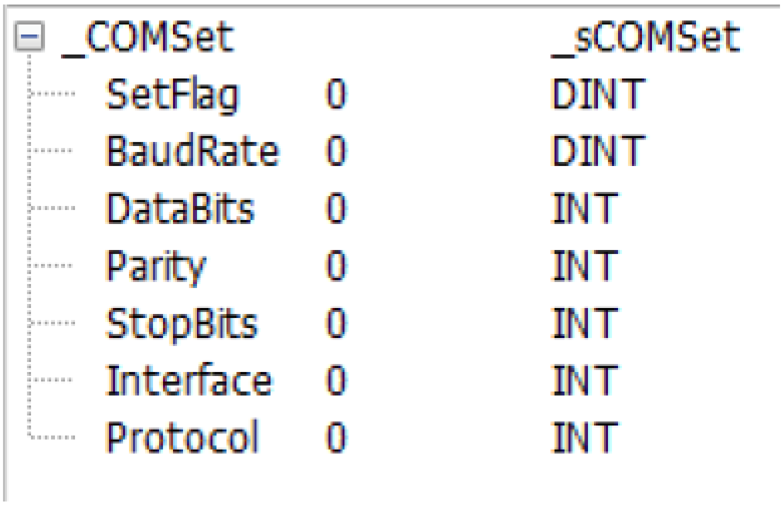



Figure 6-2 COMSet structure

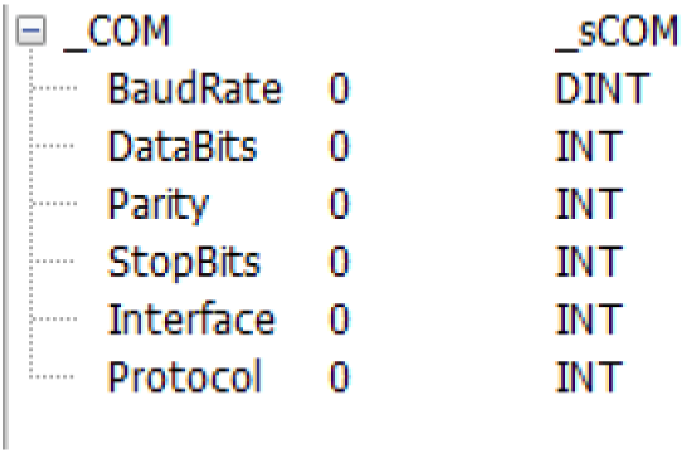



Figure 6-3 _COM structure

## Usage:

1. When _COMSet.SetFlag is set to a non-zero value, parameters of the COM port can be modified online.
2. Only the baud rate, data bit, parity bit, and stop bit can be modified. The physical port and communication protocol parameters are read-only and cannot be modified.
3. Modification to these parameters takes effect only after STOP–RUN is executed on the PLC. The effective parameters can be viewed through the system variable _COM.
4. Note that when the baud rate, data bit, parity bit, or stop bit is set to an invalid value, the parameter will be reset by the system to the system background configuration parameter.
5. When the PLC is used as the Modbus-RTU or Modbus-ASC master station, the Modbus configuration table must be added; otherwise, modification to the parameter _COMSet is not synchronized to _COM.
6. After the COM parameters of the PLC are modified, parameters of the communication device connected to the port will be automatically synchronized.

## 6.7.2 Modifying Slave Address Parameters

When Modbus-RTU or Modbus-ASC slave is set for the COM port, you can use the system variable _COMProtocolSet to modify the slave address parameter SlaveAddress of the COM port. After the modification takes effect, the parameter Address is synchronized to the SlaveAddress in the parameter _MbSlv, as shown in the following figure.

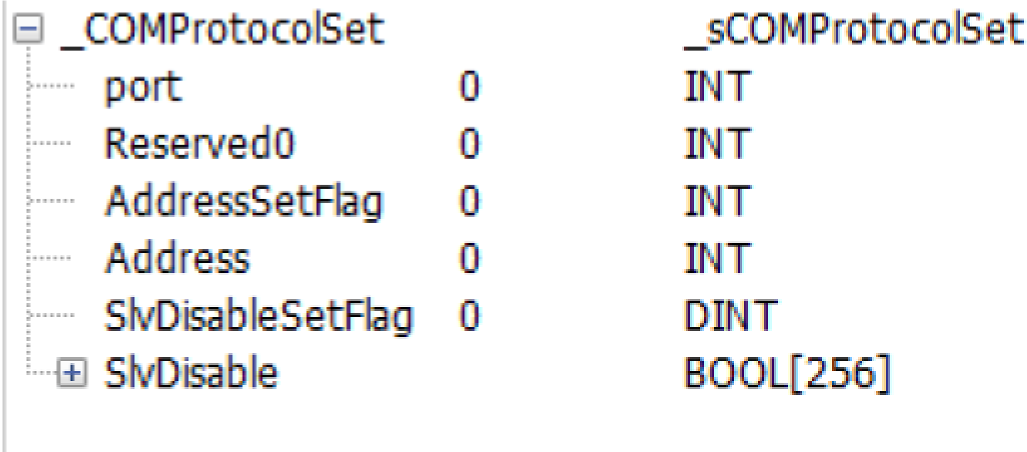



Figure 6-4 _COMProtocolSet structure

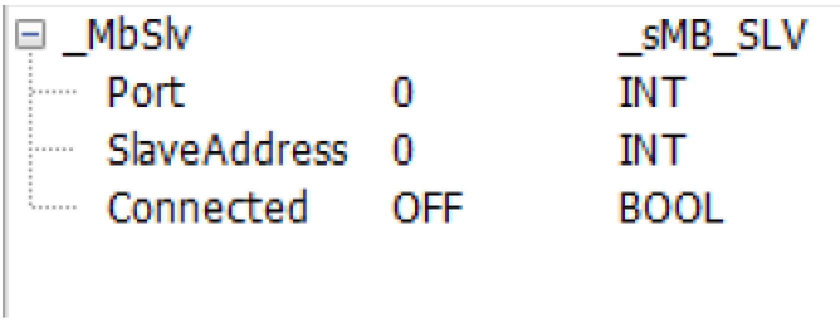



Figure 6-5 _MbSlv structure

### Usage:

1. When _COMProtocolSet.AddressSetFlag is set to a non-zero value, the parameter Address can be modified online.
2. _COMProtocolSet can be used to modify the parameter Address only.
3. Modification to these parameters takes effect only after STOP–RUN is executed on the PLC. The effective parameters can be viewed through the system variable _COM.

# 7 Ethernet Communication

## 7.1 Overview

H5U provides an Ethernet port. The Easy320 and Easy52X series provide two Ethernet ports. You can use AutoShop to monitor and commission the PLC and download and upload parameters from and to the PLC through Ethernet quickly and conveniently. You can also exchange data with other devices in the network through Ethernet.

The small PLC supports the Modbus-TCP protocol and includes a server and a client. It can communicate and exchange data with devices supporting Modbus-TCP. It provides socket instructions for devices not supporting Modbus-TCP to implement application protocols based on TCP/UDP. For details, see the section "Socket Instructions" in the instruction manual.

## 7.2 Hardware Ports

H5U provides a standard Ethernet port (one RJ45 port) and supports the Modbus-TCP Ethernet communication protocol.

The PLC hosts of the Easy320 and Easy52X series support Ethernet and the Modbus-TCP Ethernet communication protocol, as shown in the table below.

| Series | Easy320 | Easy521 | Easy522 | Easy523 |
|---|---|---|---|---|
| Ethernet port | Supports two Ethernet ports, Modbus-TCP master-slave (when it is used as the client, a maximum of 31 servers are supported), TCP/IP, UDP, and EtherNet/IP master-slave. Supports a maximum of 32 slave stations and a minimum communication cycle of 5 ms. | Supports two Ethernet ports, Modbus-TCP master-slave (when it is used as the client, a maximum of 31 servers are supported), TCP/IP, UDP, and EtherNet/IP master-slave. Supports a maximum of 32 slave stations and a minimum communication cycle of 5 ms. | | |

**RJ45 port specifications**

| Item | Ethernet Port |
|---|---|
| Transmission rate | 10 Mbps: 10BASE-T<br>100 Mbps: 100BASE-TX<br>10 Mbps/100 Mbps self-adaptive |
| Modulation | Baseband |
| Topology | Star |
| Medium | Cat5 twisted pairs or shielded twisted pairs with aluminum foil and braided mesh |
| Transmission distance | Distance between nodes: 100 m or less |
| Number of connections | 31 |

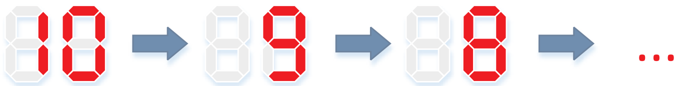
## 7.3 IP Address Settings

### Restoring the default IP address for the H5U series PLC

The default IP address of H5U is 192.168.1.88. You can press the MFK key on the operating panel to restore the IP address to the default value as follows.

Switch the status of H5U to Stop, press and hold the MFK key until "IP" is displayed on the LED, and then press the MFK key for no more than 2s.

Then, a countdown is displayed on the LED. When the countdown reaches 0, the IP address is restored to the default value. You can press the MFK key during countdown to cancel the restoration operation.



Note: This IP address setting method is not supported by the Easy series.

### Setting the IP address through a USB flash drive

For how to set the IP address through a USB flash drive, see the description in the section *“2.2.3 USB Connection” on page 35Direct connection through USB*.

### Setting the IP address through Ethernet

For how to set the IP address through Ethernet, see the description in the section *“2.2.2 Ethernet Connection” on page 29Connection through Ethernet*.

### Setting the IP address through system variables

You can use the system variable to modify the IP address in the running state. For example, to set the variable Ethernet, perform the following operations.

1. Modify the value of the variable _Ethernet.IPCommand to 1.
2. Modify the variable _Ethernet.IPAddress to the target IP address. If the value of this variable is hexadecimal, such as 192.168.1.88, input C0A80158.
3. After inputting the IP address, modify the value of the variable _Ethernet.IPCommand to 2. Then, the value of this variable is automatically changed to 0 (display mode).

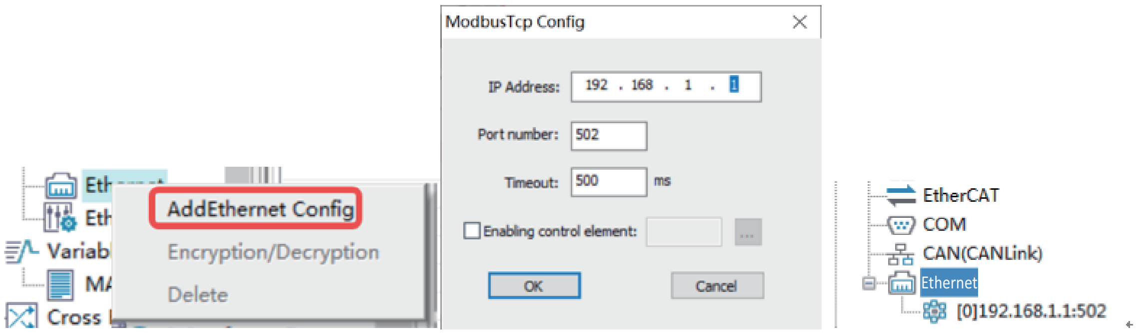
***Note***This variable can only modify the IP address and cannot modify other variables.

| | |
|---|---|
| _Ethernet | _sETHERNET |
| MACAddress | INT[3] |
| MACAddress[0] | INT |
| MACAddress[1] | INT |
| MACAddress[2] | INT |
| IPAddress | DINT |
| Mask | DINT |
| Gateway | DINT |
| IPCommand | INT |

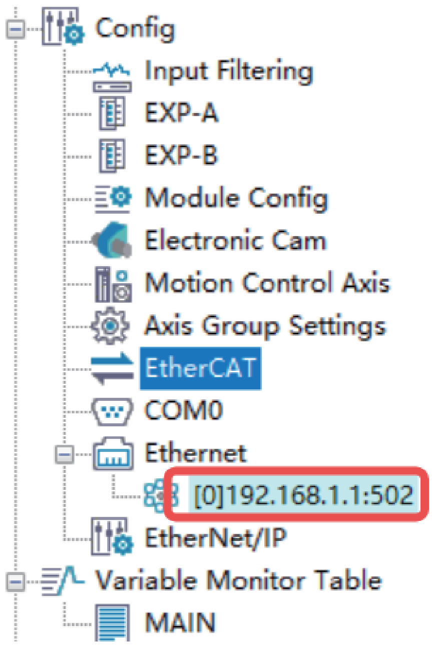
## 7.4 Master Configuration

### 7.4.1 Modbus-TCP Master

The Modbus-TCP master station is the Modbus-TCP client, which can be configured through Modbus-TCP. It can communicate with a maximum of 31 Modbus-TCP servers (slave stations) at a time. Configure the Modbus-TCP master station as follows.

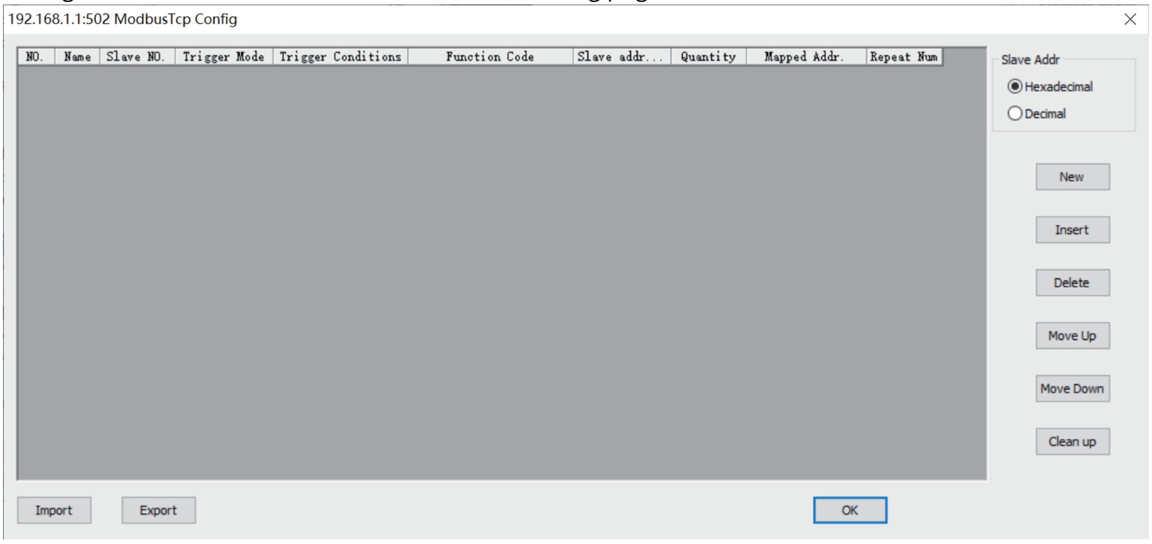



1. Set the IP address of the PLC. For details, see *“2.2.2 Ethernet Connection” on page 29Connection through Ethernet*.
2. Add a Modbus-TCP connection.
   - Timeout: Sets the period for the master station to wait for the slave station to answer, in the unit of ms.
   - Enabling control element: Enables or disables the connection. Customized variables are supported. If this option is not selected, the master station is enabled by default.
3. Access detailed configuration.
   Double-click the connected station to access the "Modbus Config" window. For details, see *“6.4.2 Modbus Master Configuration Table” on page 239Modbus Master Configuration Table*.




## 7.4.2 Modbus Master Configuration Table

Configure the Modbus master station on the following page.




The following describes relevant configuration items:

- Name

  The name that labels this condition configuration.

- Slave No.

  The number of the slave station you want to access. Up to 255 slave stations can be specified.

  Modbus-TCP communication identifies slave stations by IP address. The slave No. is not checked. You can use the default slave No..

- Trigger mode and condition

  The communication modes are "Cycle" and "Trigger".

When "Cycle" is selected, the trigger condition is used to set the cycle time in ms. Then the configurations are executed according to the specified cycle.

### Note

When the set cycle is smaller than the time required for communication, the configuration is executed according to the time required for communication. For example, if the set cycle is 10 ms and the actual slave response requires 20 ms, the actual execution cycle is 20 ms.

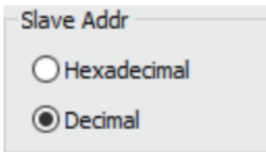
When "Trigger" is selected, the trigger condition is used to set the trigger condition variable/element. In this mode you can set the trigger condition to trigger a communication. If the slave station responds to the request, the trigger condition is automatically reset; otherwise, the trigger condition remains unchanged. If one trigger variable/element is used to trigger multiple configurations, the trigger condition will be automatically reset after all the triggered configurations are executed and the triggered configurations are not executed again.

- Function code

| Function Code | Definition |
|---|---|
| 0x01 (01) | Reads coils |
| 0x02 (02) | Reads discrete inputs |
| 0x03 (03) | Reads registers |
| 0x04 (04) | Reads input registers |
| 0x05 (05) | Single coil |
| 0x06 (06) | Single register |
| 0x0f (15) | Writes multiple coils |
| 0x10 (16) | Writes multiple registers |

- Slave register address
  The slave register address to be accessed.

  You can set the slave register address format to hexadecimal or decimal.




- Quantity
  The number of coils, discrete quantities, or registers to be accessed.

| Function Code | Name | Max. |
|---|---|---|
| 0x01 (01) | Reads coils | 2000 |
| 0x02 (02) | Reads discrete inputs | 2000 |
| 0x03 (03) | Reads registers | 125 |
| 0x04 (04) | Reads input registers | 125 |
| 0x05 (05) | Single coil | 1 |
| 0x06 (06) | Single register | 1 |
| 0x0f (15) | Writes multiple coils | 1968 |
| 0x10 (16) | Writes multiple registers | 123 |

- Mapped address

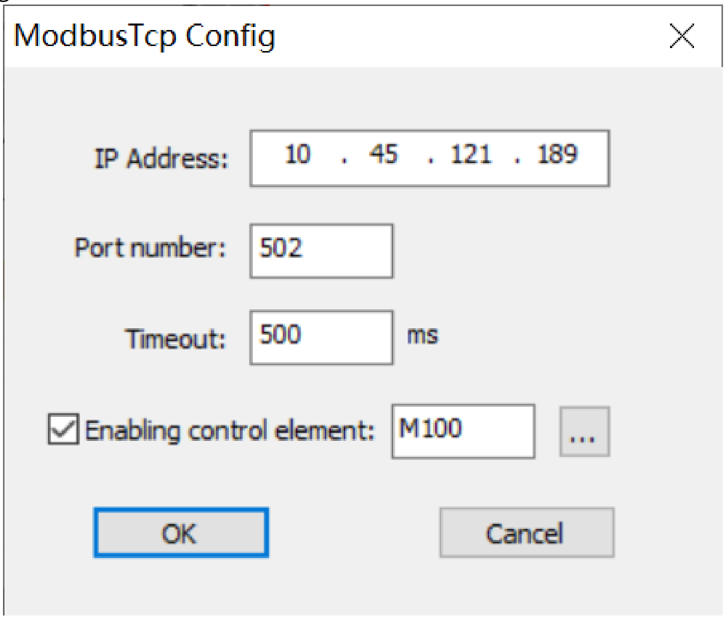
The mapped address of the slave coil, discrete quantity, or register in the master station. Customized variables are supported.

- Repeat number
  The number of retries after the slave station response times out.

## 7.4.3 Modbus-TCP Slave Disable

### Configuration

1. Configure the PLC slave connection. Create three server connections numbered 0, 1, and 2, as shown in the following figure.

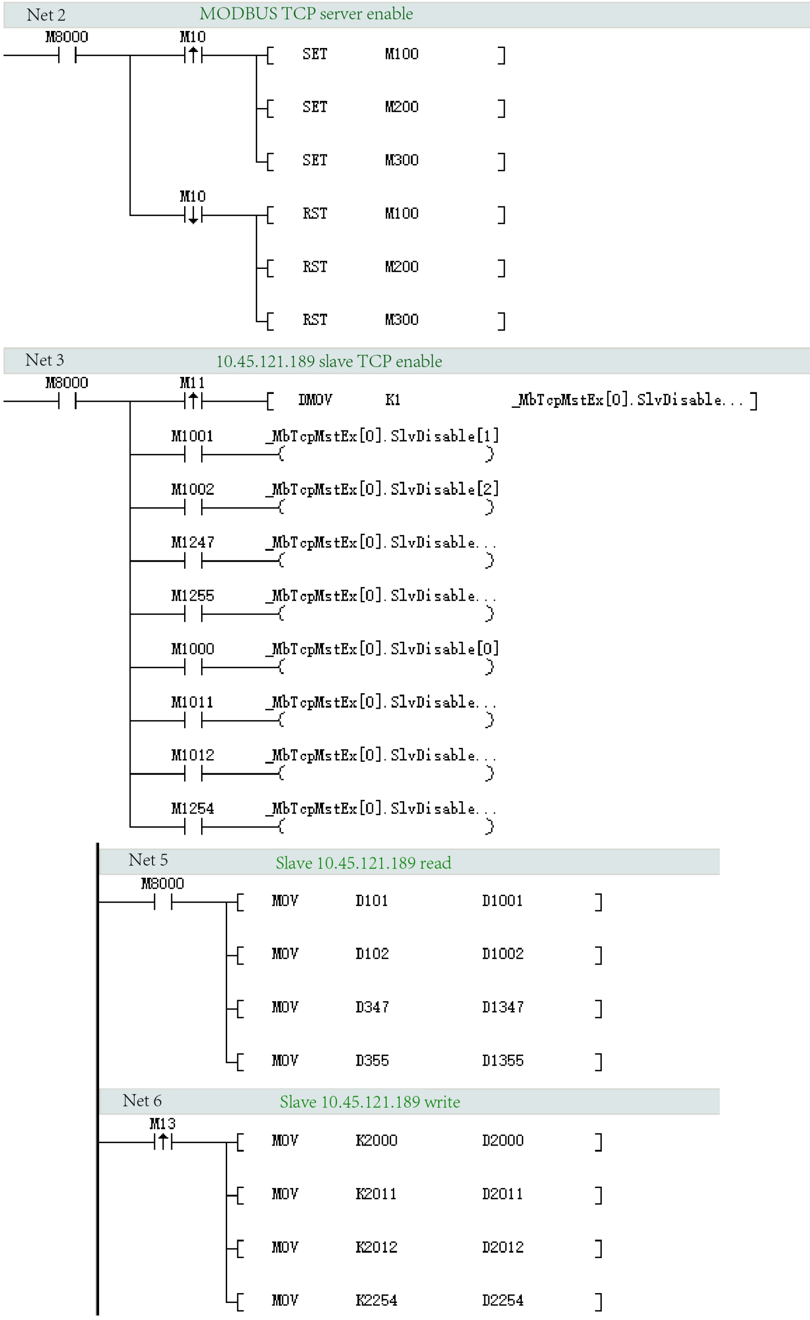



2. Add the configuration table.
3. Locate the slave station you want to disable based on the slave No. or slot No..
4. Configure the _MbTcpMstEx structure array to disable slave stations under the corresponding host.

***Note***

- In the _MbTcpMstEx[N] structure array, N is the server number. In this example, N is 0.
- _MbTcpMstEx[N].SlvDisableSetFlag is used to enable or disable the Slave Disable function. When it is non-zero, the Slave Disable function is enabled.
- In _MbTcpMstEx[N].SlvDisable[M], M is the Slave Disable flag corresponding to the slave station number mentioned in step 3. It is only valid when _MbTcpMstEx[N].SlvDisableSetFlag is enabled.

**Program example**




**Note**: When M1001, M1002, …, and M1254 are used to disable a single slave station, the read or write operation on this slave station is invalid.

# 7.5 Slave Configuration References

## 7.5.1 Modbus-TCP Slave

A Modbus-TCP slave station is a Modbus-TCP server enabled with Modbus-TCP and port 502 by default.

One H5U can connect to a maximum of 16 Modbus-TCP clients (master stations) at a time. When serving as the client, the Easy320 and Easy52X series can connect to a maximum of 31 Modbus-TCP servers. Configure the slave station as follows:

1. Set the IP address. Then, the Modbus-TCP slave function is enabled and you do not need to set the communication protocol.
2. Configure the Modbus-TCP master station and create a connection. Then, you can use the IP address of the PLC to communicate with H5U through the port 502.

### 7.5.2 Parameters and Addresses

- When H5U is used as the slave station, the following function codes are supported:

| Function Code | Definition |
|---|---|
| 0x01 | Reads coils |
| 0x02 | Reads discrete quantities (same as 0x01). |
| 0x03 | Reads registers |
| 0x04 | Reads input registers (same as 0x03). |
| 0x05 | Writes a single coil. |
| 0x06 | Writes a single register. |
| 0x0f | Writes multiple coils |
| 0x10 | Writes multiple registers |
| 0x80 to 0xFF | Standard Modbus fault code |

- When H5U is used as the slave station, addresses of coils that can be accessed by Modbus are listed in the following table:

| Variable | Quantity | Address Range |
|---|---|---|
| M0-M7999 | 8000 | 0x0000 to 0x1F3F (0 to 7999) |
| B0-B32767 | 32768 | 0x3000 to 0xAFFF (12288 to 45055) |
| S0-S4095 | 4096 | 0xE000 to 0xEFFF (57344 to 61439) |
| X0-X1777 (octal) | 1024 | 0xF800 to 0xFBFF (63488 to 64511) |
| Y0-Y1777 (octal) | 1024 | 0xFC00-0xFFFF (64512 to 65535) |

- When H5U is used as the slave station, addresses of registers that can be accessed by Modbus are listed in the following table:

| Variable | Quantity | Start Address |
|---|---|---|
| D0-D7999 | 8000 | 0x0000 to 0x1F3F (0 to 7999) |
| R0-R32767 | 32768 | 0x3000 to 0xAFFF (12288 to 45055) |

***Note***

W elements and Pointer variables are not supported.

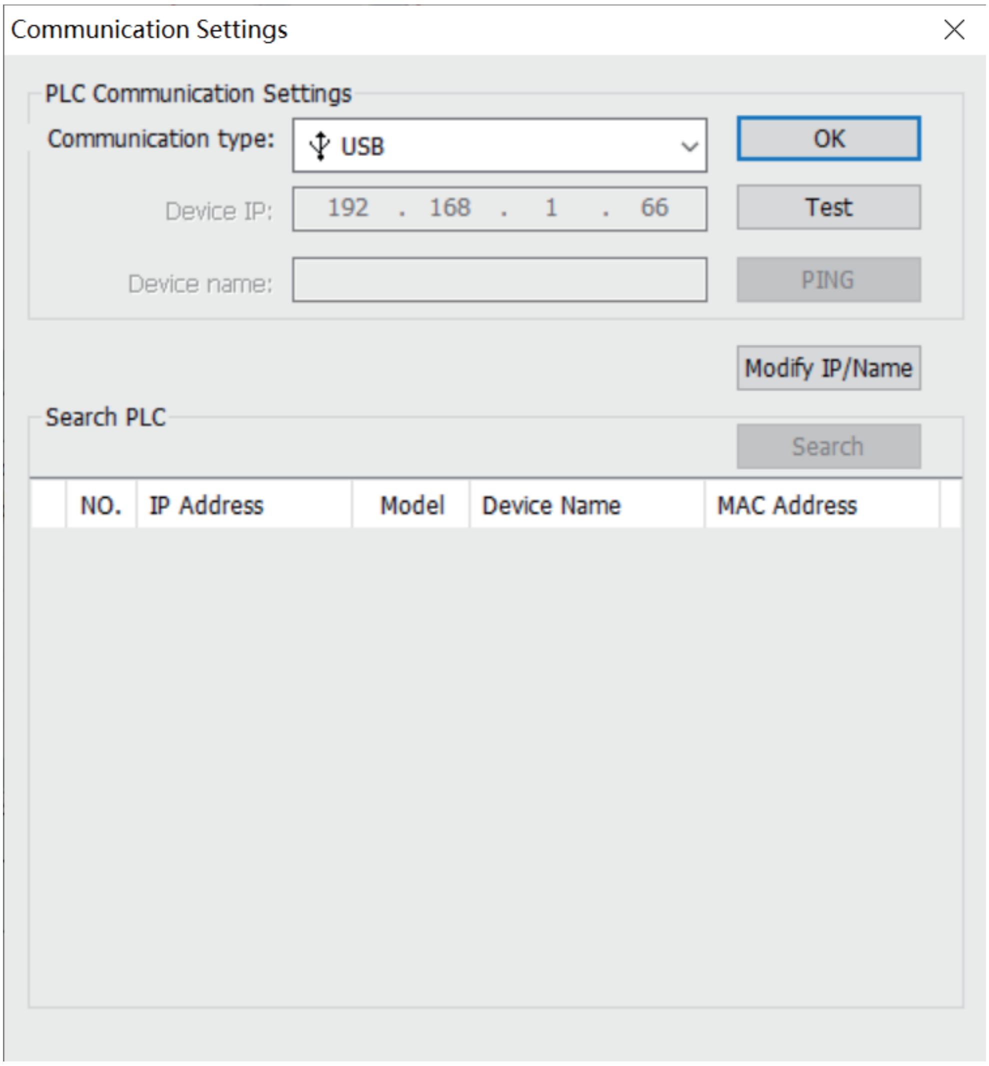
## 7.6 Example of Modbus-TCP Communication Application

**Program requirements**

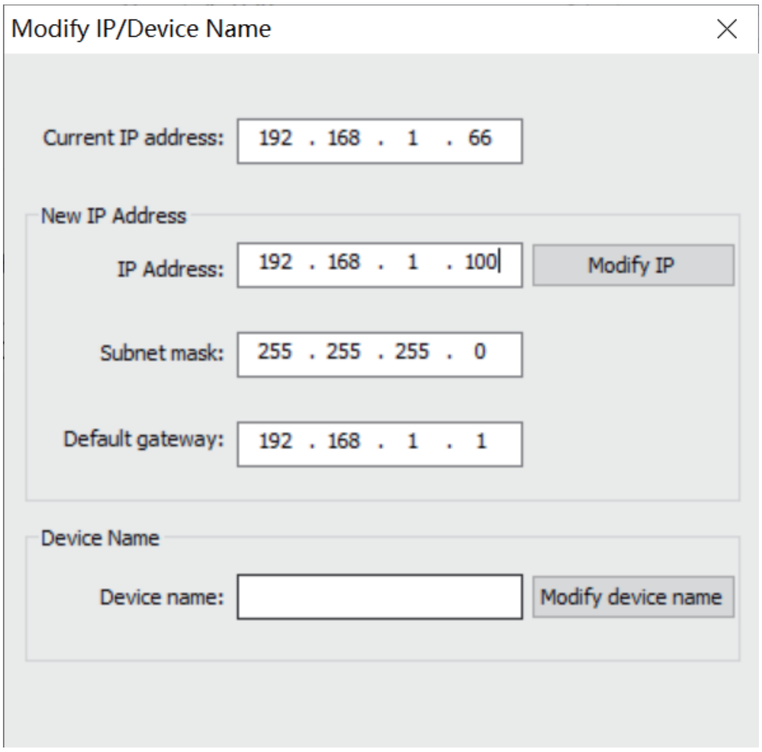
In this example, two H5Us are connected through an Ethernet port and communicate with each other through the Modbus-TCP protocol. The master PLC reads the value in the D100 register of the slave PLC every 10 ms, and the value in D100 of the slave station is added by one every second.

1. Slave configuration

Click the test communication status button . On the "Communication Settings" page displayed, click "Modify IP/Name".

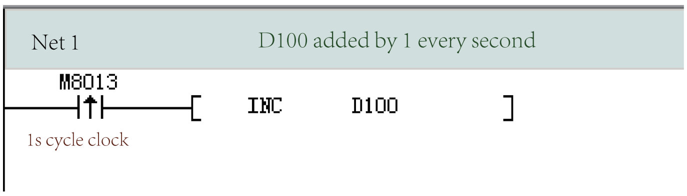



In the window displayed, set the slave IP address, subnet mask, and gateway, and then click "Modify IP" to modify the IP address. In this example, the IP address, subnet mask, and default gateway are set to 192.168.1.100, 255.255.255.0, and 192.168.1.1, respectively.




When the operation is correct, the system prompts "IP modification successful!". Click "OK" to close the dialog box.

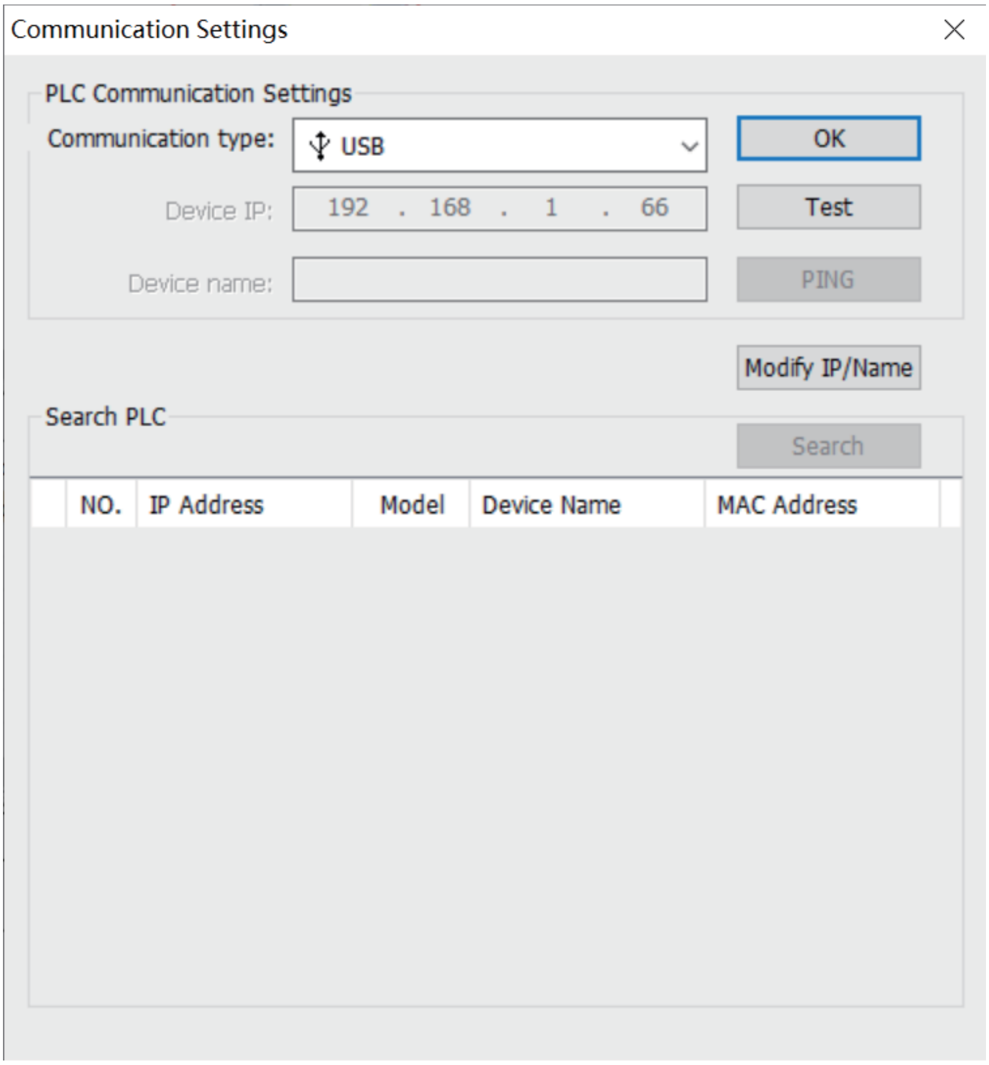
Edit the program so that the value of D100 of the slave station is added by one every second.



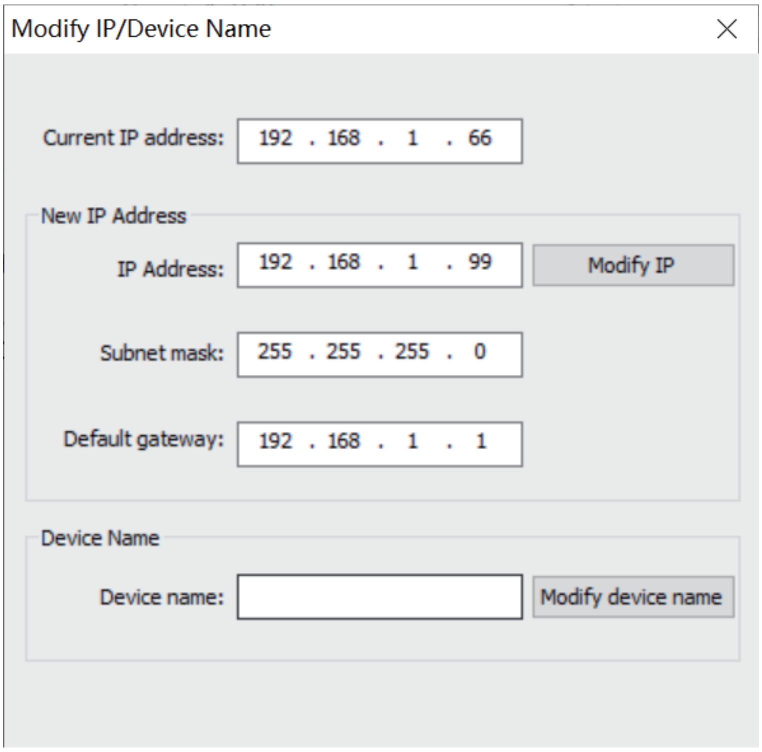

Then, click  to download the program to the PLC.

2. Master configuration

Click the test communication status button . On the "Communication Settings" page displayed, click "Modify IP/Name".

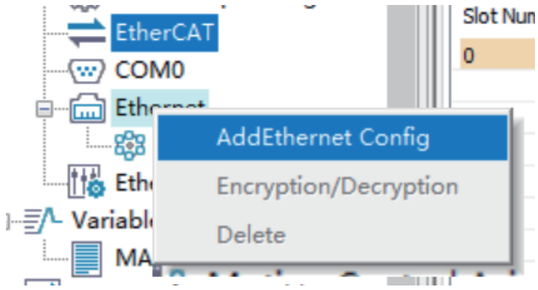



In the window displayed, set the slave IP address, subnet mask, and gateway, and then click "Modify IP" to modify the IP address. In this example, the IP address, subnet mask, and default gateway are set to 192.168.1.99, 255.255.255.0, and 192.168.1.1, respectively.

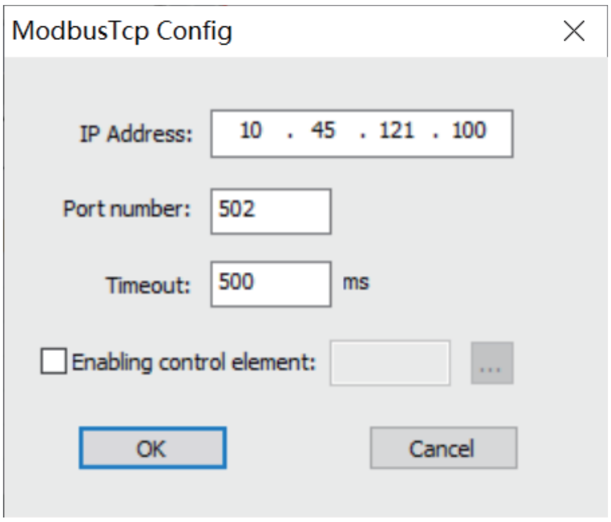



When the operation is correct, the system prompts "IP modification successful!". Click "OK" to close the dialog box.

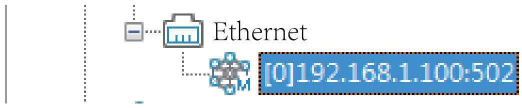
Right-click the Ethernet icon and select "Add Ethernet configuration".



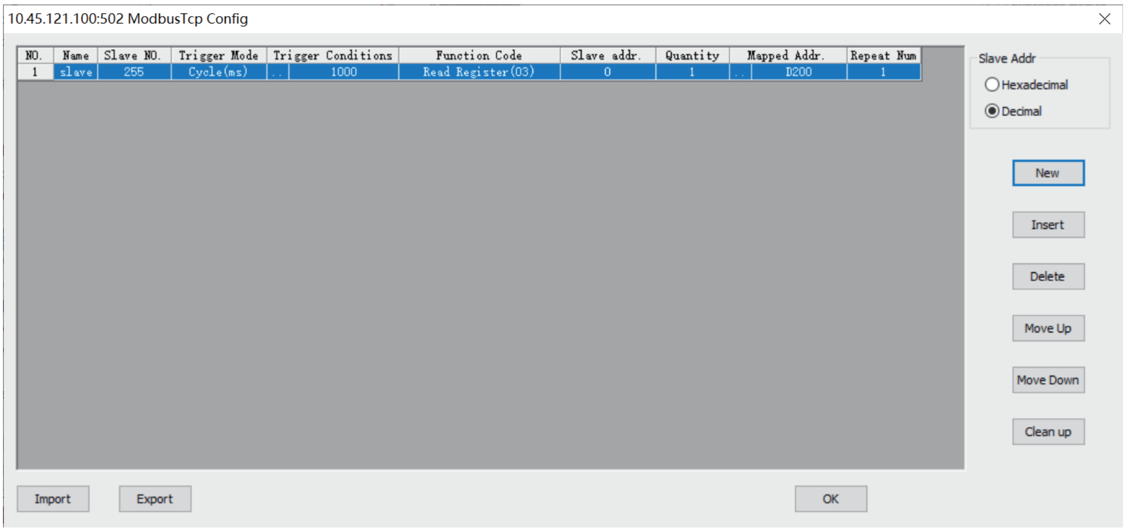

In the dialog box displayed, set "IP Address" to 192.168.1.100 and "Timeout" to 500 ms, deselect "Enabling control element", and use default values for other configurations.



Click "OK". The master configuration is generated.



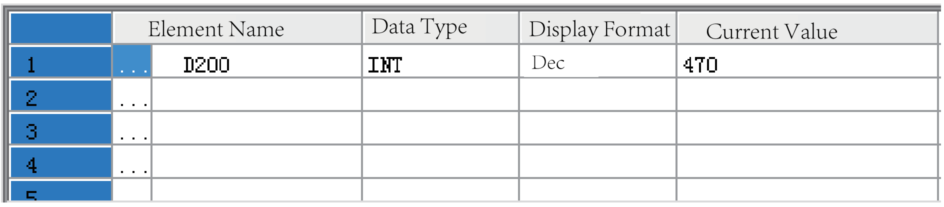

Double-click the master configuration. On the configuration table page displayed, click "Add" to add the configuration. In this example, the value of D100 of the slave station is stored in D200 of the master station.




Then, click  to download the program to the PLC.

3. Effect

The value of the D100 register of the slave station can be read from the D200 register of the master station.



| | | Element Name | Data Type | Display Format | Current Value |
|---|---|---|---|---|---|
| 1 | ... | D200 | INT | Dec | 470 |
| 2 | ... | | | | |
| 3 | ... | | | | |
| 4 | ... | | | | |
| 5 | | | | | |

# 8 CAN Communication

## 8.1 Overview

- H5U provides a CAN communication port that supports the CANlink and CANopen protocols and can be scaled up to 63 slave stations.
- The Easy series (Easy302/Easy320/Easy501/Easy502/Easy521/Easy522/Easy523) can support one master station and up to 63 slave stations by using the extension cards. They support the CANlink and CANopen protocols.

***Note***

This function requires a firmware version of V5.65.2.0 or later and a software version of V4.6.5.0 or later for the Easy302, Easy320, Easy501, and Easy502 series. It requires a firmware version of V5.66.0.0 or later and a software version of V4.8.0.0 or later for the Easy521, Easy522, and Easy523 series.

## 8.2 Hardware Ports

The CAN communication port and RS485 port of H5U are integrated to a 6-pin port. CAN extension cards of the Easy series use the RJ45 network port. For details, see the GE20-CAN-485 Communication Extension Card User Guide.

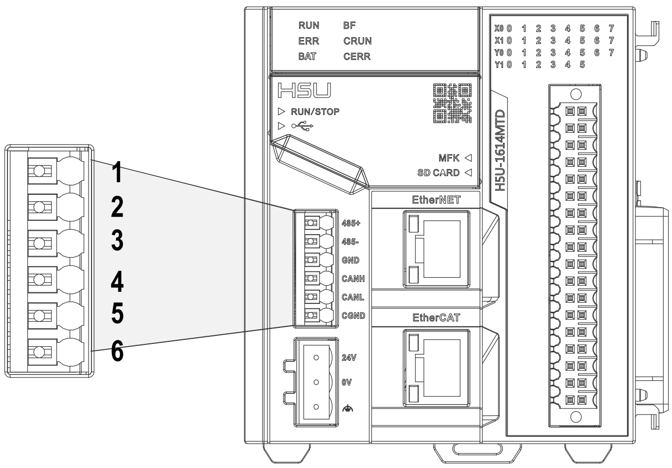



Table 8–1 Port pins

| Pin | Signal Definition | Description |
|---|---|---|
| 1 | 485+ | Positive signal of the RS485 differential pair for COM0 |
| 2 | 485– | Negative signal of the RS485 differential pair for COM0 |
| 3 | GND | Power ground of COM0 |
| 4 | CANH | CAN communication data receiving terminal |
| 5 | CANL | CAN communication data sending terminal |
| 6 | CGND | CAN communication ground |

# 8.3 CAN Network

## 8.3.1 CAN Communication Networking

The three wires of each device must be interconnected to form a CAN. 120 Ω termination resistors must be provided at both sides of the CAN bus (both the H5U and CAN extension card have a built-in resistor, which can be connected by setting the DIP switch. The default value is ON).

The CAN bus wiring diagram of H5U is as follows.

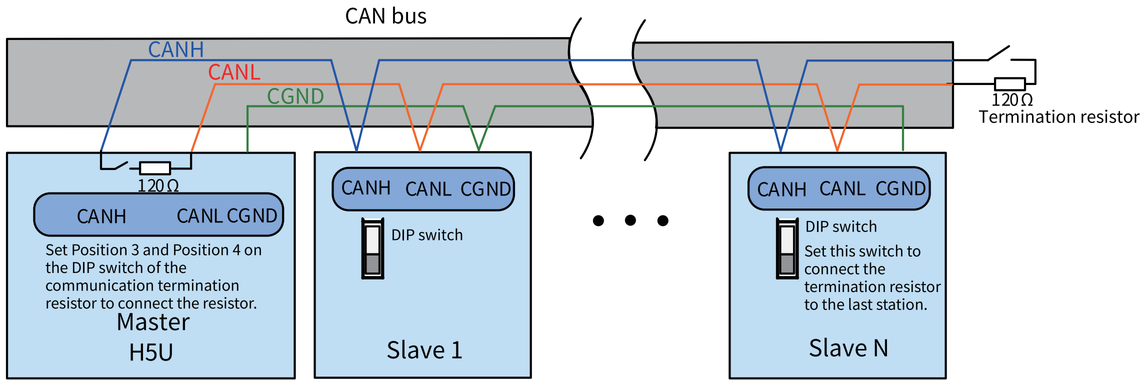



Figure 8-1 Wiring diagram of a CAN network formed by multiple devices

***Note***

The CGND terminals of all the devices must be connected together.

## 8.3.2 Relationship Between CAN Communication Distance and Baud Rate

The following table lists relationship between CAN communication distances and baud rates

| Baud Rate (kbps) | Distance (m) | Min. Cross-Sectional Area ($mm^2$) | Max. Number of Access Points |
|---|---|---|---|
| 1000 | 20 | 0.3 | 18 |
| 500 | 80 | 0.3 | 31 |
| 250 | 150 | 0.3 | 31 |
| 125 | 300 | 0.5 | 31 |
| 100 | 500 | 0.5 | 31 |
| 50 | 1000 | 0.7 | 31 |

## 8.3.3 CAN Port System Variables

H5U provides a system variable named "_CAN" to view or monitor the status of the CAN port. "_CAN" is a structure variable whose data type is "_sCAN". The following table lists its members and definitions.

| Member | Data Type | Description |
|---|---|---|
| BaudRate | INT | The baud rate, in the unit of kbps |
| LoadRate | INT | The network load rate, in the unit of % |
| RxPexSec | INT | The number of messages received per second, in the unit of FPS |
| TxPexSec | INT | The number of messages sent per second, in the unit of FPS |

| Member | Data Type | Description |
|---|---|---|
| RxErrCnt | INT | The count of errors received by the CAN controller |
| TxErrCnt | INT | The count of errors sent by the CAN controller |
| Protocol | INT | The communication protocol. 0: CANlink; 1: CANopen |

# 8.4 CANlink Communication

## 8.4.1 CANlink3.0 Communication Principles

CANlink3.0 communication is implemented through CAN network configuration rather than CAN communication instructions. When downloading user programs, you need to download CAN network configurations to the PLC.

Understanding the principle of CANlink3.0 network configuration can help you complete the CAN configuration table.

One CANlink3.0 network can have only one master station but can have one or more slave stations.

Master and slave stations on a CANlink3.0 network communicate with each other by automatically sending and writing data rather than in query-response mode.

**Example:**

- To send data to slave stations, the master station "writes" register data in slave registers based on CANlink communication configurations when trigger conditions are met.
- Slave stations automatically send data to the master station and "write" the data in the receiving unit of the master station based on CANlink communication configurations.
- Slave stations automatically send data to each other and "write" the data in receiving units of slave stations based on CANlink communication configurations.
- To send data to multiple stations, a station automatically sends the "write operation" data to itself (equivalent to broadcasts), while the other stations selectively receive the data and automatically store it in their receiving units.
- For efficient data exchange during network communication, master and slave stations save "heard" broadcast data sent by other stations. You need to click "Receive Config" to set receiving slave station numbers and addresses. In this way, the stations configured as receiving stations will ignore the broadcast data from stations not configured as sending stations.

You do not need to configure CANlink3.0 slave stations because CANlink configurations can be transmitted to slave stations through a master PLC. Therefore, CANlink3.0 communication configuration items for slave stations are forwarded by the CANlink master station through configuration frames.

Upon startup, the master station sends configuration frames to CANlink slave stations and assigns the list of communication tasks. Slave stations automatically send data based on the list.

CANlink3.0 configuration items include the address of the sent register, address of the target receiving slave station, number of data entries, address of the received register, interval for sending, and trigger condition, which are required by common communication instructions. Different from common communication operations, "communicate-write" operations do not need responses.

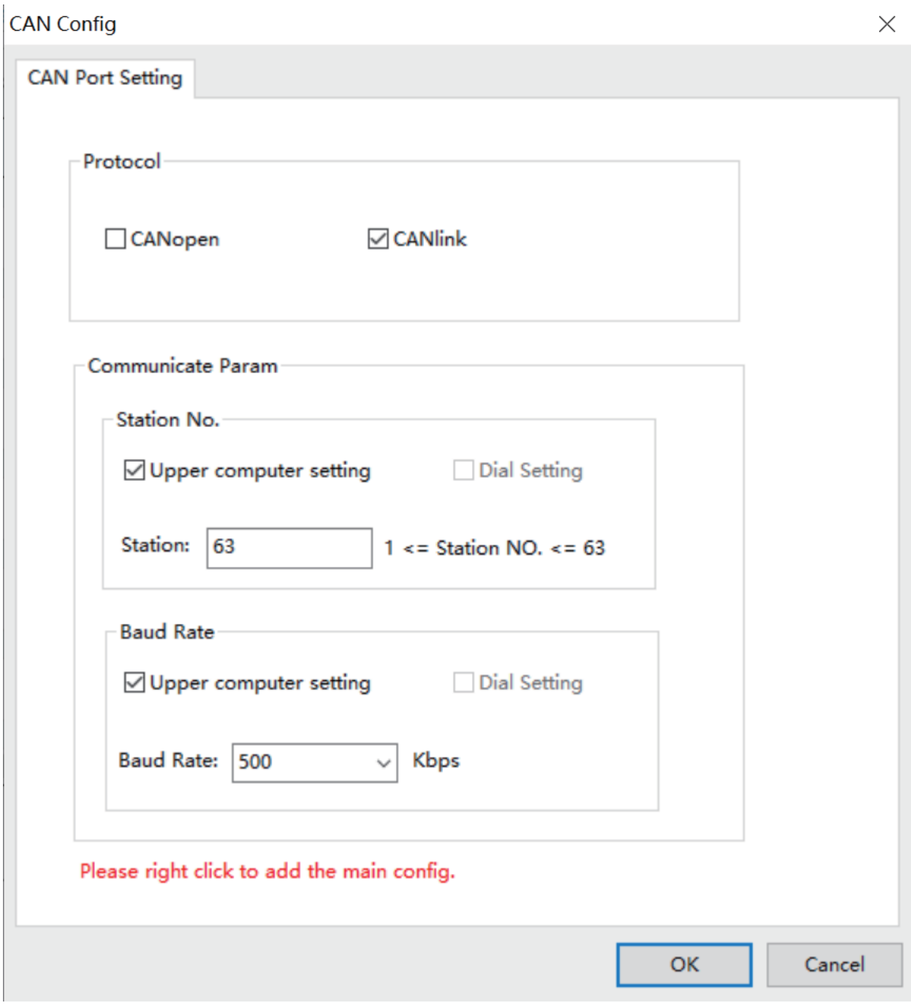
In communication scenarios where multiple slave stations must synchronously act and respond (for example, servo-driven synchronous multi-axes control and position-controlled high-speed movement), you need to set Synchronous Write for the master station. The master station writes data to slave stations and then sends broadcast command frames to make slave stations run simultaneously.

## 8.4.2 CANlink Configuration

Take the following steps to configure a CANlink network.

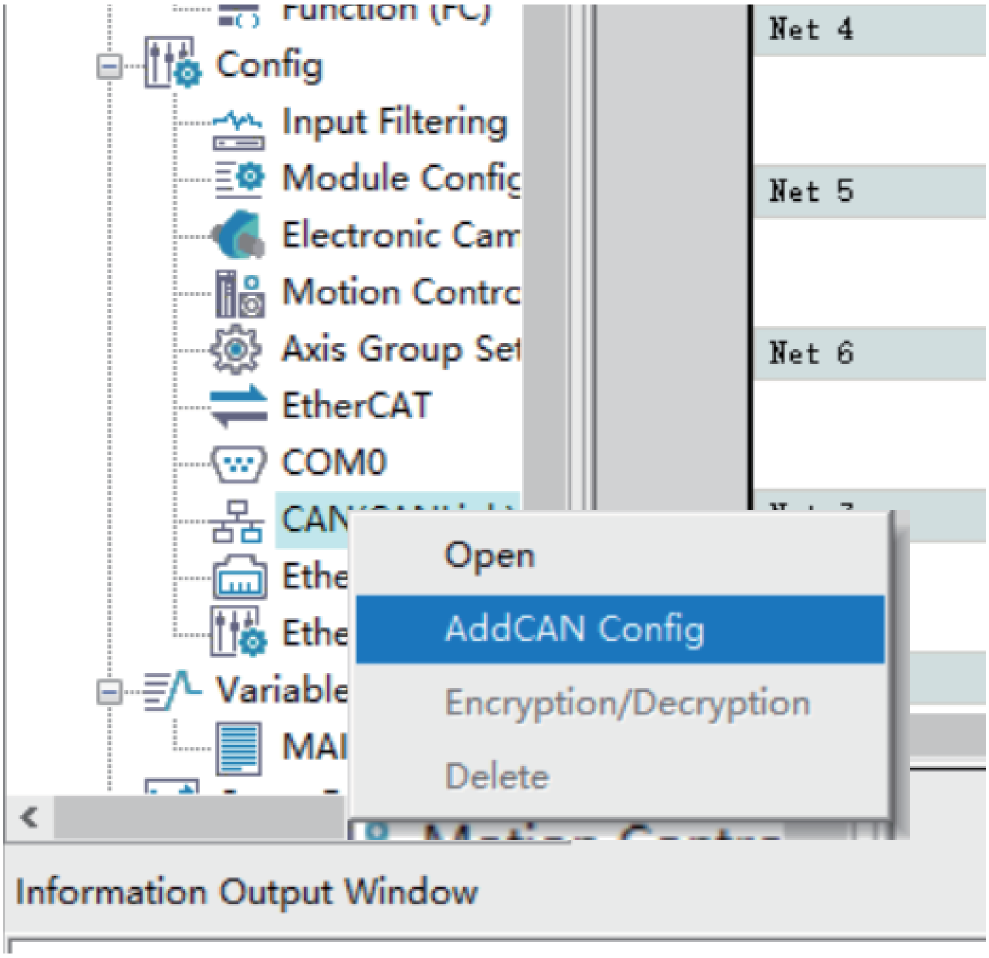
1. Configure the CANlink network through AutoShop and define the data to be exchanged.
2. Download configurations to the H5U series PLC.

After creating a project, choose "Project Manager" > "Config", and then double-click "CAN". In the window displayed, select "CANlink" as the communication protocol. Then, the system automatically determines whether the current PLC is the CANlink master station or the CANlink slave station based on the presence of the CANlink configuration.



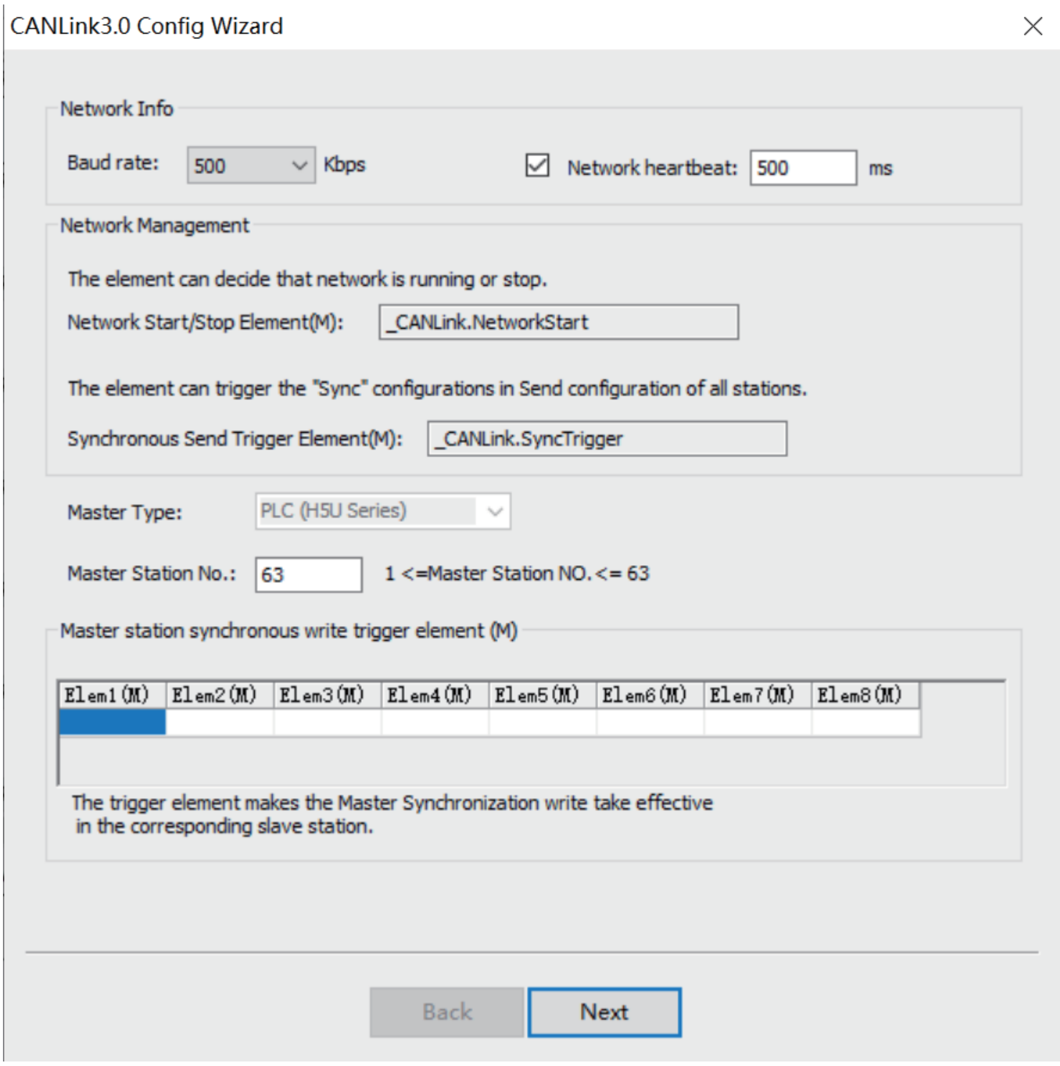

Select "CANlink", set the slave No. and baud rate, and then click "OK". When "CANlink" is selected, the system automatically determines whether the current PLC is the CANlink master station or the CANlink slave station based on the presence of the CANlink configuration.

In this example, CAN is configured as the CANlink slave station. Choose "Project Manager" > "Config". Right-click "CAN". In the window displayed, select "Add CAN configuration" to configure it as the CANlink master station, as shown in the following figure.




## CANlink3.0 Config Wizard page

Double-click "CANlink Config'. The "CANlink3.0 configuration wizard" page is displayed, as shown in the following figure.

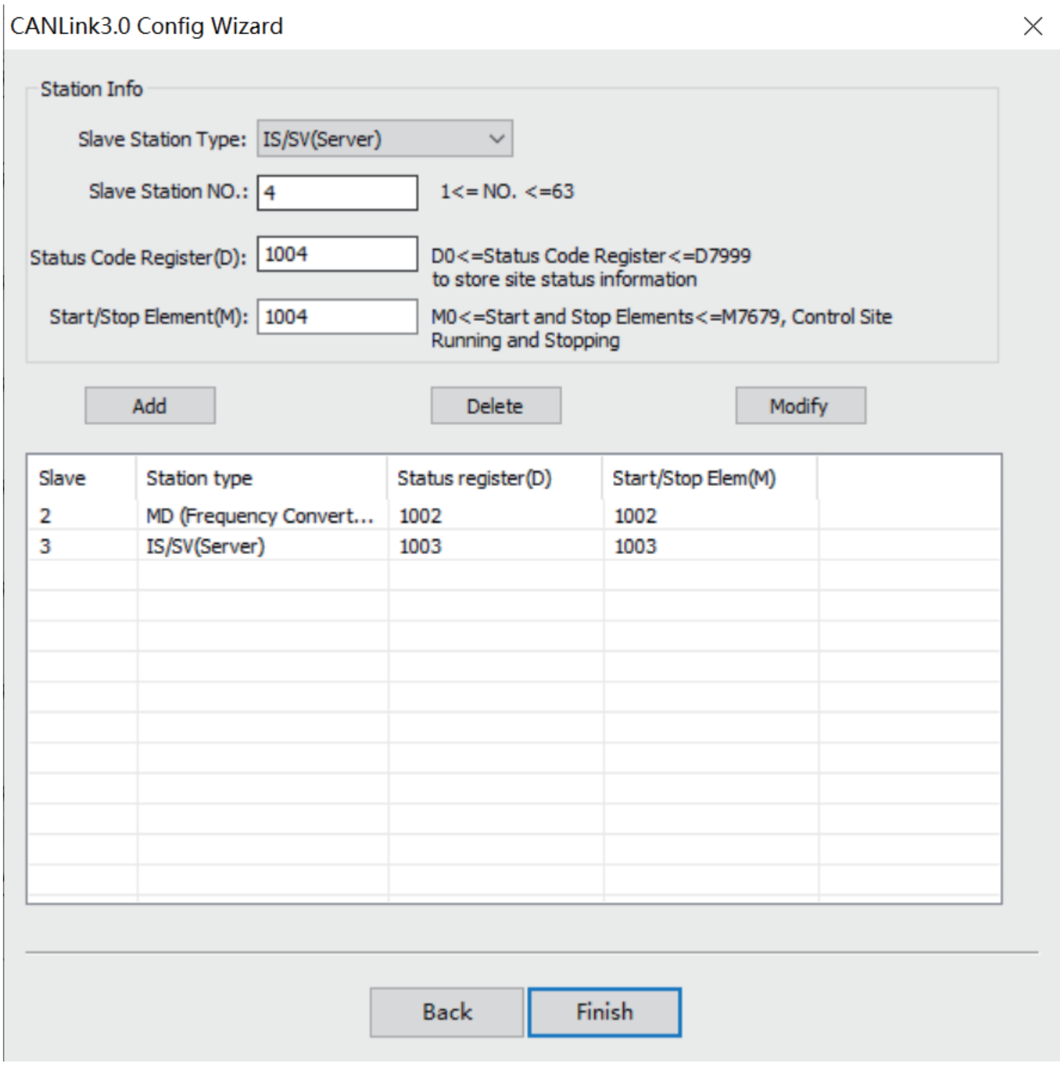



- Baud rate (required)
  Eight options are available for different scenarios: 20 kbps, 50 kbps, 100 kbps, 125 kbps, 250 kbps, 500 kbps, 800 kbps, and 1 Mbps. You can select the desired option from the drop-down list, and then download the configuration to the master station (this parameter is valid for the master station only, and needs to be manually modified on a slave station). You can select the baud rate based on the bus load and communication distance.
- Network heartbeat (optional)
  All slave stations send heartbeats to the master station at a specified interval. The master station monitors the state (online or offline) of each slave station through the heartbeat mechanism. Slave stations monitor the status of the master station through its heartbeats. (An interval of more than 200 ms is recommended.) If you deselect this parameter, the heartbeat function is disabled and the system cannot monitor the network.
- Master Station No. (required)
  In this example, the master station No. is the number of the PLC that serves as a master station. The number cannot be changed. If the number entered is inconsistent with the actual number, the PLC will determine that the downloaded configuration is invalid.

  For example, if you enter 7, the configuration is valid only when downloaded to station 7. Station 7 then assigns the configuration to other stations. The CANlink network configuration is downloaded to the master station and then assigned to slave stations. In this way, the system can monitor and manage the entire network through the master station in the background.

- Master station synchronous write trigger element (optional)
  It is an element triggering Synchronous Write for the master station. When a trigger element (M) is set, the corresponding configuration takes effect. The element is automatically reset after data is sent.

Click "Next". The window for adding a slave station is displayed as follows.




## Station information page

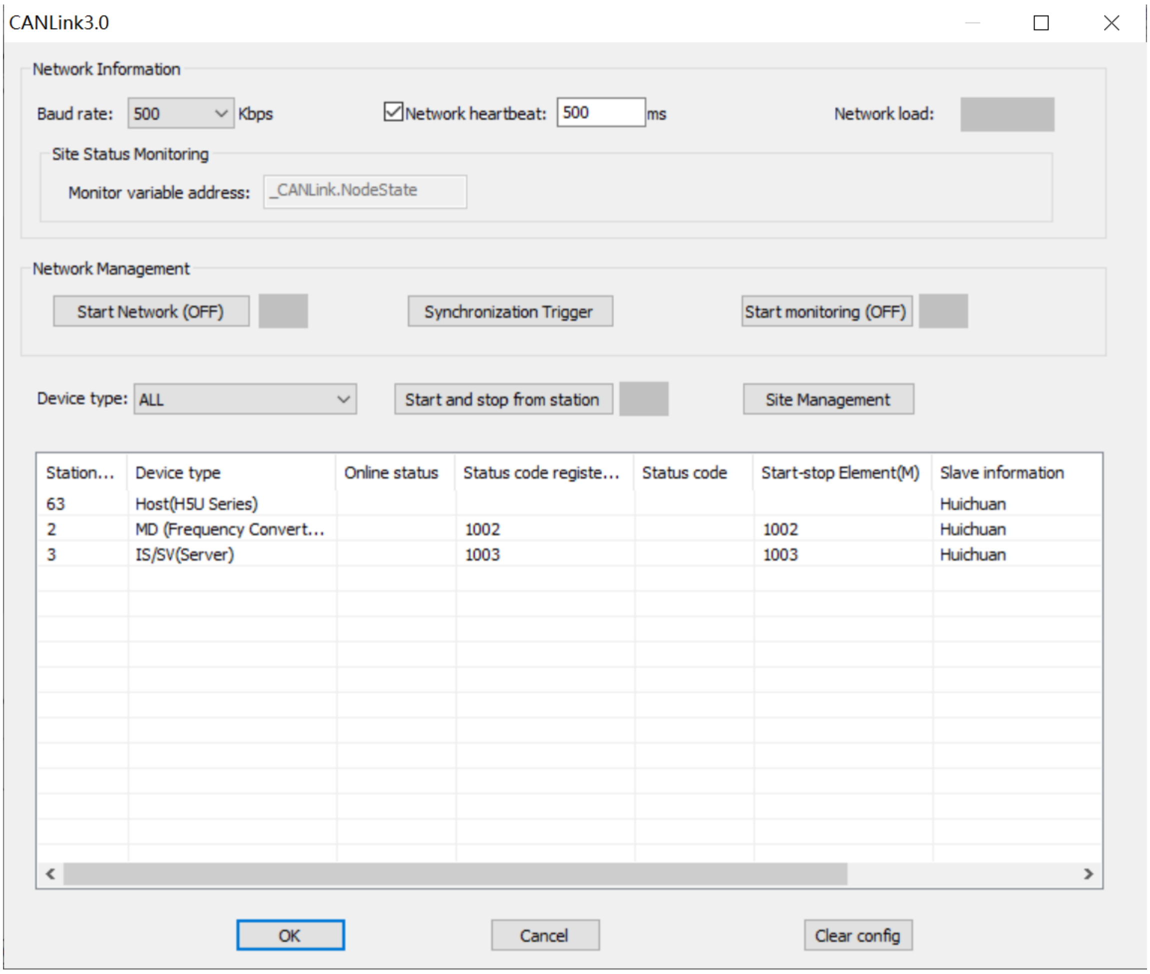
- Add
  After configuring a slave station, click "Add". The station is added to the list.
- Delete
  Select a station and click "Delete". In the confirmation dialog box "Delete it?", click "OK" (you can delete multiple stations at a time).
- Modify
  Select a slave station, modify parameters on the "Station Info" page, and then click "Modify". Do not modify the station type.

- Slave No.
  Set the CANlink slave station number.
- Status Code Register (D)
  It is used to save the status of a slave station fed back through heartbeat frames of the slave station.
- Start/Stop Element (M)
  It is an M element used to start or stop communication. When M is ON, communication is started. When M is OFF, communication is stopped.

## *Note*

In the configuration wizard, click "OK" to save the modification made in the wizard and exit; click the "X" button in the upper right corner of the wizard to cancel the modification and exit.

Then, click "Finish". The following window is displayed.




- Network Information
  Baud rate: Indicates the baud rate of the master station.

  Network heartbeat: Indicates that the heartbeat function is enabled after this parameter is selected.

  Network load: Calculates the real-time load of the network (this parameter is displayed only when the network load is monitored during running of devices).

  - Network load ⩽ 50: Green (good)
  - 50 < Network load ⩽ 75: Yellow (warning)
  - 75 < Network load ⩽ 90: Red (major warning)
  - Network load > 90: ERR, red background (error)

- Site Status Monitoring
  The online status of the station will be updated to the system variable _CANLink.NodeState[64], in which _CANLink.NodeState[0] is the status of the local station, while _CANLink.NodeState[station No.] is the status of the slave station.

| Status Value | Definition |
|---|---|
| 1 | Configurations of the slave station are available. |
| 2 | The slave station is running. |
| 5 | The slave station is disconnected. |

### *Note*

If the heartbeat function is disabled, the station monitoring function is meaningless.

- Network Management
  Start/Stop Network (OFF) (enabled when monitoring is enabled): Starts and stops network communication.

  Synchronous Send: Synchronization will be triggered. You can enable the function in the user program by setting _CANLink.SyncTrigger. After synchronous data frames are sent, _CANLink.SyncTrigger will be automatically reset.

  Start Monitor (OFF): Starts and stops network monitoring.

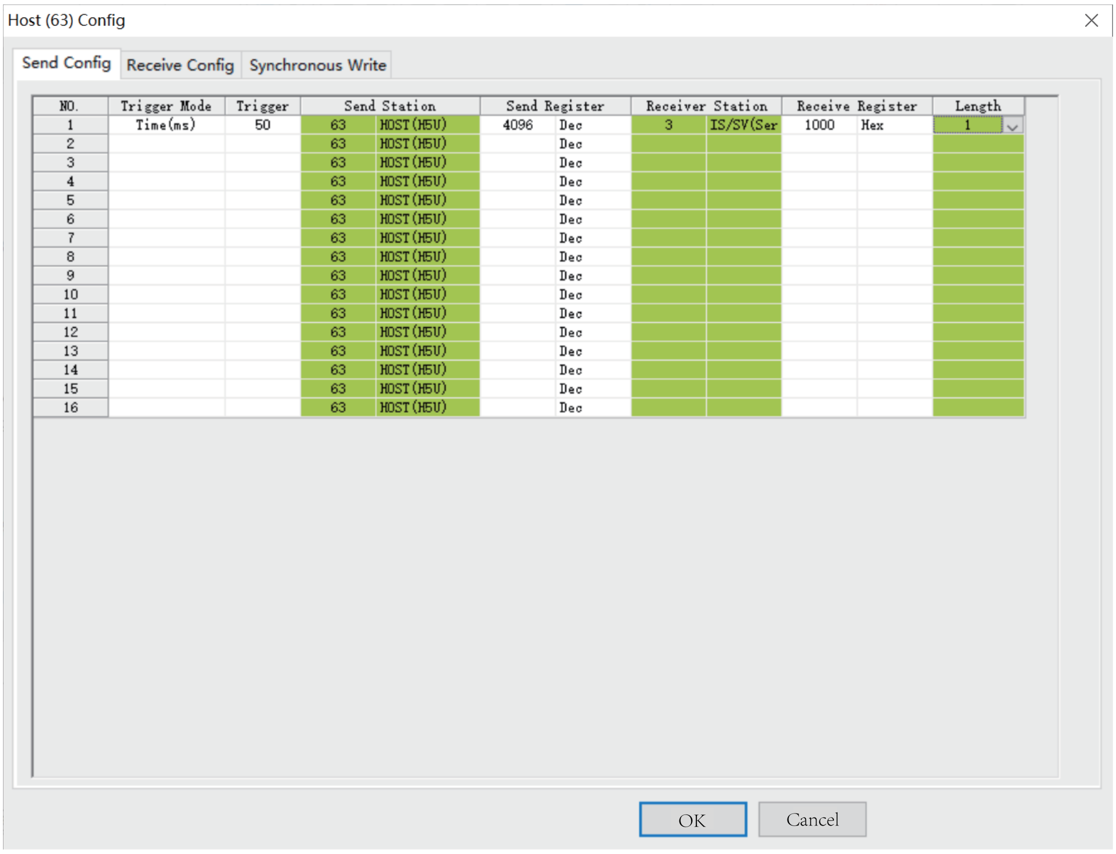
  Device type: Filters displayed stations.

  Slave start/stop: Select a slave station and control its start/stop of communication.

  Station management: Click "Station Management". The initialization wizard page is displayed. You can modify parameters of the master or slave station.

  Station configuration: On the main screen, double-click a station. The communication configuration window is displayed. Communication configuration includes sending configuration, receiving configuration, and synchronization configuration (for the master station only).

  Sending configuration:




- Trigger mode

  Time (ms): It is applicable to all devices. The station applies the configuration at a fixed interval. The value ranges from 1 ms to 30000 ms.

  Event (M): It is applicable to the host and PLC. The station applies the configuration when the trigger condition (M element) is set. Multiple configurations can be triggered by the same M element. The element is automatically reset after data is sent. Edge trigger instructions must be used to operate M elements; otherwise, the network load will be excessive.

  Synchronization: It is applicable to all devices. The master station applies the configuration when the system variable _CANLink.SyncTrigger is set. The element is automatically reset after data is sent.

  Event (ms): It is applicable to IS, MD, and remote extension modules (TCM/NTCM). The station applies the configuration when it detects the changed value of the sent register and the trigger condition (disabling time) is met.

  The disabling time indicates the minimum interval for sending the same configuration.

  Maximum number of configuration items for one station: 256 for the host (master station), 16 for one slave station, and 256 for all slave stations.

  If you select a configuration item and press "Insert", an empty configuration line will be added following the item. If you select a configuration item and press "Delete", the item will be deleted. In addition, you can press shortcut keys or right-click an item to copy-paste or delete it, and insert or delete a line.

- Register

Host and PLC register values correspond to D elements. IS and MD register values correspond to function codes. TCM/NTCM corresponds to BFM.

- Number of registers
  It is the number of sent or received consecutive D elements or function codes.
- Point-to-multi-point configuration
  When a sending station is also a receiving station, the station applies the point-to-multi-point configuration, in which no receiving station is specified. If you enter the sending station number into the receiving configuration table, the configured station can receive data sent by the sending station. The received register is the D element or function code corresponding to the receiving station.
- Received data
  The entries in the gray background indicate data received from other stations, including point-to-point and point-to-multi-point data. You can see which element or function code of which station will affect the configured station.
- Receiving configuration
  Receiving configuration applies to receiving point-to-multi-point data from other stations. Each station can receive point-to-multi-point data from eight stations.

***Note***

The point-to-multipoint configuration enables simultaneous application of data. This is equivalent to master synchronous configuration, but does not limit the data sending capability to the master alone. Each station can receive point-to-multipoint data from up to eight different stations, but the number of stations each station can send point-to-multipoint data to is not limited. In other words, all nodes in the network except for the sending station can receive such point-to-multipoint data. However, to receive point-to-multipoint data from a station, the receiver must be configured to allow receiving such data from the station.

## Synchronous write configuration for the master station

When the trigger condition (M) is set, the Synchronous Send configuration for the master station takes effect. You can select different trigger conditions (M) to display, add, modify, or delete synchronization configurations. Synchronization configuration is applicable to scenarios in which an operation needs to be initiated synchronously.

As shown in the figure, when M1 is 1, the master station sends the three configuration items successively. Upon receipt of the items, slave stations store them in the buffer. After the last data entry is sent, the master station automatically sends a configuration application command. Upon receipt of the command, all slave stations automatically write the data in the buffer in corresponding elements or function codes. As shown in the figure, PLC 10 writes the D10 value in D10, servo 20 writes the D20 value in H200, and AC drive 30 writes the D30 value in HF003. All these values are synchronously written when slave stations receive the configuration application command. After the command is sent, the master station automatically resets the trigger element M1. Edge trigger instructions must be used to operate M elements; otherwise, the network load will be excessive.

**Precautions for the trigger condition (M):**

- Each trigger condition associates a maximum of 16 configuration items. It determines whether the associated synchronization configuration is valid. A maximum of 8 trigger conditions (M) are allowed.

- You can select a trigger condition from the drop-down list.
- During synchronization configuration of a 32-bit servo register, data must correspond to high-order 16 bits and low-order 16 bits respectively for the same trigger element. That is, two data entries must be written for one trigger element, one corresponding to high address bits of the 32-bit function code, and the other corresponding to low address bits. If only one entry is written or two entries are written for two trigger elements respectively, the servo will return an error, and the configuration cannot continue.

**Example of 32-bit servo register synchronization configuration:**

As shown in the following figure, H1112 is a 32-bit function code of the servo. During configuration of the function code, two data entries must be written, corresponding to high and low address bits respectively. When M3 is set, the master station writes D201 and D202 values in H1112. When all of the five data entries of M3 are sent, the master station sends a command to enable the slave stations and apply the configurations. Then M3 is automatically reset.

If only one address is processed for one trigger element, the servo will return an error so that synchronization cannot continue. The error will be recorded in D8307 of the master station. Fault codes are listed in *"8.5.6.2 Fault Code List" on page 300Fault Code List*.

- Master station fault codes and processing
  The following table lists configuration errors and causes. You can use the system variable _CANLink. ConfigErr to view the details.

Table 8–2 Configuration errors

| Fault Code※ | Cause | Solution |
|---|---|---|
| XX00 | Reserved | None |
| XX01 | Incorrect code | Check whether the internal definition is correct. |
| XX02 | Incorrect index | Check whether the device type is correct. |
| XX03 | Incorrect information | Check whether the address is valid and check the read-write property. |
| XX04 | Reserved | Reserved |
| XX05 | Incorrect data length | Check whether the data length exceeds the limit. |
| XX06 | Configuration frames failing to respond within a specified time | Check whether the connection is normal. |

The following table lists abnormality codes and causes. You can use the system variable _CANLink. SyncWrErr to view the details.

Table 8–3 Fault codes

| Fault Code※ | Cause | Solution |
|---|---|---|
| XX00 | Reserved | Reserved |
| XX01 | Invalid command code | Check whether the internal definition is correct. |
| XX02 | Abnormal address | Check whether the address is normal or whether the address can be accessed. |
| XX03 | Abnormal data | Check whether the data is within a specified range. |
| XX04 | Invalid operation | Check whether the operation is authorized. |
| XX05 | Invalid length | Check whether the data length exceeds the limit. |
| XX06 | Responding timeout | Check whether the connection is normal. |

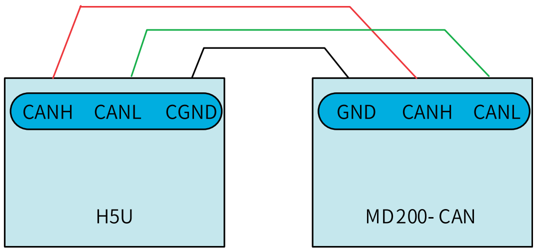
***Note***

- The fault codes are in decimal, where XX indicates the station number. Specifically, a fault code indicates that an error occurred when configuring XX station or sending commands to XX station.
- Fault codes of PLC slaves are similar to those of the master, except that the fault codes of PLC slaves do not contain a station number.

### 8.4.3 AC Drive Communication Example

Use one H5U and one MD200-CAN AC drive to control the start/stop and write the frequency of the AC drive through the CANlink bus.

1. Connect the CANlink bus.




2. Configure function codes for the slave MD200 AC drive.

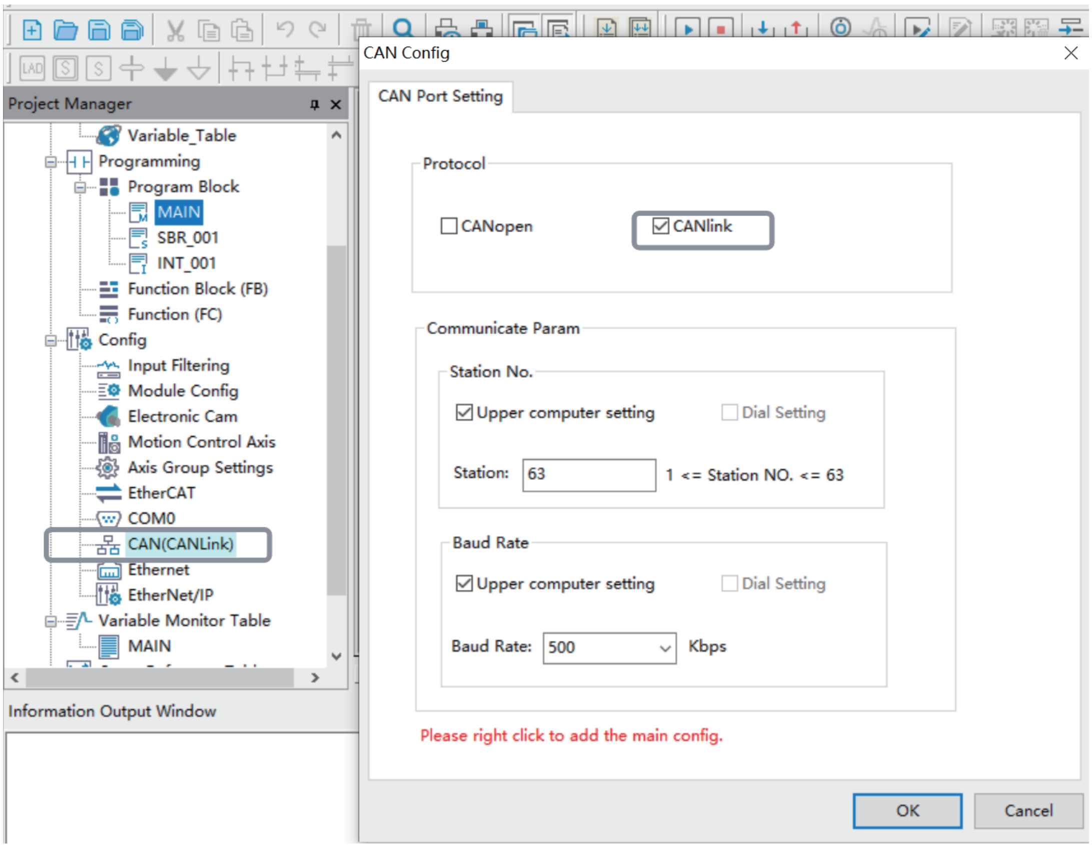
| Function Code | Name | Value | Description |
|---|---|---|---|
| FD-00 | Baud rate | 5005 | CANlink baud rate: 500 kbps |
| FD-02 | Local address | 1 | Local station No. is 1. |
| F0-02 | Command source selection | 2 | Communication setting |
| F0-03 | Main frequency reference source | 9 | Communication setting |

Control parameter addresses when MD200-CAN is used for communication with the host controller PLC:

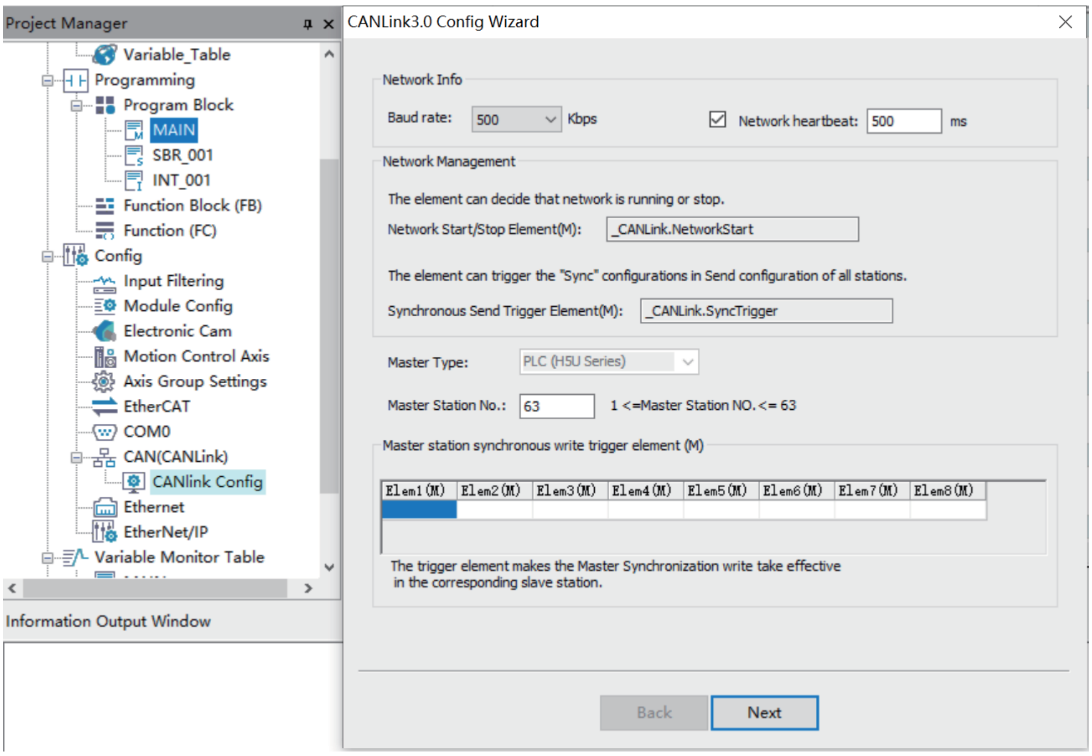
| Address | Name | Description |
|---|---|---|
| H1000 | Communication frequency reference | –10000 to +10000 (decimal) |
| H1001 | Feedback running frequency | - |
| H2000 | Control commands | 0001: Forward running<br>0002: Reverse running<br>0003: Forward jog<br>0004: Reverse jog<br>0005: Coast to stop<br>0006: Decelerate to stop<br>0007: Fault reset |

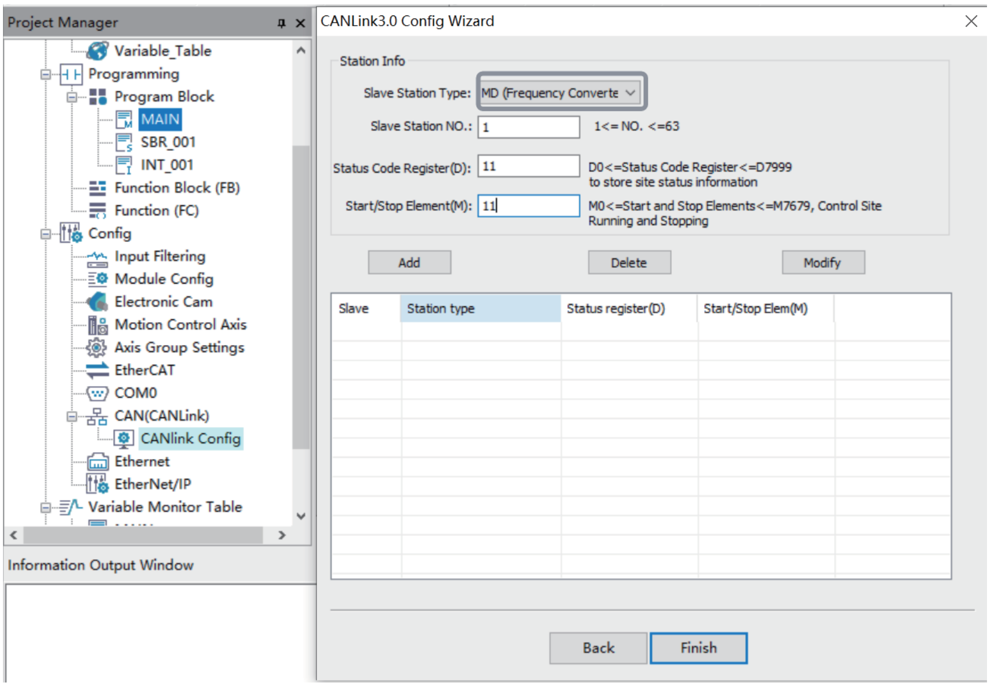
3. Configure the H5U master station

- In AutoShop, right-click CANlink, set the station No. of the H5U master station to 63, and set the baud rate to 500 kbps.



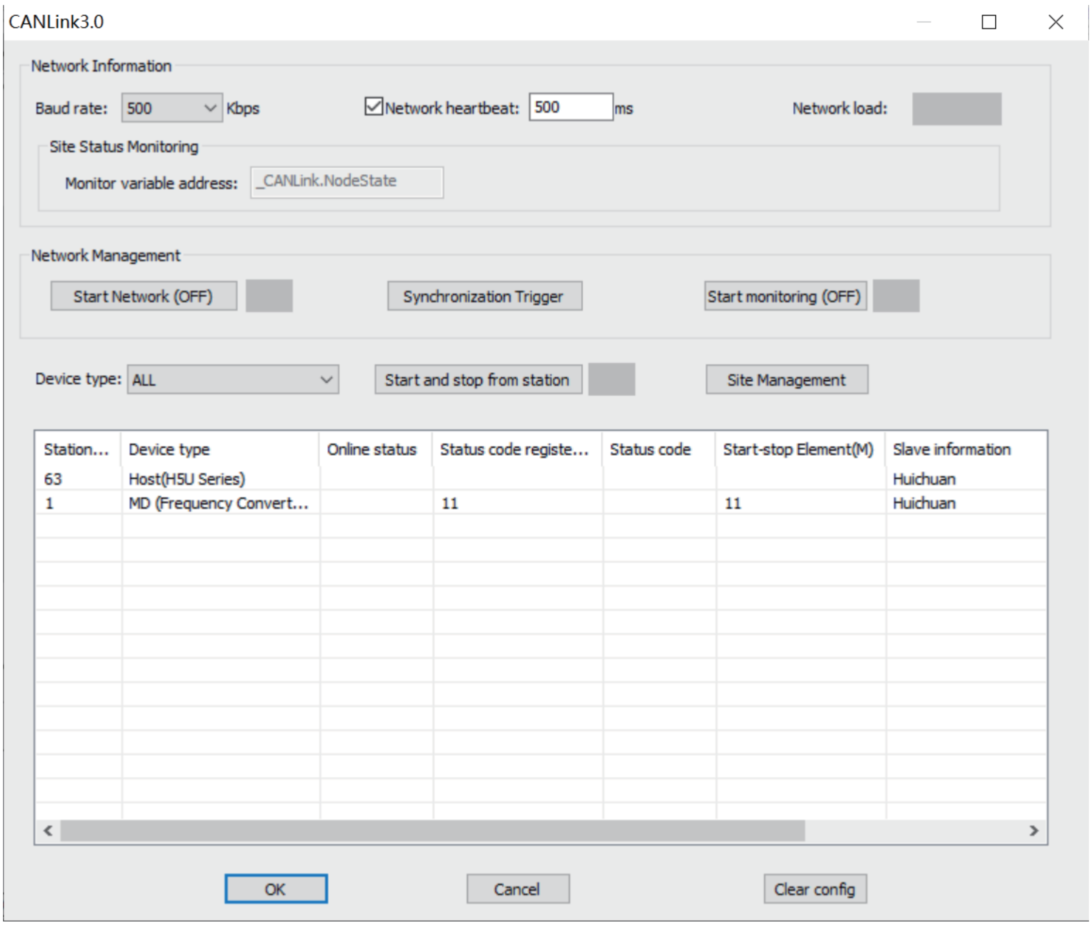

- Add an MD AC drive.

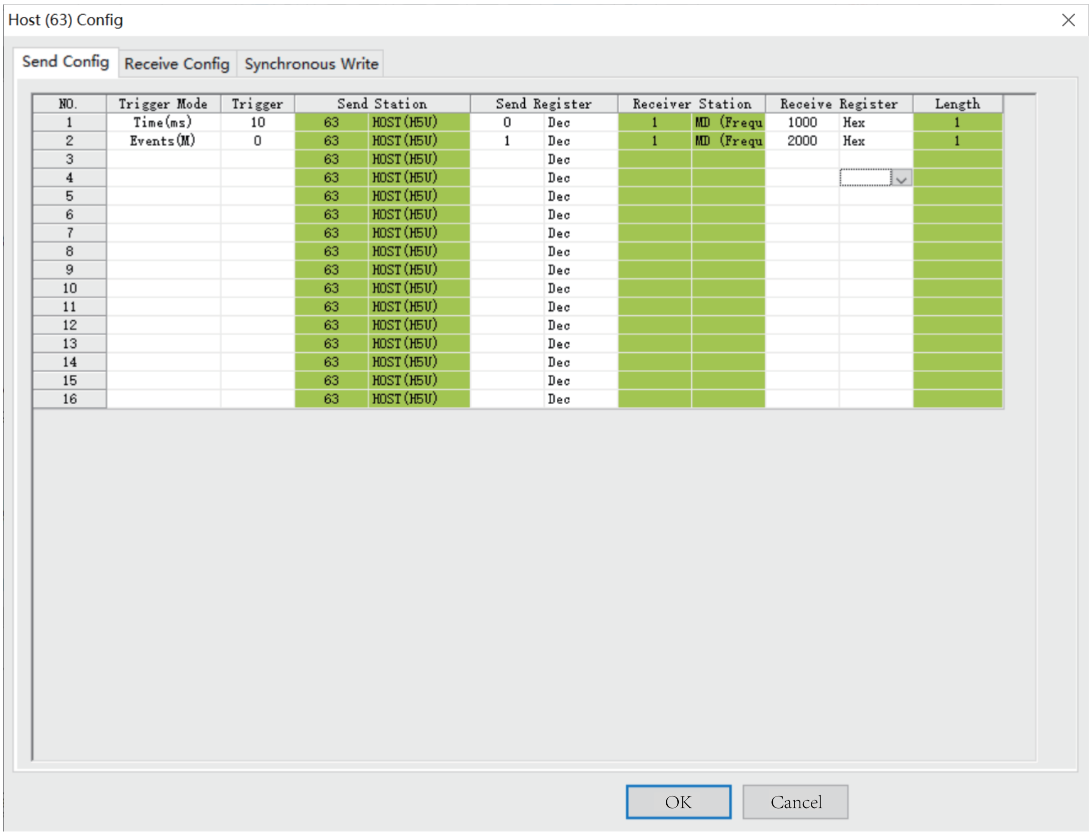





Set the slave station No. according to that defined by FD-02 of the AC drive.

- Configure the master station to send data.





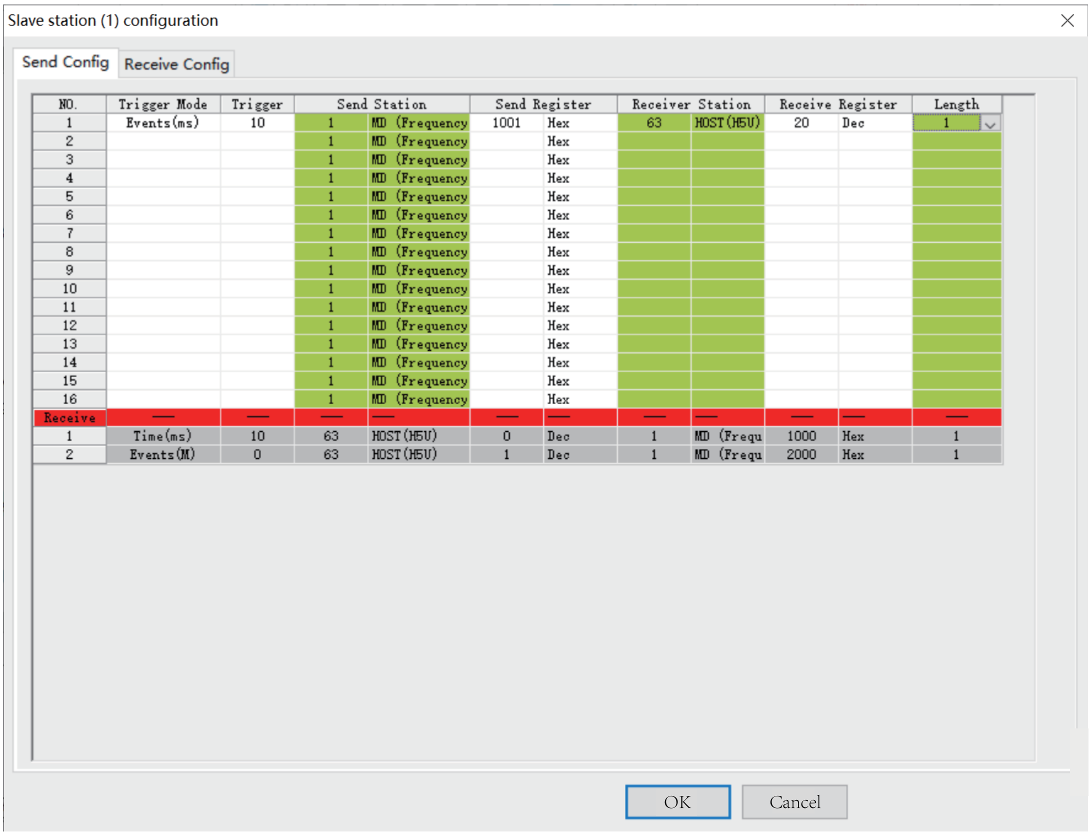

| NO. | Trigger Mode | Trigger | Send Station | | Send Register | | Receiver Station | | Receive Register | | Length |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Time(ms) | 10 | 63 | HOST(H5U) | 0 | Dec | 1 | MD (Frequ | 1000 | Hex | 1 |
| 2 | Events(M) | 0 | 63 | HOST(H5U) | 1 | Dec | 1 | MD (Frequ | 2000 | Hex | 1 |
| 3 | | | 63 | HOST(H5U) | | Dec | | | | | |
| 4 | | | 63 | HOST(H5U) | | Dec | | | | | |
| 5 | | | 63 | HOST(H5U) | | Dec | | | | | |
| 6 | | | 63 | HOST(H5U) | | Dec | | | | | |
| 7 | | | 63 | HOST(H5U) | | Dec | | | | | |
| 8 | | | 63 | HOST(H5U) | | Dec | | | | | |
| 9 | | | 63 | HOST(H5U) | | Dec | | | | | |
| 10 | | | 63 | HOST(H5U) | | Dec | | | | | |
| 11 | | | 63 | HOST(H5U) | | Dec | | | | | |
| 12 | | | 63 | HOST(H5U) | | Dec | | | | | |
| 13 | | | 63 | HOST(H5U) | | Dec | | | | | |
| 14 | | | 63 | HOST(H5U) | | Dec | | | | | |
| 15 | | | 63 | HOST(H5U) | | Dec | | | | | |
| 16 | | | 63 | HOST(H5U) | | Dec | | | | | |

Then:

The H5U master station writes the value of the D0 element to the 1000 (frequency reference) address register of the slave station 1# at an interval of 10 ms.

When the M0 element is ON, the H5U master station writes the value of the D1 element to the 2000 (AC drive control word) address register of the slave station 1#.

- Configure the slave station to send data.



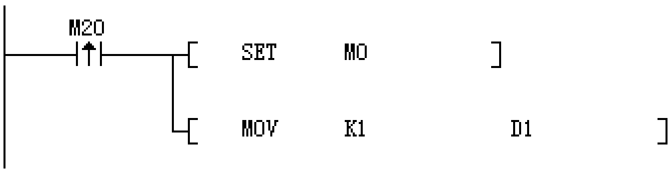

| NO. | Trigger Mode | Trigger | Send Station | | Send Register | | Receiver Station | | Receive Register | | Length |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Events(ms) | 10 | 1 | MD (Frequency | 1001 | Hex | 63 | HOST(H5U) | 20 | Dec | 1 |
| 2 | | | 1 | MD (Frequency | | Hex | | | | | |
| 3 | | | 1 | MD (Frequency | | Hex | | | | | |
| 4 | | | 1 | MD (Frequency | | Hex | | | | | |
| 5 | | | 1 | MD (Frequency | | Hex | | | | | |
| 6 | | | 1 | MD (Frequency | | Hex | | | | | |
| 7 | | | 1 | MD (Frequency | | Hex | | | | | |
| 8 | | | 1 | MD (Frequency | | Hex | | | | | |
| 9 | | | 1 | MD (Frequency | | Hex | | | | | |
| 10 | | | 1 | MD (Frequency | | Hex | | | | | |
| 11 | | | 1 | MD (Frequency | | Hex | | | | | |
| 12 | | | 1 | MD (Frequency | | Hex | | | | | |
| 13 | | | 1 | MD (Frequency | | Hex | | | | | |
| 14 | | | 1 | MD (Frequency | | Hex | | | | | |
| 15 | | | 1 | MD (Frequency | | Hex | | | | | |
| 16 | | | 1 | MD (Frequency | | Hex | | | | | |
| Receive | — | — | — | — | — | — | — | — | — | — | — |
| 1 | Time(ms) | 10 | 63 | HOST(H5U) | 0 | Dec | 1 | MD (Frequ | 1000 | Hex | 1 |
| 2 | Events(M) | 0 | 63 | HOST(H5U) | 1 | Dec | 1 | MD (Frequ | 2000 | Hex | 1 |

The slave AC drive 1# converts the value in the 1001 (running frequency) address register and then writes the value to the D20 element of the master station 63# at an interval of 10 ms.

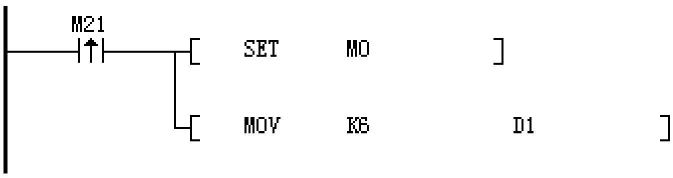
- PLC programming

Set the AC drive running frequency to 20 Hz.


Set M20 to ON to start the AC drive and make it rotate in the forward direction.

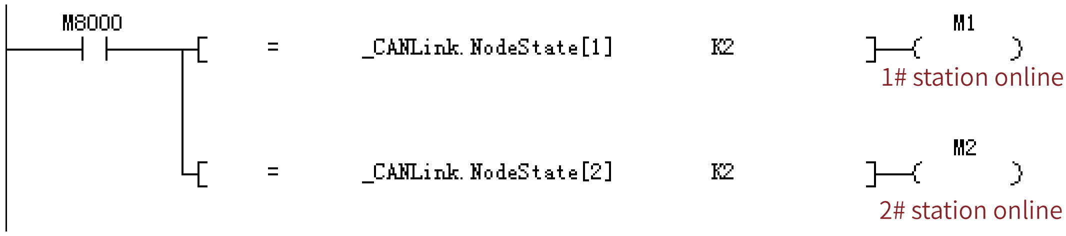



Set M21 to OFF to stop the AC drive.




Judge the online status of the CANlink slave station.

The online status of the slave station will be updated to the system variable _CANLink.NodeState [64], in which _CANLink.NodeState[1] is the state of the station 1.




### 8.4.4 CANlink Indicator

You can judge the CANlink communication state based on the CANlink indicator.

Table 8–4 States of CANlink indicator

| Indicator | State | Description |
|---|---|---|
| Communication (green) | Off | CANlink bus not connected or disconnected |
| | On | CANlink bus connected (remote frames received on the node) |
| | Flashing (⩽ 3 Hz) | During CANlink communication, one flashing per frame of bus data sent or received |
| | Flashing (5 Hz) | Flag monitor |
| Fault (red) | Off | No fault |
| | On | Monitor timeout (node), no node (monitor) |
| | Flashing (0.5 Hz) | CANlink configuration error (for the configurator) |
| | Flashing (1 Hz) | Node lost or crash (for the monitor) |
| | Flashing (5 Hz) | CANlink address conflict |

### 8.4.5 CANlink Communication Troubleshooting

Check the following items when a CANlink communication error occurs.

- Check the termination resistor
  Power off all devices. Use a multimeter to measure the resistance between CANH and CANL. The resistance should be about 60 Ω. If the resistance is too small, there are termination resistors incorrectly connected at other locations. In this case, disconnect these termination resistors. If only one termination resistor is available, the resistance is about 120 Ω, and the network connection is bad. If no termination resistor is available, communication fails. Provide termination resistors between the stations at both ends of the network.
- Check the baud rate
  Check whether the baud rate is normal. Baud rates of all stations in the network must be the same; otherwise, communication fails. Power off and then on the device or switch it from STOP to RUN so that the baud rate can take effect.
- Others
  In case of strong interference, reduce the baud rate.

# 8.5 CANopen Communication

## 8.5.1 CANopen Communication Protocol

The H5U supports the CANopen communication standard protocol DS301.

Table 8–5 CANopen communication protocol standard

| Software Function Module | Slave | Master |
|---|---|---|
| Supported protocol | DS301 V4.02 | DS301 V4.02 |
| Maximum number of TPDOs | 8 | 64 |
| Maximum number of RPDOs | 8 | 64 |
| Number of slave station nodes | / | 30 |
| Baud rate and communication distance | 1 Mbps/25 m<br>800 kbps/50 m<br>500 kbps/100 m<br>250 kbps/250 m<br>125 kbps/500 m<br>50 kbps/1000 m<br>20 kbps/2500 m<br>100 kbps<br>10 kbps | 1 Mbps/25 m<br>800 kbps/50 m<br>500 kbps/100 m<br>250 kbps/250 m<br>125 kbps/500 m<br>50 kbps/1000 m<br>20 kbps/2500 m<br>100 kbps<br>10 kbps |
| Soft element for data exchange | W300 to W363 | D0 to D7999 (configurable) |

## 8.5.2 CANopen Axis Control Instruction List

The following table lists CANopen axis control instructions supported by H5U. See H5U Series Programmable Logic Controller Instructions Guide for detailed usage of related instructions.

Table 8–6 Instruction list

| Name | Function |
|---|---|
| MC_Power_CO | Instruction for enabling the communication control servo axis |
| MC_Reset_CO | Instruction for resetting faults of the communication control servo axis |
| MC_ReadActualPosition_CO | Instruction for reading the current position of the communication control axis |
| MC_ReadActualVelocity_CO | Instruction for reading the current velocity of the communication control axis |
| MC_Halt_CO | Instruction for halting the motion of the communication control servo axis |
| MC_Stop_CO | Instruction for stopping the communication control servo axis |
| MC_MoveAbsolute_CO | Instruction for obtaining the absolute position of the communication control axis |
| MC_MoveRelative_CO | Instruction for obtaining the relative position of the communication control axis |
| MC_MoveVelocity_CO | Instruction for selecting the velocity operation mode of the communication control axis |

| Name | Function |
| --- | --- |
| MC_Jog_CO | Instruction for communication control axis jogging |
| MC_Home_CO | Instruction for communication control axis homing |
| MC_WriteParameter_CO | Instruction for writing parameters of the communication control axis |
| MC_ReadParameter_CO | Instruction for reading parameters of the communication control axis |

### 8.5.3 CANopen Terminology

- NMT: Network Management
  Network management includes management of application layers, network states, and node ID allocation. It is implemented in master-slave communication mode. That is, on a CAN network, only one NMT master station exists with one or more slave stations. The service is used to control the slave station state.
- SDO: Service Data Object
  An SDO can access the data in the slave station object dictionary through indexes and sub-indexes. SDOs are used for slave station configuration. Each frame of an SDO request must be answered.
- PDO: Process Data Object
  PDOs are used to transmit real-time data. The data length ranges from one to eight bytes. Data can be transmitted in synchronous and asynchronous modes. PDO frames are primary data exchange frames after slave stations are started.
- SYNC: Synchronous
  Synchronization is implemented in master-slave communication mode. The master SYNC node regularly sends SYNC objects, and the SYNC slave node synchronously executes tasks upon receipt of the objects. SYNC frames are used for synchronous transmission through PDOs.
- COB-ID: Communication Object Identifier
  Each CANopen frame starts with a COB-ID. A COB-ID is not the slave station number. However, it is associated with the slave station number by default.

### 8.5.4 CANopen Indicator

You can judge the CANopen communication state based on the CANopen indicator.

Table 8–7 States of the CANopen indicator

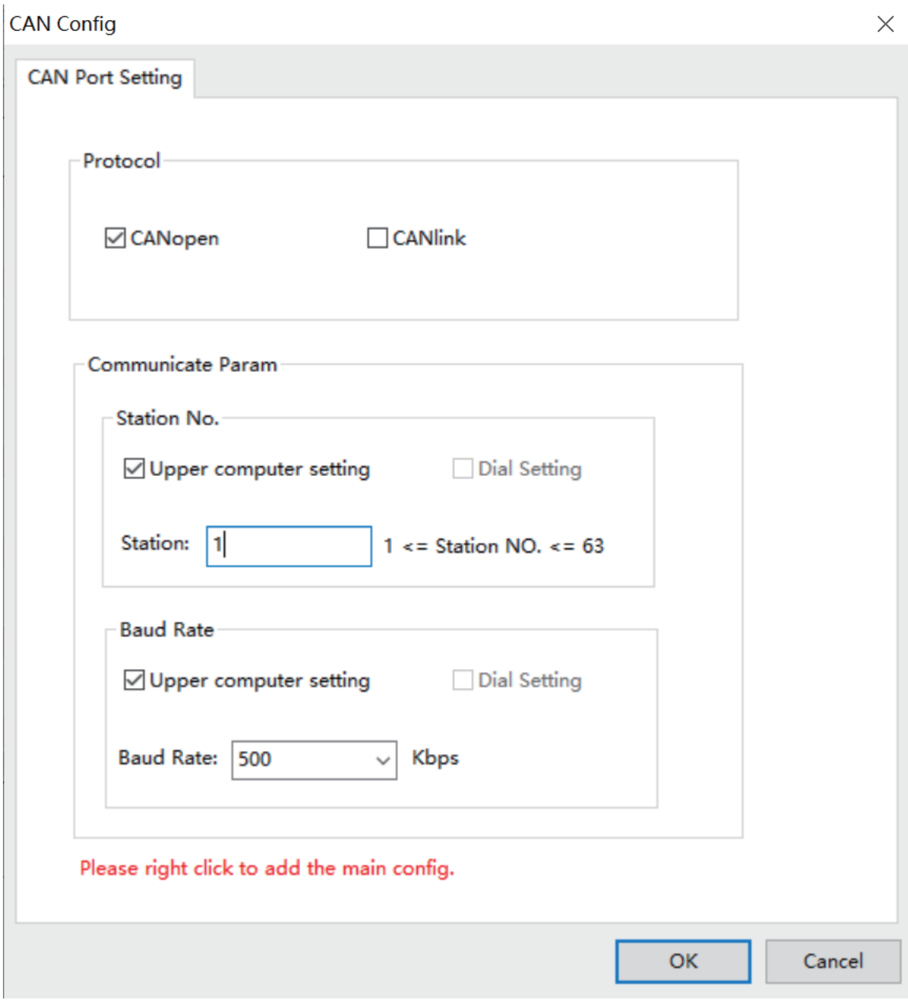
| LED Indicator | CAN RUN (Green) | CAN ERR (Red) |
| --- | --- | --- |
| Off | None | No error |
| On | Operational | Bus disconnected |
| Flashing slowly (at an interval of 0.8s) | Pre-operational | Pre-operational |
| Flashing slowly (at an interval of 1.2s) | Stopped | At least one error counter of the CAN controller hitting or exceeding the threshold (too many error frames) |
| Flashing twice slowly (at an interval of 1.6s) | None | Incorrect control event (node protection or heartbeat timeout) |

## 8.5.5 CANopen Configuration

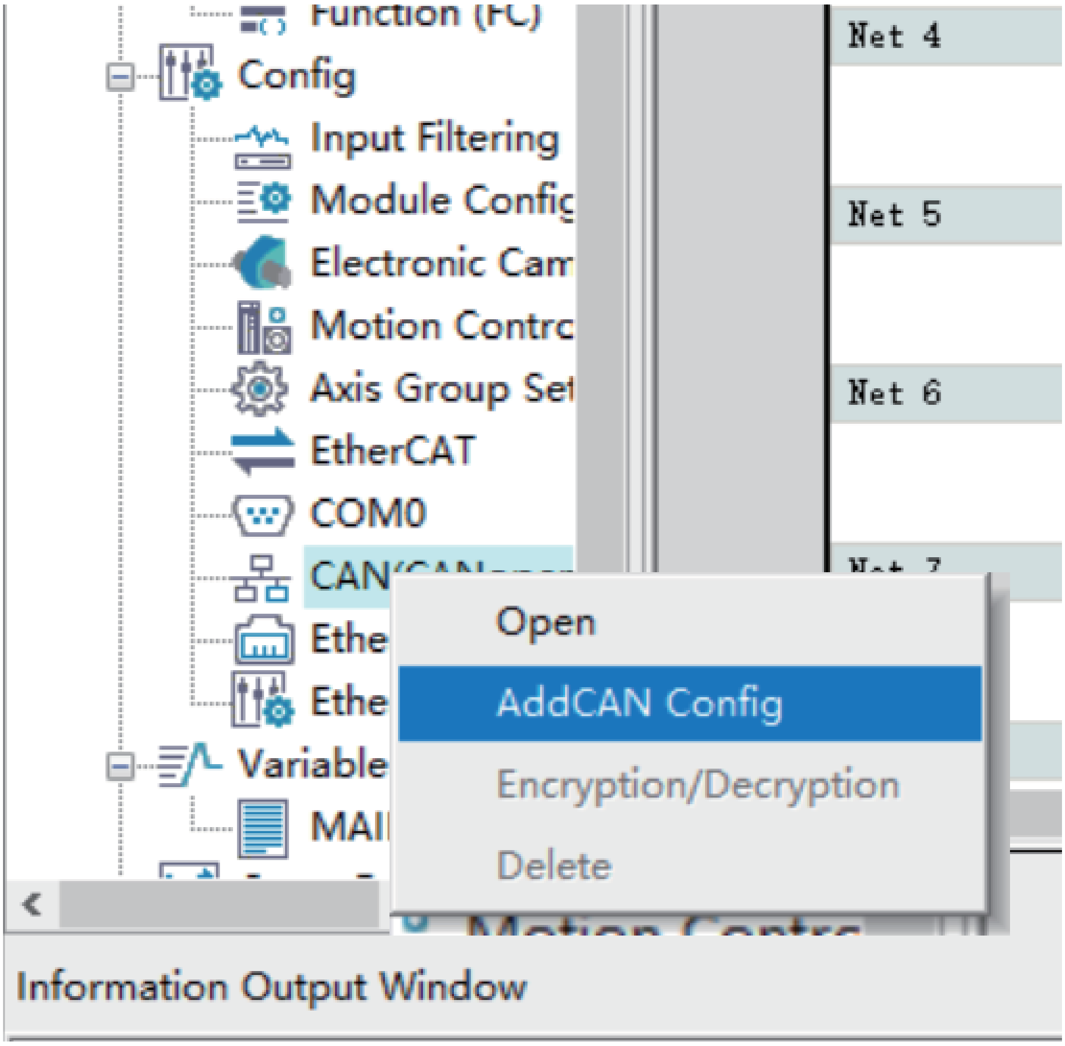
### 8.5.5.1 Master Configuration

When "CANopen" is selected, the system automatically determines whether the current PLC is the CANopen master station or the CANopen slave station based on the presence of the CANopen configuration.

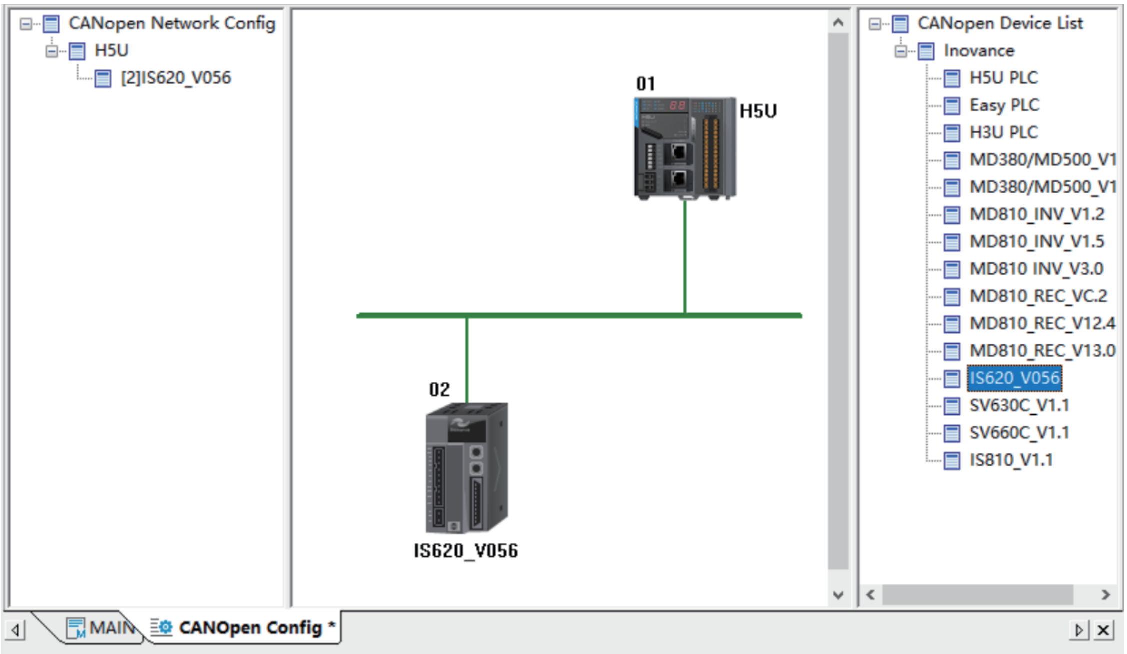
1. After creating a project, choose "Project Manager" > "Config", and then double-click "CAN". The following window is displayed.



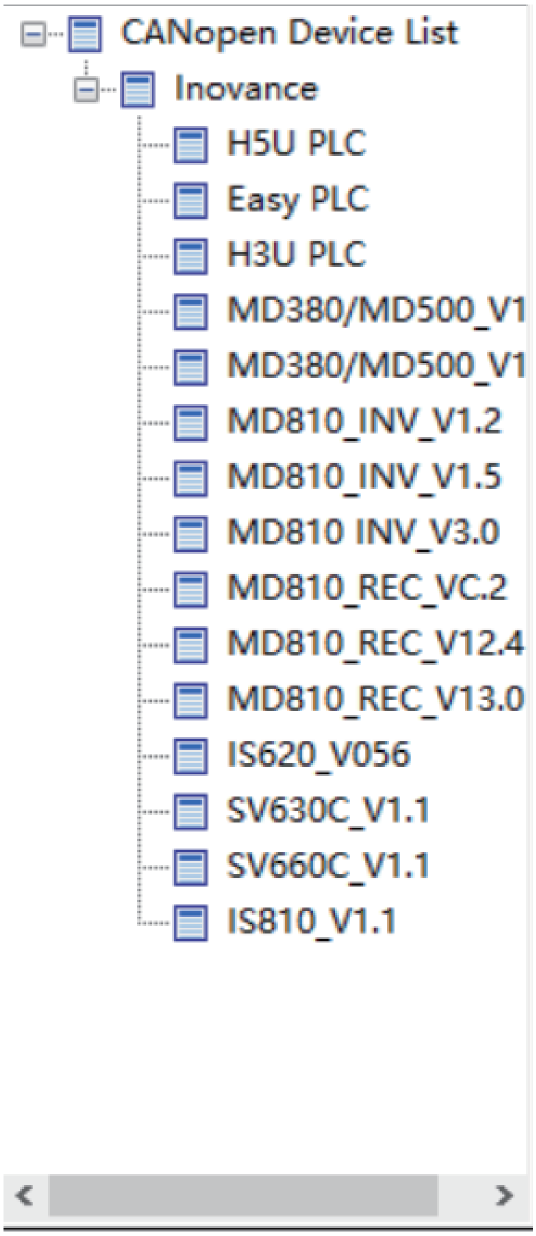

2. Select "CANopen", set the station number and baud rate, and click "OK".
   In this example, CAN is configured as the CANopen slave station. Choose "Project Manager" > "Config". Right-click "CAN". In the window displayed, select "Add CAN configuration" to configure it as the CANopen master station, as shown in the following figure.



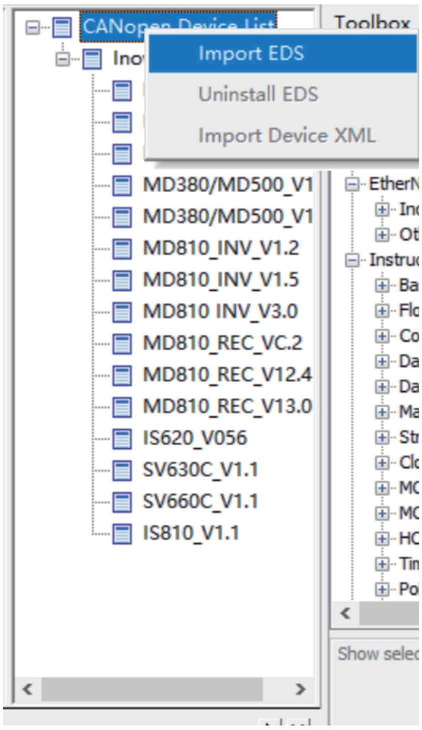

3. Double-click "CANOpen Config". The following CANopen configuration page is displayed:




4. Double-click or drag the CANopen slave station you want to add in the device list.

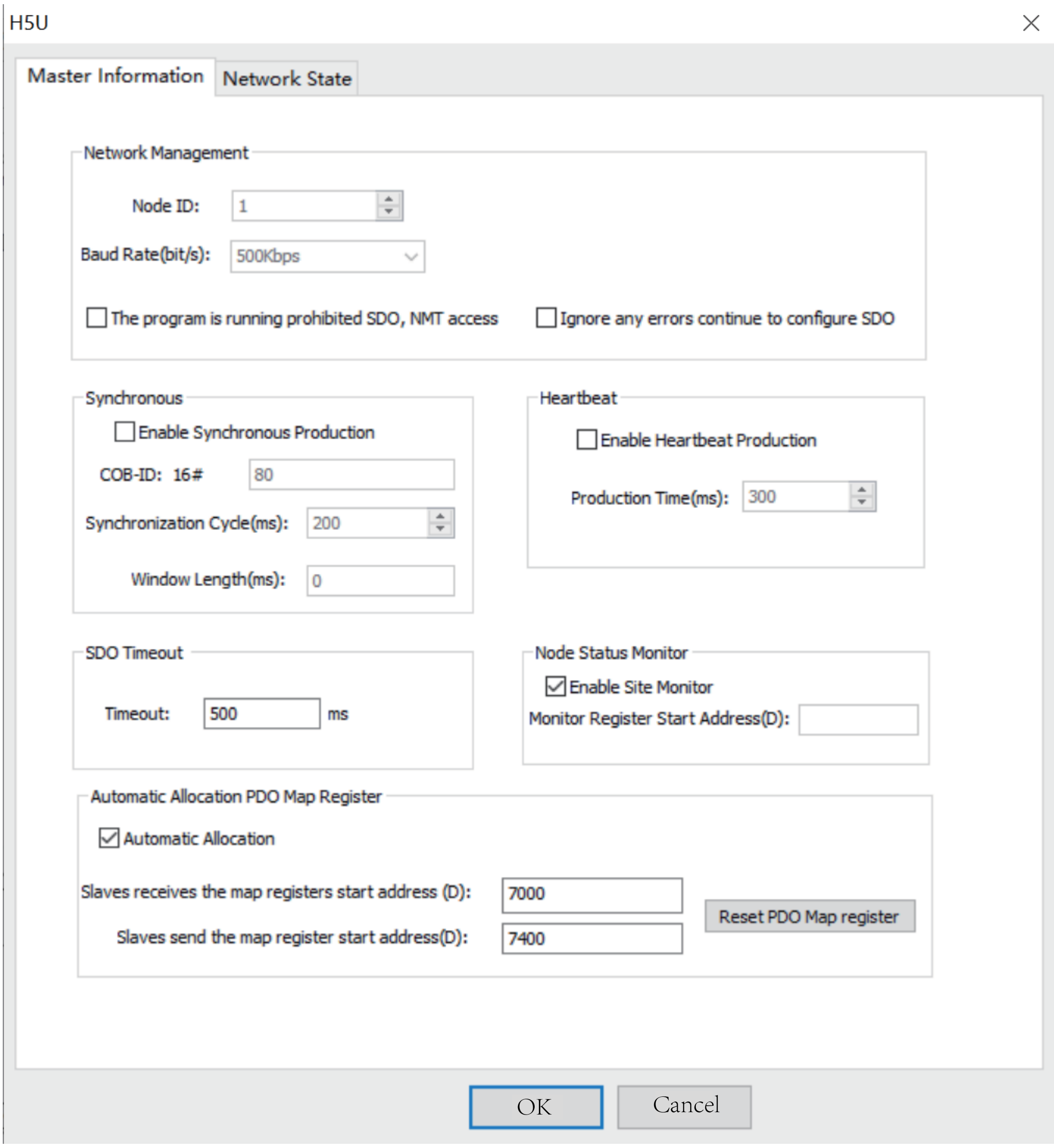



5. If the target slave station is not in the list, right-click the CANopen device list, and click "Import EDS" to import the EDS file, which can be obtained from the device supplier.




## Master information page

Set the master parameters. Double-click the H5U master station in the network. The following window is displayed.




- Network management

  Node ID: Indicates the master station number. If the station number is identical to the PLC number, the PLC will be initialized as the CANopen master station. If the station number is different from the PLC number, the PLC will be initialized as a CANopen slave station.

  Baud Rate: Indicates the communication baud rate valid for the master station.

  The program is running prohibited SDO, NMT access: If this option is selected, online commissioning is disabled during running of the program. The function only applies to background software.

  Ignore any errors continue to configure SDO: After this option is selected, if SDO configuration errors occur, configuration will continue. The function is valid for all slave stations. If the option is not selected, when SDO errors occur, the master station will reset slave stations through broadcasts.

- Synchronous

Enable Synchronous Production: If this option is selected, the configured station will send a sync frame repeatedly in the set synchronization cycle.

COB-ID: Indicates the ID for sync frame sending. The default value is 0x80. The parameter cannot be configured.

Synchronization Cycle (ms): Indicates the cycle for sync frame sending. The default value is 200, in the unit of ms.

Window Length (ms): The value is 0 by default. The parameter cannot be configured.

---

***Note***

Only one synchronous frame transmission can exist in one network.

---

- Heartbeat
  Enable Heartbeat Production: If this option is selected, the configured station will send heartbeat frames repeatedly in the set cycle.

  Production Time (ms): Indicates the cycle for heartbeat sending. The default value is 300, in the unit of ms.

---

***Note***

The default heartbeat monitoring consumption time of the master is 2.5 times the heartbeat production time. (The timeout threshold for heartbeat monitoring is 2.5 times the heartbeat production time.)

---

- SDO Timeout
  Timeout: Indicates the SDO waiting time. The default value is 500, in the unit of ms. SDO frames are used for network configuration. If the SDO fails to receive return frames after the third try, the master station determines that configuration times out. The waiting time for each frame is called SDO timeout.
- Node Status Monitor
  The online status of the station will be updated to the system variable _CANOpen.NodeState[64], in which _CANOpen.NodeState[0] is the status of the local station, while _CANOpen.NodeState[station No.] is the status of the slave station.

| Value | State |
|---|---|
| 0 | Initializing |
| 4 | Stopped |
| 5 | Operational |
| 127 | Pre-operational |
| 255 | Offline |

---

***Note***

If the corresponding slave does not exist, the corresponding register will not be updated. For example, if station 3 does not exist, the data of _CANOpen.NodeState[3] will not be updated.

This function works only when the heartbeat or node protection function is set on the slave, because the relevant status is fed back by the heartbeat or node protection frame of the slave.

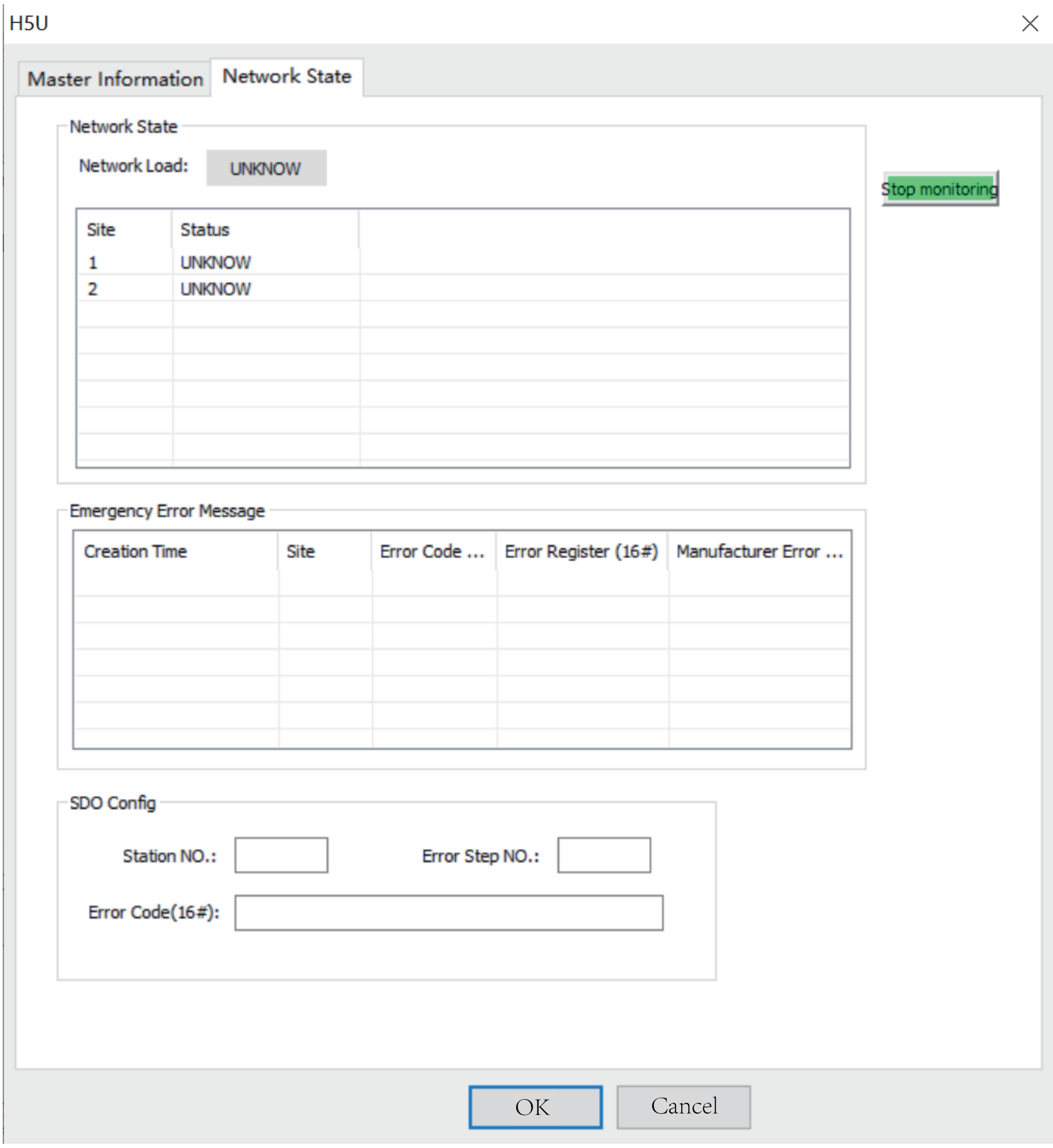
---

- Automatic Allocation PDO Map Register
  Automatic Allocation: If this option is selected, the system will automatically assign the address of the register for master-slave data exchange. If this option is not selected, you need to configure the start address for data exchange (by configuring the start address of each PDO). This option is selected by default.

  Slaves receive the map registers start address: Indicates the automatically assigned start address of data sent by the master station ("Automatic Allocation" must be selected).

  Slaves send the map register start address: Indicates the automatically assigned start address of data received by the master station ("Automatic Allocation" must be selected).

## Network State




Start Monitor/Stop Monitor: Information monitoring is enabled by clicking this option. Monitoring is disabled by clicking the option again.

Network Load: Monitors the network load in real time.

Network state table: Displays the station state. The table is applicable only to the master station. The state value is from the node state monitoring register.

- Emergency Error Message
  The table lists emergency error messages on the network. It is applicable only to the master station. The master PLC only caches the latest error message. If background programs are not shut down, a maximum of five messages will be cached in the background.

- SDO Config
  Station NO.: Indicates the number of the station with SDO configuration errors.

  Error Step NO.: Indicates the SDO error number. To check numbers of slave stations with parameter errors, click the SDO tab.

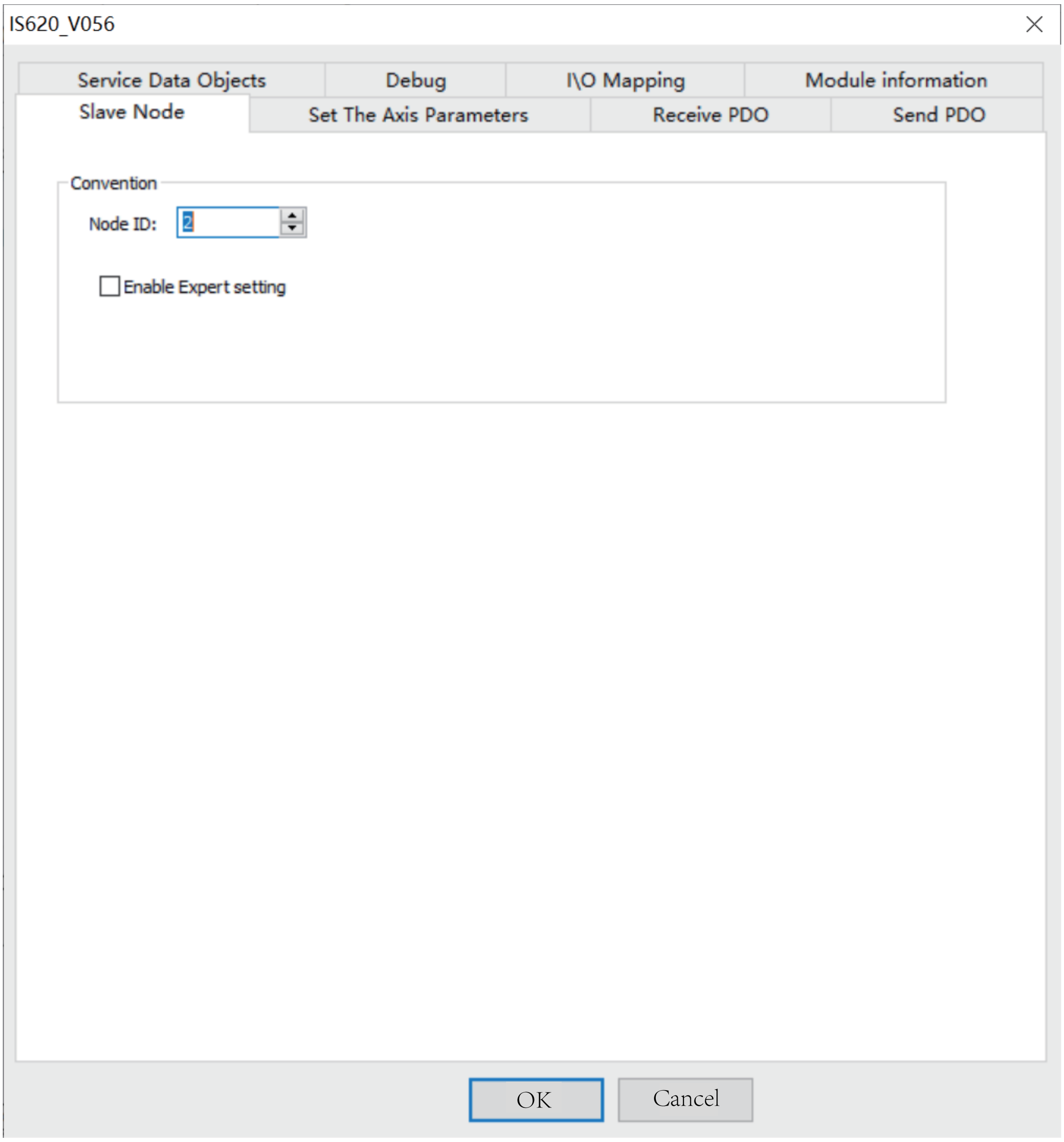
  Fault Code: Indicates the SDO fault code (standard CANopen fault code).

### 8.5.5.2 Slave Configuration

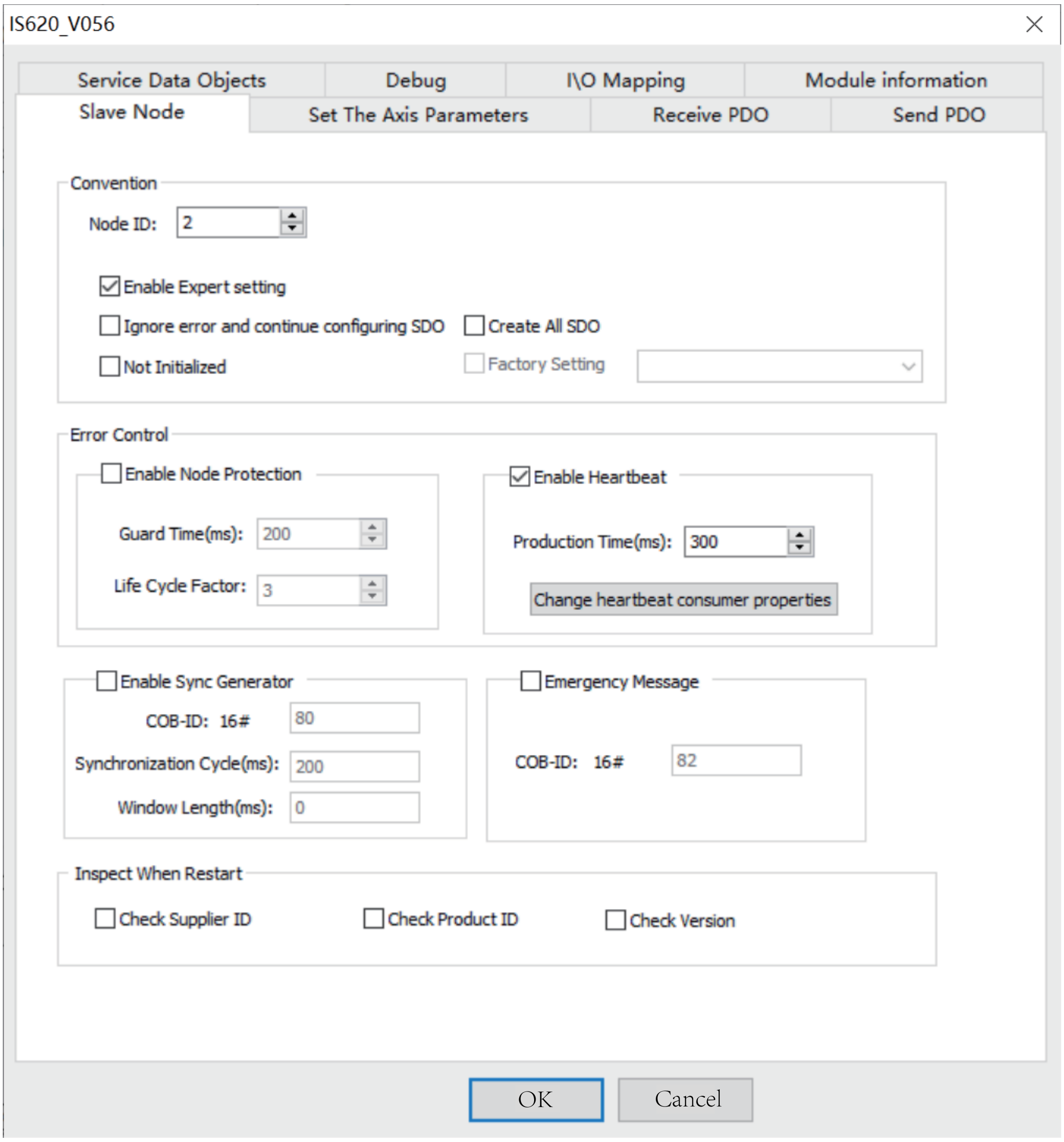
This section takes the IS620 slave station as an example to describe how to configure the CANopen slave station and its parameters.

## General settings

Double-click a slave station in the network. The following window is displayed.




Select "Enable Expert setting". The following window is displayed. (By default, this option is not selected.)




- Convention
  Node ID: Indicates the ID of a slave station node.

  Enable Expert setting: When this option is selected, detailed configurations of the slave station are displayed. By default, this option is not selected.

- Ignore error and continue configuring SDO
  Valid: When a configuration error (other than a check type error) occurs, configuration continues.

  Invalid: When a configuration error occurs, configuration cannot continue, and the entire network is disconnected. By default, this option is not selected.

- Create All SDO
  If this option is selected, all writable object dictionaries in the EDS will be added and initialized. By default, this option is not selected.

- Not Initialized

If this option is selected, the slave station will not be initialized (this option can be selected only when the station applies the default configuration). By default, this option is not selected.

- Factory Setting
  If this option is selected, you can select options from the drop-down list. By default, the option is not selected.

## Error Control

- Node protection properties
  Enable Node Protection: If this option is selected, node protection will be enabled. By default, the option is not selected.

  Node protection timeout = Guard time x Life cycle factor

  Node protection provides a network evaluation platform on which master station and slave station monitor each other with return frames. Either the heartbeat or node protection function can be selected.

  Guard Time (ms): Indicates the node protection time, which is 200 ms by default.

  Life Cycle Factor: Indicates the node protection factor, which is 3 by default.

- Heartbeat properties
  Enable Heartbeat: If this option is selected, heartbeats will be generated. By default, this option is selected. When this option is selected, the master station will monitor the heartbeat state by default.

  Production Time (ms): Indicates the cycle for heartbeat sending.

  Change heartbeat consumer properties: It is used to set heartbeats of other stations to be monitored by the configured station. This function is disabled by default. The function can be enabled only when the slave station supports heartbeat monitoring.

- Synchronous (if supported)
  Enable Synchronous Production: If this option is selected, the configured station will send a sync frame repeatedly in the set synchronization cycle.

  COB-ID: Indicates the ID for sync frame sending. The default value is 0x80. The parameter cannot be configured.

  Synchronization Cycle (ms): Indicates the cycle for sync frame sending. The default value is 200, in the unit of ms.

  Window Length (ms): The value is 0 by default. The parameter cannot be configured.

---

### *Note*

Only one synchronous frame transmission can exist in one network.

---

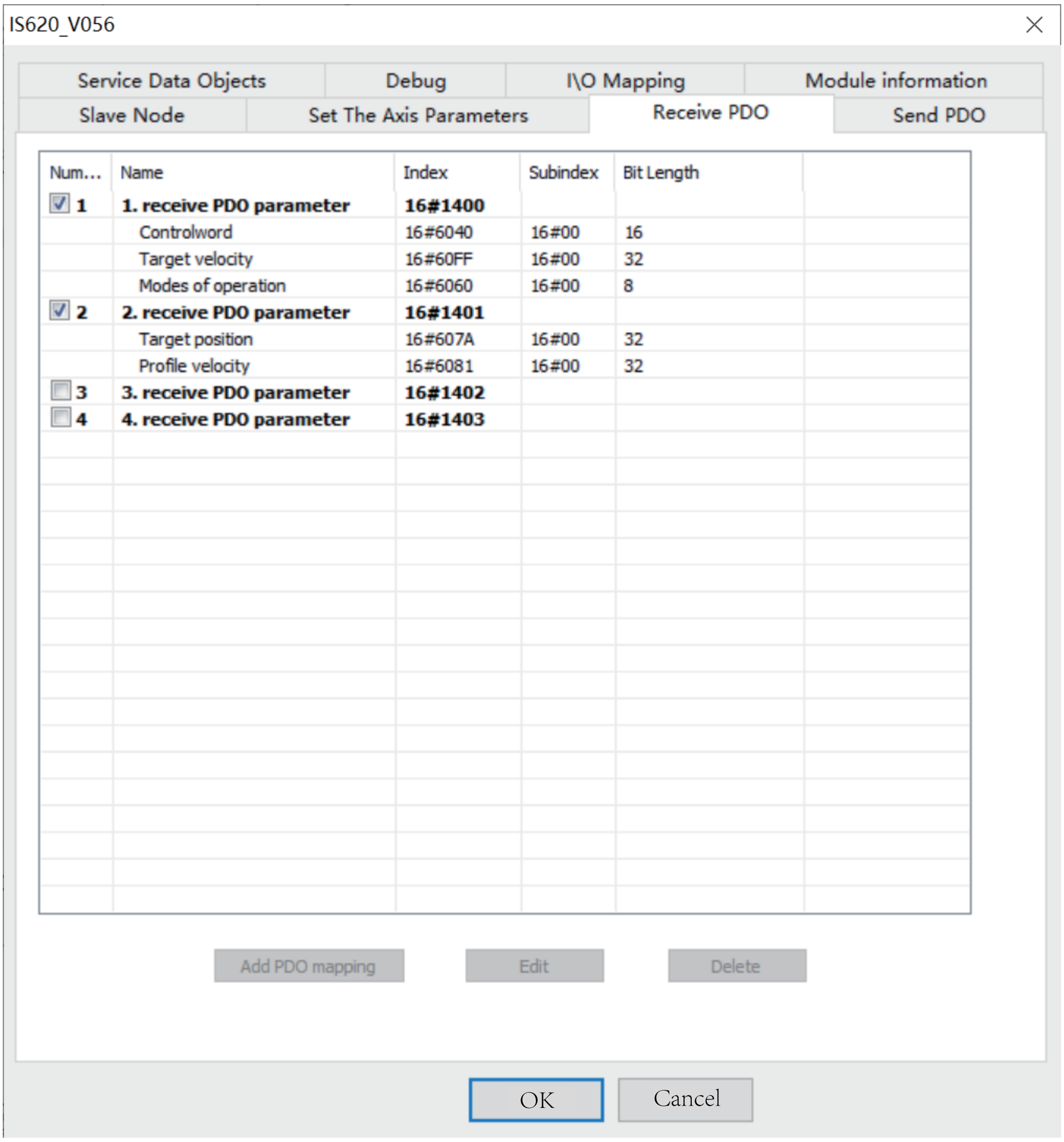
- Emergency Message
  Emergency Message: If this option is selected, you can set the COB-ID of an emergency message. By default, this option is not selected.

- Inspect When Restart

If "Check Supplier ID", "Check Product ID", or "Check Version" is selected, corresponding data will be checked before configuration of the slave station. If the check fails, the network cannot be connected.

## Receive PDO/Send PDO

Click "Receive PDO" or "Send PDO". The following page is displayed.




Receive PDO: Indicates the data sent by the master station to a slave station.

Send PDO: Indicates the data sent by a slave station to the master station.

### 8.5.5.3 PDO Enable

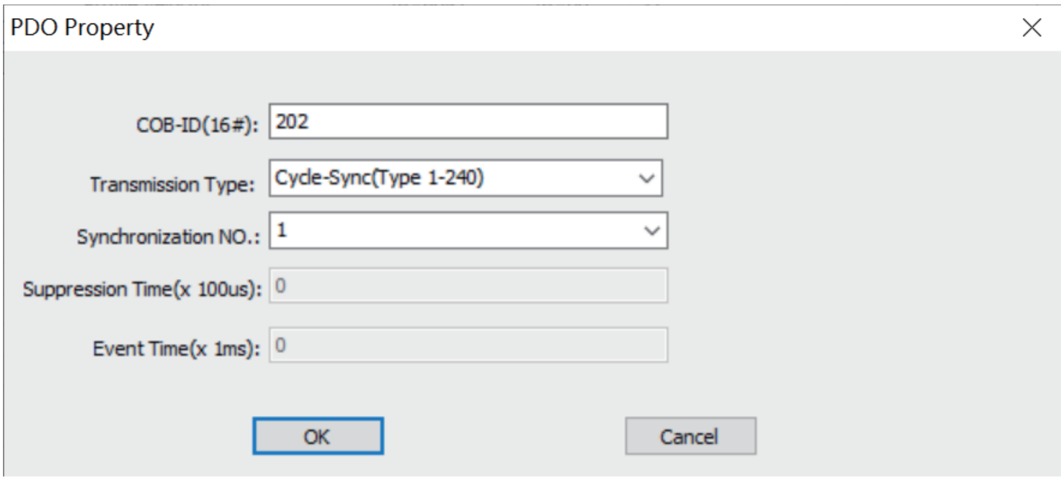
You can check the box in front of the number to enable a PDO. The PDOs in the EDS file that take effect are checked by default.

### 8.5.5.4 PDO Mapping Edit

You can click "Add PDO mapping", "Edit", or "Delete" to edit PDO mapping.

### 8.5.5.5 PDO Property Settings

The "PDO Property" page is as follows.




- COB-ID
  Indicates the ID for sending a PDO parameter. Based on the CANopen DS301 protocol, default COB-IDs are available for the first four PDO parameters. COB-IDs must be different from each other, ranging from 0x180 to 0x57F.
- Transmission Type

| Type | Condition for Data Sending | Condition for Valid Data |
|---|---|---|
| Loop-synchronization (Type 0) | Data is changed, and a sync frame is received. | Data does not take effect immediately but takes effect after a sync frame is received. |
| Loop-synchronization (Types 1 to 240) | Data is sent after the corresponding "number of synchronizations" frame is received. | Data does not take effect immediately but takes effect after a sync frame is received. |
| Asynchronization-only RTR (Type 252) | Not supported | Not supported |
| Asynchronization-only RTR (Type 253) | Not supported | Not supported |
| Asynchronization-specified by manufacturers (Type 254) | Manufacturer-defined | Manufacturer-defined |
| Asynchronization-specified by the configuration file (Type 255) | Data is changed or the event time is correct, and the change cycle is shorter than the suppression time. | Immediately |

***Note***

To use the synchronous type, it is necessary to enable synchronous production on a station, usually the master.

- Synchronization NO.

The number of synchronizations takes effect after "loop-synchronization (types 1 to 240)" is selected.

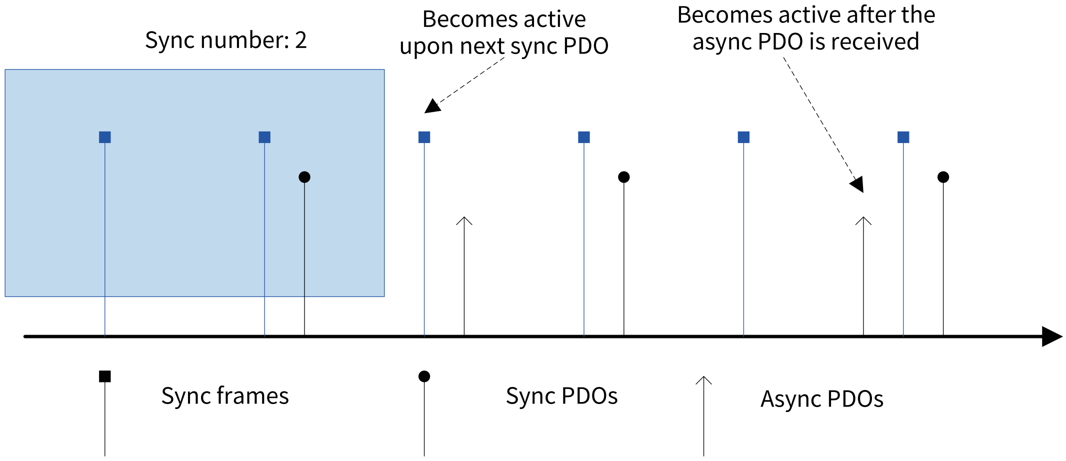
- Suppression Time

  The suppression time can be set after "asynchronization-specified by the configuration file (Type 255)" is selected. If the value is 0, the function is disabled. If the value is not 0, the suppression time is the minimum interval for frame sending.

- Event Time

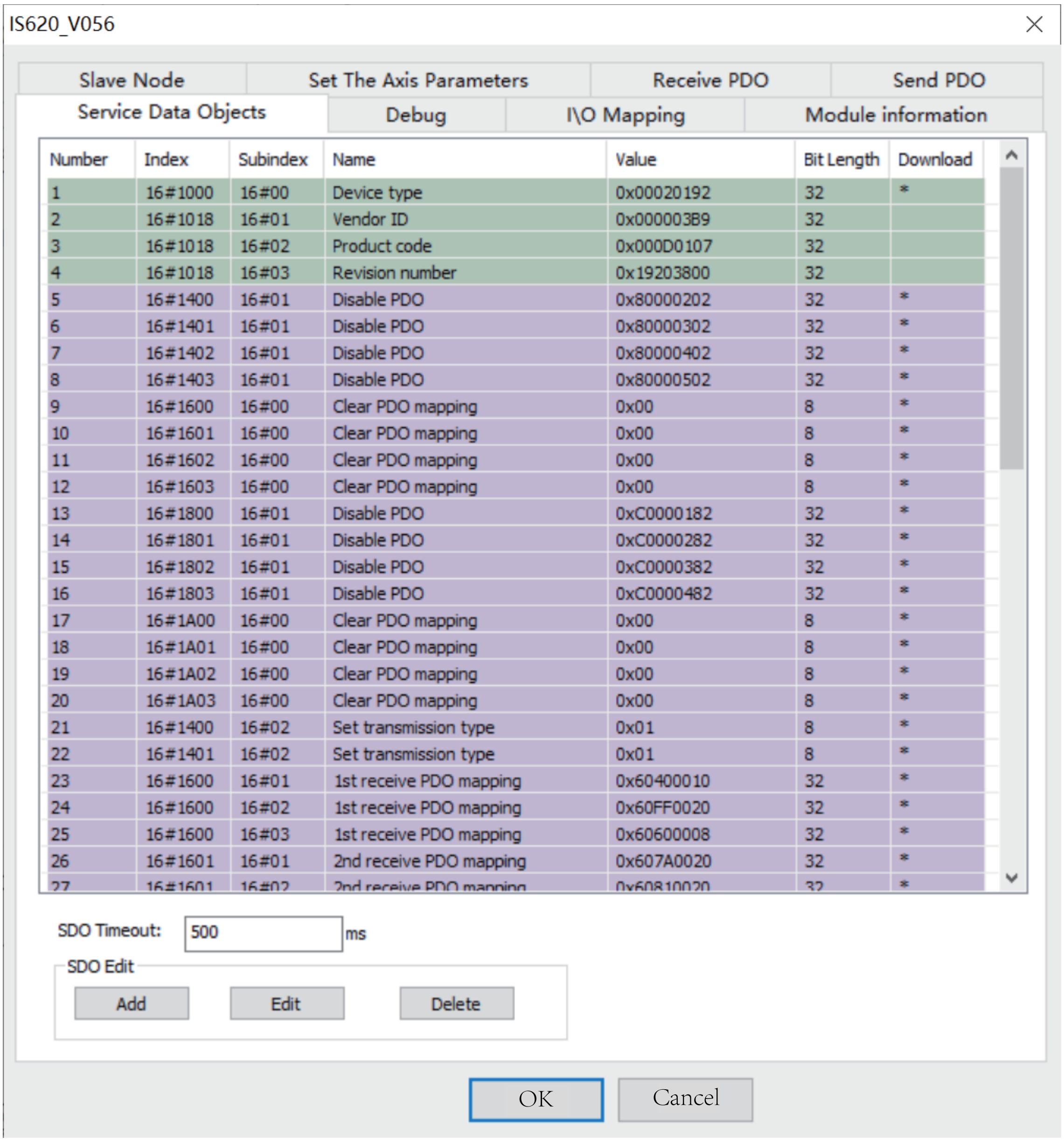
  The event time can be set after "asynchronization-specified by the configuration file (Type 255)" is selected. If the value is 0, the function is disabled. If the value is not 0, the event time is the cycle for data sending. (Data sending is limited by the suppression time.)

The following figure shows the example of loop-synchronization (Type 2).




#### 8.5.5.6 Service Data Object (SDO)

Click the "Service Data Objects" tab. The following page is displayed.




| Number | Index | Subindex | Name | Value | Bit Length | Download |
|---|---|---|---|---|---|---|
| 1 | 16#1000 | 16#00 | Device type | 0x00020192 | 32 | * |
| 2 | 16#1018 | 16#01 | Vendor ID | 0x000003B9 | 32 | |
| 3 | 16#1018 | 16#02 | Product code | 0x000D0107 | 32 | |
| 4 | 16#1018 | 16#03 | Revision number | 0x19203800 | 32 | |
| 5 | 16#1400 | 16#01 | Disable PDO | 0x80000202 | 32 | * |
| 6 | 16#1401 | 16#01 | Disable PDO | 0x80000302 | 32 | * |
| 7 | 16#1402 | 16#01 | Disable PDO | 0x80000402 | 32 | * |
| 8 | 16#1403 | 16#01 | Disable PDO | 0x80000502 | 32 | * |
| 9 | 16#1600 | 16#00 | Clear PDO mapping | 0x00 | 8 | * |
| 10 | 16#1601 | 16#00 | Clear PDO mapping | 0x00 | 8 | * |
| 11 | 16#1602 | 16#00 | Clear PDO mapping | 0x00 | 8 | * |
| 12 | 16#1603 | 16#00 | Clear PDO mapping | 0x00 | 8 | * |
| 13 | 16#1800 | 16#01 | Disable PDO | 0xC0000182 | 32 | * |
| 14 | 16#1801 | 16#01 | Disable PDO | 0xC0000282 | 32 | * |
| 15 | 16#1802 | 16#01 | Disable PDO | 0xC0000382 | 32 | * |
| 16 | 16#1803 | 16#01 | Disable PDO | 0xC0000482 | 32 | * |
| 17 | 16#1A00 | 16#00 | Clear PDO mapping | 0x00 | 8 | * |
| 18 | 16#1A01 | 16#00 | Clear PDO mapping | 0x00 | 8 | * |
| 19 | 16#1A02 | 16#00 | Clear PDO mapping | 0x00 | 8 | * |
| 20 | 16#1A03 | 16#00 | Clear PDO mapping | 0x00 | 8 | * |
| 21 | 16#1400 | 16#02 | Set transmission type | 0x01 | 8 | * |
| 22 | 16#1401 | 16#02 | Set transmission type | 0x01 | 8 | * |
| 23 | 16#1600 | 16#01 | 1st receive PDO mapping | 0x60400010 | 32 | * |
| 24 | 16#1600 | 16#02 | 1st receive PDO mapping | 0x60FF0020 | 32 | * |
| 25 | 16#1600 | 16#03 | 1st receive PDO mapping | 0x60600008 | 32 | * |
| 26 | 16#1601 | 16#01 | 2nd receive PDO mapping | 0x607A0020 | 32 | * |
| 27 | 16#1601 | 16#02 | 2nd receive PDO mapping | 0x60810020 | 32 | * |

The table lists SDO configurations automatically generated based on user settings.

## SDO Edit

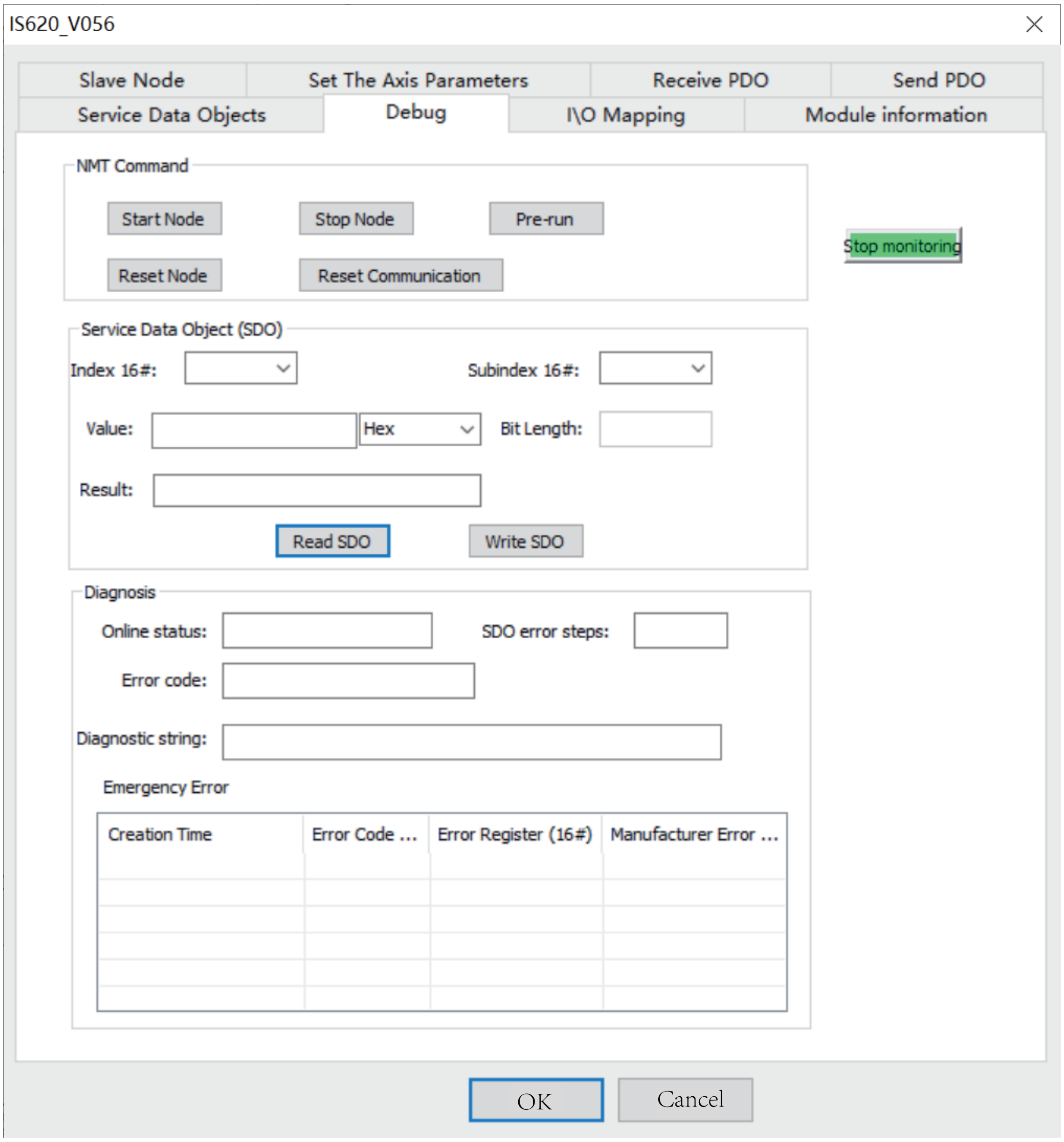
Add: Adds configurations. It is used to assign initial values to object dictionaries of a slave station.

Edit: Edits configurations.

Delete: Deletes configurations.

### 8.5.5.7 Online Commissioning

Click the "Debug" tab. The following page is displayed.




## *Note*

This function cannot be used if "The program is running, prohibited SDO, NMT access" is selected in the master.

- NMT Command

  Start Node: Sends a command to the slave station to start a node.

  Stop Node: Sends a command to the slave station to stop a node.

  Pre-run: Sends a command to the node to pre-run it.

  Reset Node: Sends a command to the node to reset it.

  Reset Communication: Sends a command to the node to reset communication.

- Service Data Object

  Index and sub-index: You can only select object dictionaries in the EDS as indexes or sub-indexes.

Value: Indicates sent or returned data.

Bit Length: It is automatically generated based on an object dictionary in the EDS. It must not be modified.

Result: Indicates abnormality information.

Read SDO and Write SDO: Reads and writes object dictionaries.

- Diagnosis
  Online status: Indicates the status of the slave station (fed back based on heartbeat or node protection).

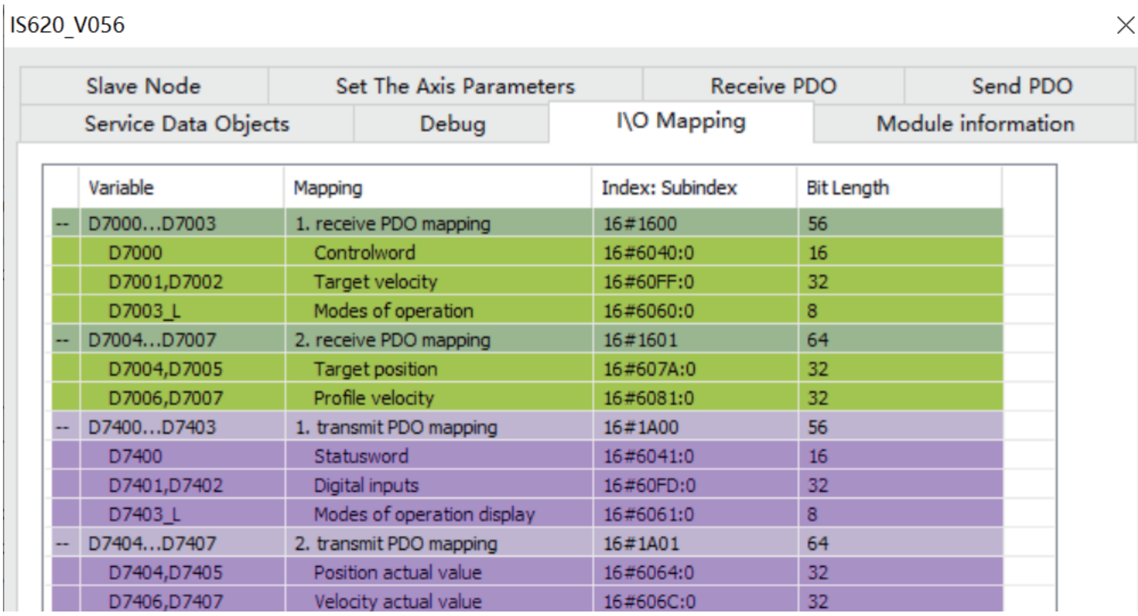
  SDO error steps: Indicates the SDO error number. This number corresponds to the "Service Data Objects" tab.

  Diagnostic string: Indicates the error message (SDO error).

  Emergency Error Information: Indicates an emergency error frame (the system monitors real-time errors and caches five error messages in the background; the PLC only caches the latest error message) (emergency error).

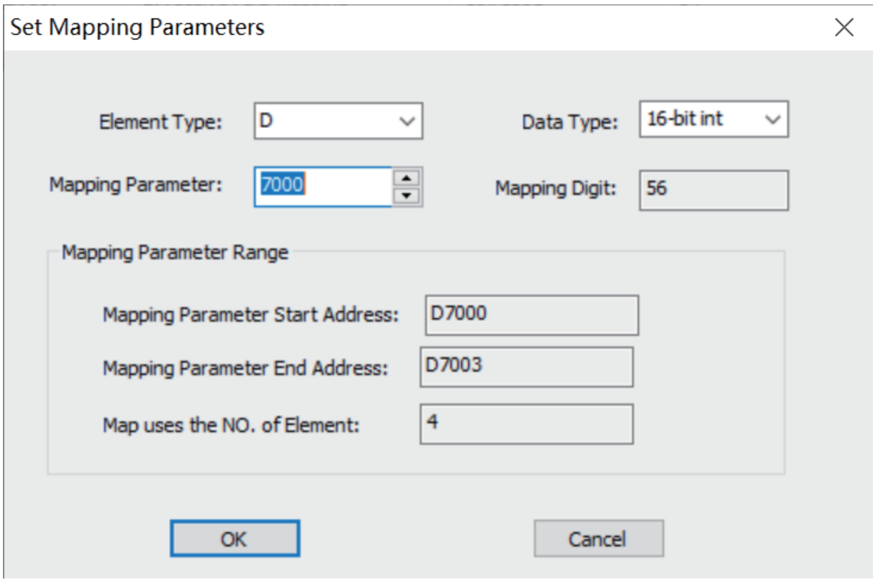
### 8.5.5.8 I/O Mapping

The "IO Mapping" tab page is as follows.




| | Variable | Mapping | Index: Subindex | Bit Length |
|---|---|---|---|---|
| -- | D7000...D7003 | 1. receive PDO mapping | 16#1600 | 56 |
| | D7000 | Controlword | 16#6040:0 | 16 |
| | D7001,D7002 | Target velocity | 16#60FF:0 | 32 |
| | D7003_L | Modes of operation | 16#6060:0 | 8 |
| -- | D7004...D7007 | 2. receive PDO mapping | 16#1601 | 64 |
| | D7004,D7005 | Target position | 16#607A:0 | 32 |
| | D7006,D7007 | Profile velocity | 16#6081:0 | 32 |
| -- | D7400...D7403 | 1. transmit PDO mapping | 16#1A00 | 56 |
| | D7400 | Statusword | 16#6041:0 | 16 |
| | D7401,D7402 | Digital inputs | 16#60FD:0 | 32 |
| | D7403_L | Modes of operation display | 16#6061:0 | 8 |
| -- | D7404...D7407 | 2. transmit PDO mapping | 16#1A01 | 64 |
| | D7404,D7405 | Position actual value | 16#6064:0 | 32 |
| | D7406,D7407 | Velocity actual value | 16#606C:0 | 32 |

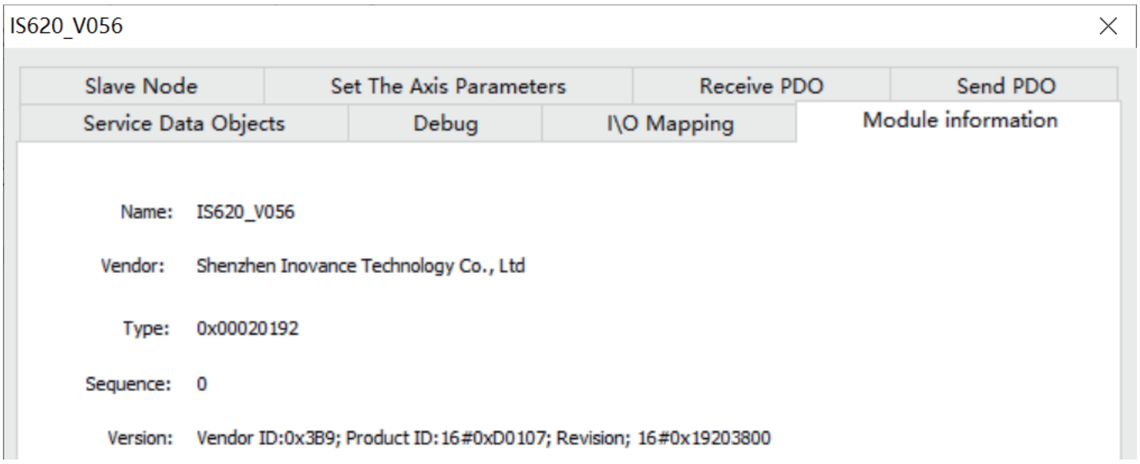
This tab is used to set the communication relationship between master and slave PDOs. If "Automatic Allocation" is not selected, when you double-click an item, the following page is displayed.




You can configure the start register address for the master station corresponding to a slave PDO.

#### 8.5.5.9 Device Information

The "Module information" tab page is as follows.




Device information can be obtained from the EDS file.

### 8.5.6 CANopen Communication Troubleshooting

#### 8.5.6.1 General Troubleshooting Steps

- Check the termination resistor
  Power off all devices. Use a multimeter to measure the resistance between CANH and CANL. The resistance should be about 60 Ω. If the resistance is too small, there are termination resistors incorrectly connected at other locations. In this case, disconnect these termination resistors. If only one termination resistor is available, the resistance is about 120 Ω, and the network connection is bad. If no termination resistor is available, communication fails. Provide termination resistors between the stations at both ends of the network.
- Check the baud rate

Check whether the baud rate is normal. Baud rates of all stations in the network must the same; otherwise, communication fails. Power off and then on the device or switch it from STOP to RUN so that the baud rate can take effect.

For the relationship between communication distance and baud rate, see *"8.3.2 Relationship Between CAN Communication Distance and Baud Rate" on page 263Relationship Between CAN Communication Distance and Baud Rate*.

- Check cable connections
  Interconnect CGND pins of all CAN devices to ensure that all devices share one power supply CGND port of CAN communication.

  Check whether the communication cable, shielded cable, and power supply are short-circuited.
- Others
  In case of strong interference, reduce the baud rate.

### 8.5.6.2 Fault Code List

## SDO fault codes

| Abort Code | Description | Abort Code | Description |
|---|---|---|---|
| 0503 0000 | Trigger bit not alternated | 0601 0002 | Attempt to write a read-only object |
| 0504 0000 | SDO protocol timed out | 0602 0000 | Object not exist in the object dictionary |
| 0504 0001 | Invalid or unknown Client/Server command word | 0604 0041 | Object cannot be mapped to the PDO |
| 0504 0002 | Invalid block size (for the Block Transfer mode only) | 0604 0042 | The number and length of the objects to be mapped exceed the PDO length |
| 0504 0003 | Invalid serial number (for the Block Transfer mode only) | 0604 0043 | General parameter incompatibility |
| 0503 0004 | CRC error (for the Block Transfer mode only) | 0604 0047 | General internal incompatibility in the device |
| 0503 0005 | Memory overflow | 0606 0000 | Access to an object failed due to a hardware error |
| 0601 0000 | Access to an object unsupported | 0606 0010 | Data type does not match. Length of service parameters does not match |
| 0601 0001 | Attempt to read a write-only object | 0606 0012 | Data type does not match. Length of service parameters too high |
| 0601 0002 | Attempt to write a read-only object | 0606 0013 | Data type does not match. Length of service parameters too short |
| 0602 0000 | Object not exist in the object dictionary | 0609 0011 | Sub-index does not exist |
| 0604 0041 | Object cannot be mapped to the PDO | 0609 0030 | Beyond the value range (for write access) |
| 0503 0000 | Trigger bit not alternated | 0609 0031 | Value of parameter written too large |
| 0504 0000 | SDO protocol timed out | 0609 0032 | Value of parameter written too small |
| 0504 0001 | Invalid or unknown Client/Server command word | 0609 0036 | Maximum value is less than minimum value |
| 0504 0002 | Invalid block size (for the Block Transfer mode only) | 0800 0000 | General error |
| 0504 0003 | Invalid serial number (for the Block Transfer mode only) | 0800 0020 | Data cannot be transmitted or stored to the application |

| Abort Code | Description | Abort Code | Description |
|---|---|---|---|
| 0503 0004 | CRC error (for the Block Transfer mode only) | 0800 0021 | Data cannot be transmitted or stored to the application due to local control |
| 0503 0005 | Memory overflow | 0800 0022 | Data cannot be transmitted or stored to the application due to current device state |
| 0601 0000 | Access to an object unsupported | 0800 0023 | Object dictionary dynamic generation fails or no object dictionary is available<br>(for example, an object dictionary is generated through a file, but an error occurs because the file is corrupted) |
| 0601 0001 | Attempt to read a write-only object | | |

## Emergency fault codes

Table 8–8 Main table 1 (hexadecimal)

| Emergency Fault Code | Description | Emergency Fault Code | Description |
|---|---|---|---|
| 00xx | No error | 50xx | Device hardware |
| 10xx | General error | 60xx | Device software |
| 20xx | Current | 61xx | Internal software |
| 21xx | Current at input end | 62xx | User software |
| 22xx | Internal current | 63xx | Data setting |
| 23xx | Current at output end | 70xx | Extra module |
| 30xx | Voltage | 80xx | Monitoring |
| 31xx | Power voltage | 81xx | Communication |
| 32xx | Internal voltage | 82xx | Protocol error |
| 33xx | Output voltage | 90** | External error |
| 40xx | Temperature | F0** | Extra function |
| 41xx | Ambient temperature | FF** | Special device |
| 42xx | Device temperature | | |

Table 8–9 Table 2 (hexadecimal)

| Emergency Fault Code | Description | Emergency Fault Code | Description |
|---|---|---|---|
| 0000 | Incorrect reset or no error | 6300 | Data setting |
| 1000 | General error | 7000 | Extra module error |
| 2000 | Current error | 8000 | Monitoring error |
| 2100 | Input current | 8100 | General communication error |
| 2200 | Internal current | 8110 | CAN communication overload |
| 2300 | Output current | 8120 | Incorrect CAN passive method |
| 3000 | Voltage error | 8130 | Node protection or heartbeat error |
| 3100 | Power voltage | 8140 | Bus disconnection |
| 3200 | Internal voltage | 8150 | CAN-ID impulse |
| 3300 | Output voltage | 8200 | Protocol error |
| 4000 | Temperature error | 8210 | PDO length error |
| 4100 | Ambient temperature | 8220 | Excessive PDO length |
| 4200 | Device temperature | 8240 | Unidentifiable SYNC data length |
| 5000 | Device hardware error | 8250 | RPDO timeout |

| Emergency Fault Code | Description | Emergency Fault Code | Description |
|---|---|---|---|
| 6000 | Device software error | 9000 | External error |
| 6100 | Internal software | F000 | Extra function error |
| 6200 | User software | FF00 | Special device error |

# 9 EtherCAT Communication

## 9.1 Overview

EtherCAT is an open industrial field technology based on Ethernet. It features short communication refresh cycles, low synchronization jitter, and low hardware costs. For details about EtherCAT principles and related technologies, see the book "Industrial Ethernet Fieldbus EtherCAT Driver Design and Applications" or visit the official website of the EtherCAT Technical Group at **https://www.EtherCAT.org.cn**.

The H5U and Easy500 series support standard EtherCAT ports (one RJ45 port). In the linear topology, they support a maximum of 72 EtherCAT slave stations and a minimum EtherCAT bus cycle of 1 ms.

Table 9–1 EtherCAT port specifications

| Item | Specifications |
|---|---|
| Transmission rate | 100 Mbps: 100BASE-TX |
| Modulation | Baseband |
| Topology | Linear and daisy chain |
| Medium | Cat5 twisted pairs or shielded twisted pairs with aluminum foil and braided mesh |
| Transmission distance | Distance between nodes: 100 m or less |
| Number of connections | 72 |

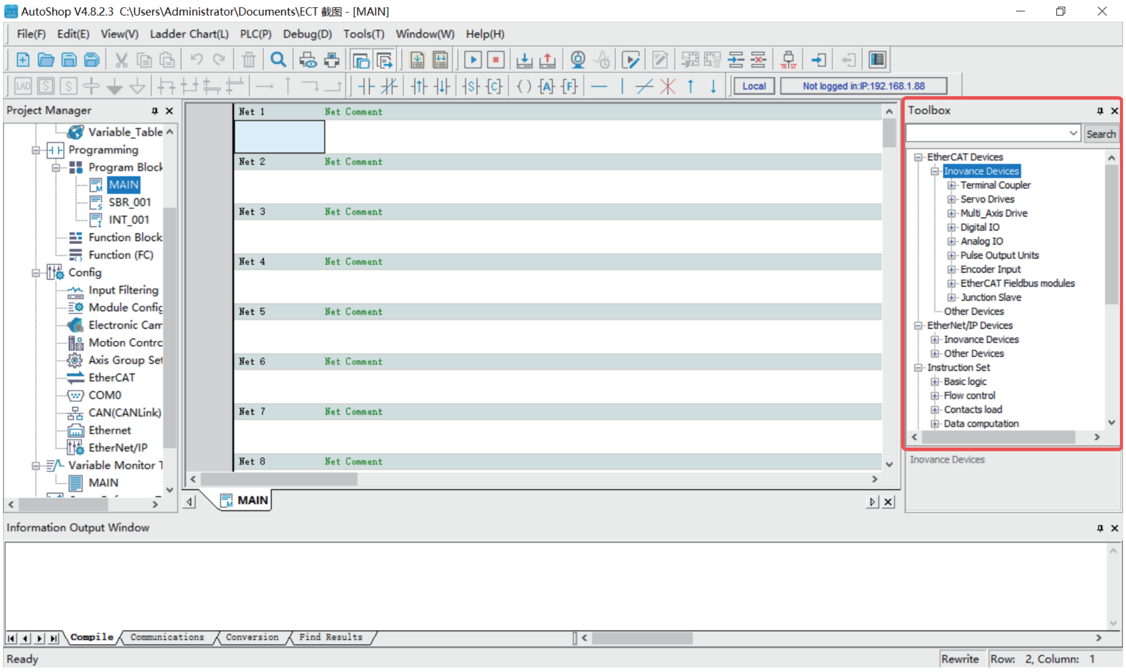
## 9.2 Master Configuration

### 9.2.1 Importing Device Description (XML)

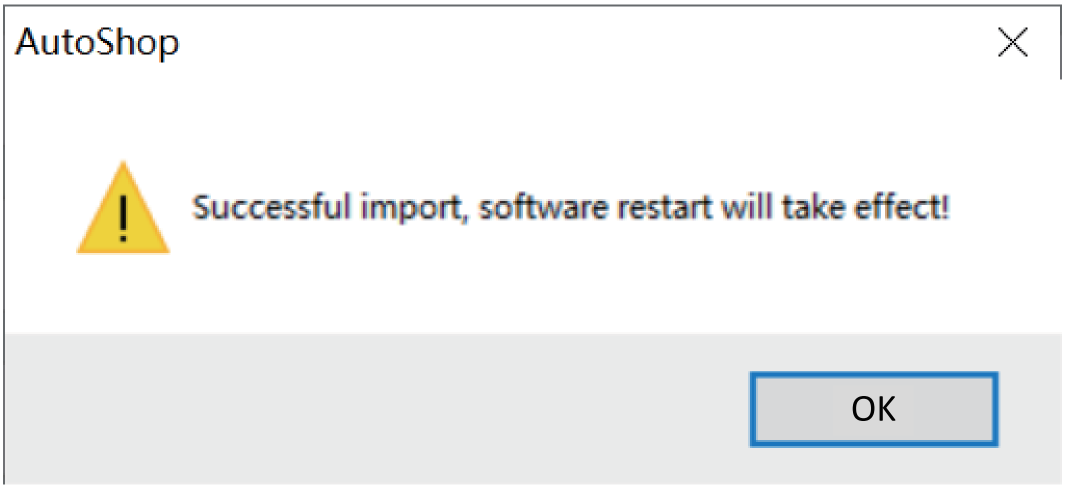
Importing device XML means importing the device description file with the suffix ".XML" that meets standards of the EtherCAT Technical Group (ETG) into the programming software AutoShop, in which, the file is parsed into EtherCAT configuration devices that can be added or deleted by users.

AutoShop provides built-in EtherCAT slave stations of Inovance, and therefore the device description files do not need to be installed. To use third-party EtherCAT devices, their description files must be installed. The following section takes importing the description file of Inovance bus motor drive SV520N as an example.

1. Create a project, open the toolbox, and locate "EtherCAT Devices".

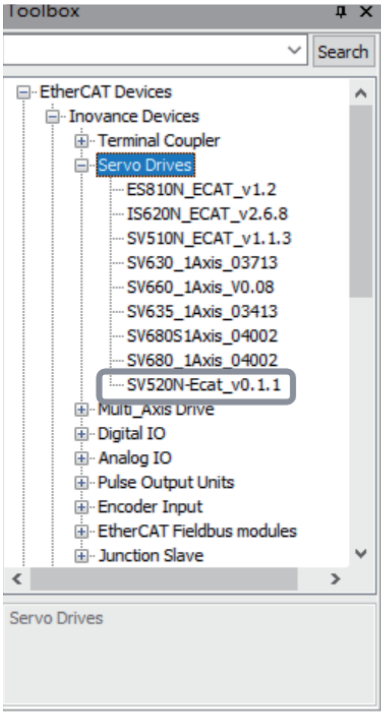



2. Right-click "EtherCAT Devices". In the dialog box displayed, select and import the target XML file.
3. Restart the software to make the imported XML file take effect. To import the XML files of multiple devices, repeat Step 2 and then restart the device.




You must manually restart the software before the added devices take effect.

4. The added devices are added to the list after the software is reaccessed.




## 9.2.2 Scanning Devices

The following section describes how to scan a device when the communication mode is Ethernet.

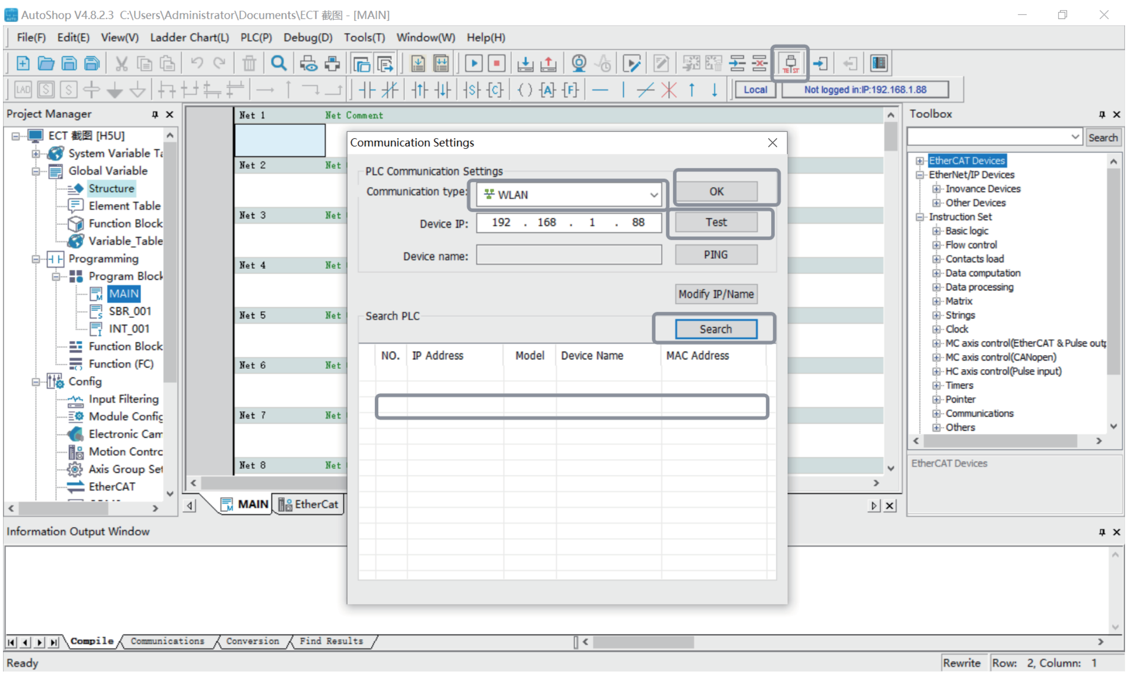
---

### *Note*

EtherCAT slaves can only be scanned when the PLC is in the stopped state.

---

1. Select the target host.



① Click "Test communication status".

② On the page displayed, click "Search".

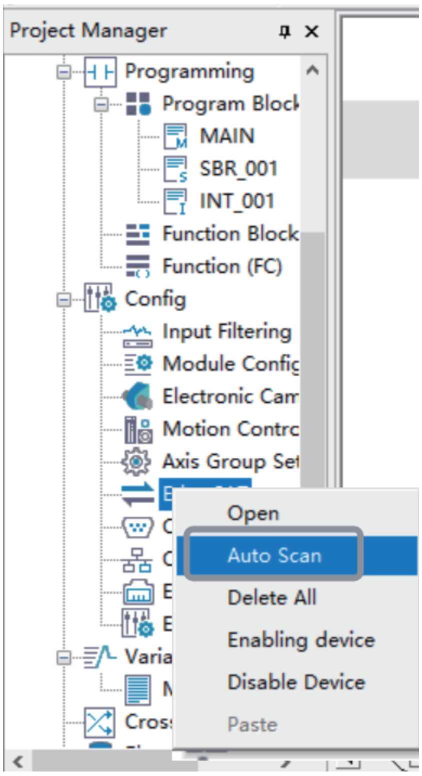
③ Select the target host.

④ Click "Test".

⑤ After confirming that the host is connected, click "OK".

2. Determine whether to automatically associate the motion control axis.
   If "Automatically create axes and associate slaves when creating new slaves" is selected, each time an EtherCAT slave station of the drive type (such as IS620N) is added, a motion control axis is automatically added. In this case, this option is not selected.

3. Right-click EtherCAT and then select "Auto Scan".




4. In the dialog box displayed, click "Start Scan". If the PLC is running, click "Yes" to stop the PLC first.
5. When scanning is completed, the found slave stations are displayed. Click "Update Config" to add the found devices to the configuration list, or click "Exit" to not add the found devices to the configuration list.
   After the configuration list is updated, the following figure is displayed and IS620N is automatically associated with the motion control axis.

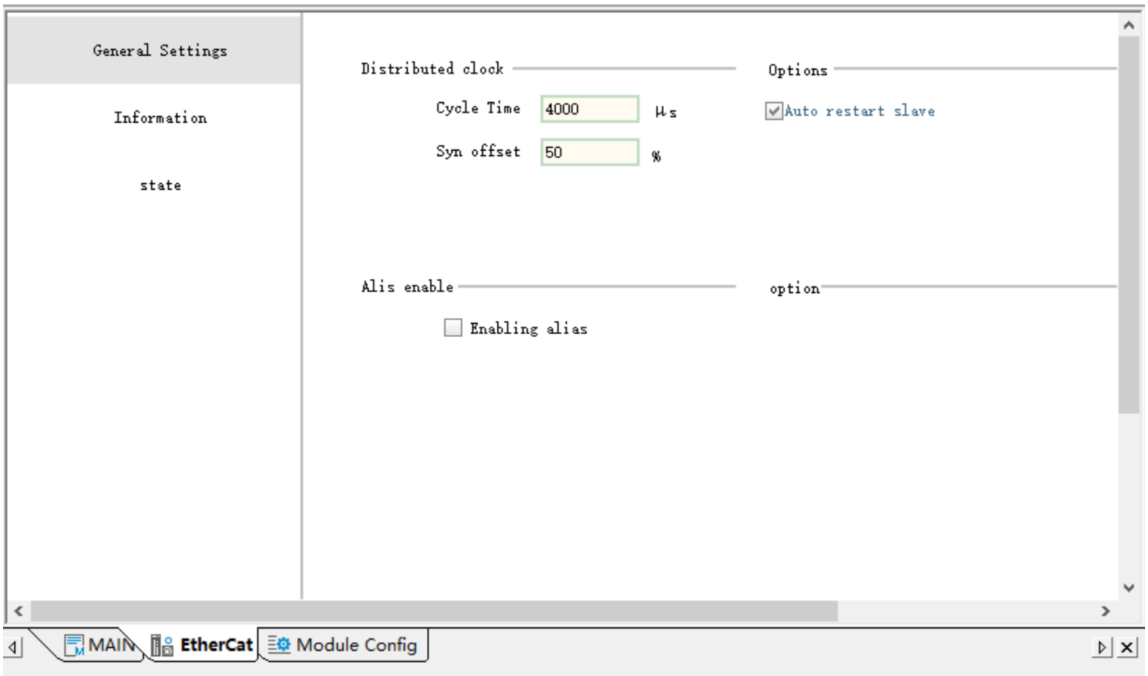
   When the IN/OUT pins of the slave station are reversed, the message "IN/OUT port connection error" is displayed in the "Message" column. In this case, the "Update Config" button is grayed out, and you need to manually check the connection of the physical link and perform scanning again.

## Note

The IN/OUT reversal detection is available to H5U with the firmware version of V6.0 or later. This function is unavailable to the Easy series.

## 9.2.3 Master Configuration

On the "Normal setting" page, set parameters shown in the following figure.




| Parameter Name | Description |
|---|---|
| Cycle time | Indicates the EtherCAT data frame sending interval and the EtherCAT task cycle time. |
| Synchronization offset | Indicates the relative offset (in percentage) of the EtherCAT task with respect to the Sync0 interrupt of the slave station. |
| Automatic restart of slave | When this option is selected, the EtherCAT slave station is automatically restarted when it attempts to connect to the network after disconnection.<br>**Note: This function is supported by AutoShop 4.0.0.0 matching the PCB software 3.0.0.0.** |
| Alias enable | After this option is selected, the aliases of all EtherCAT slave stations are enabled. In this case, even "Alias enable" is not selected for some slave stations, such slave stations are stilled started with their aliases. When the network contains branch modules, you are recommended to select this option.<br>If "Alias enable" is not selected for the master station, when you select "Alias enable" for a single slave station, the alias mode is applied only to this slave station. Then, aliases are mixed with formal names, causing a communication error. |

## 9.2.4 Start/Stop, Disable, and Enable

### Start/Stop control

You can start or stop an EtherCAT bus but cannot start or stop a single slave station. The procedure is as follows.

When the PLC state changes from STOP to RUN, the EtherCAT master station starts to run automatically.

When the PLC state changes from RUN to STOP, the EtherCAT master station stops automatically.

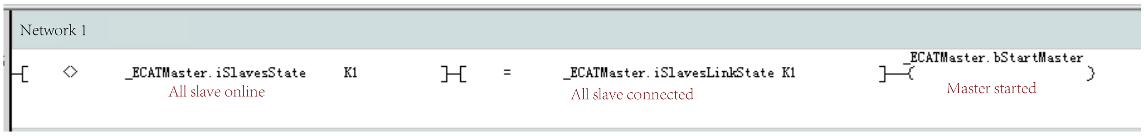
When the PLC is running, you can use the system variables to start or stop the EtherCAT master station.

***Note*** Only the startup and stop of EtherCAT bus are supported, while the startup and stop of individual slaves are not supported.

| System Variable | Data Type | Function |
|---|---|---|
| bStopMaster | BOOL | Stop of the EtherCAT master station<br>The EtherCAT master station stops at the rising edge of the variable input and then the variable is automatically reset. |
| bStartMaster | BOOL | Startup of the EtherCAT master station<br>When the EtherCAT bus fails or stops, the EtherCAT master station is restarted at the rising edge of the variable input and then the variable is automatically reset. |

## Auto Restart

For AutoShop 4.0.0.0 matching PCB software of a version earlier than 3.0.0.0, you can run the PLC program together with system variables iSlavesState, iSlavesLinkState, and bStartMaster to automatically restart the EtherCAT bus.

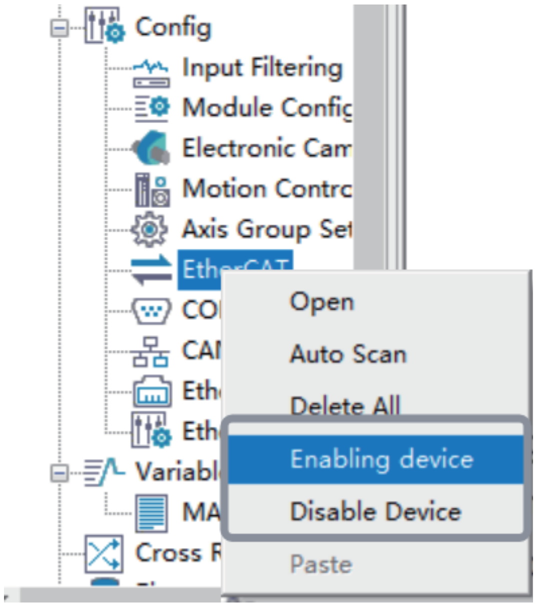



For AutoShop 4.0.0.0 matching PCB software of version 3.0.0.0 or later, you can select "Auto restart of slave" on the "Normal setting" tab page to automatically restart the slave station.

## Disable and Enable

When "Motion control axis-Virtual axis mode" is selected, even if you disable the EtherCAT master station (all the master and slave stations under this bus are disabled), you can still control the motion control axis through the program. For details, see description of the virtual axis mode of the motion control axis. Note that after the EtherCAT master station is disabled, all EtherCAT slave stations are disabled and bus servo axes associated with the slave stations cannot move.

Right-click the EtherCAT master station, and then select "Enabling device" or "Disable Device".

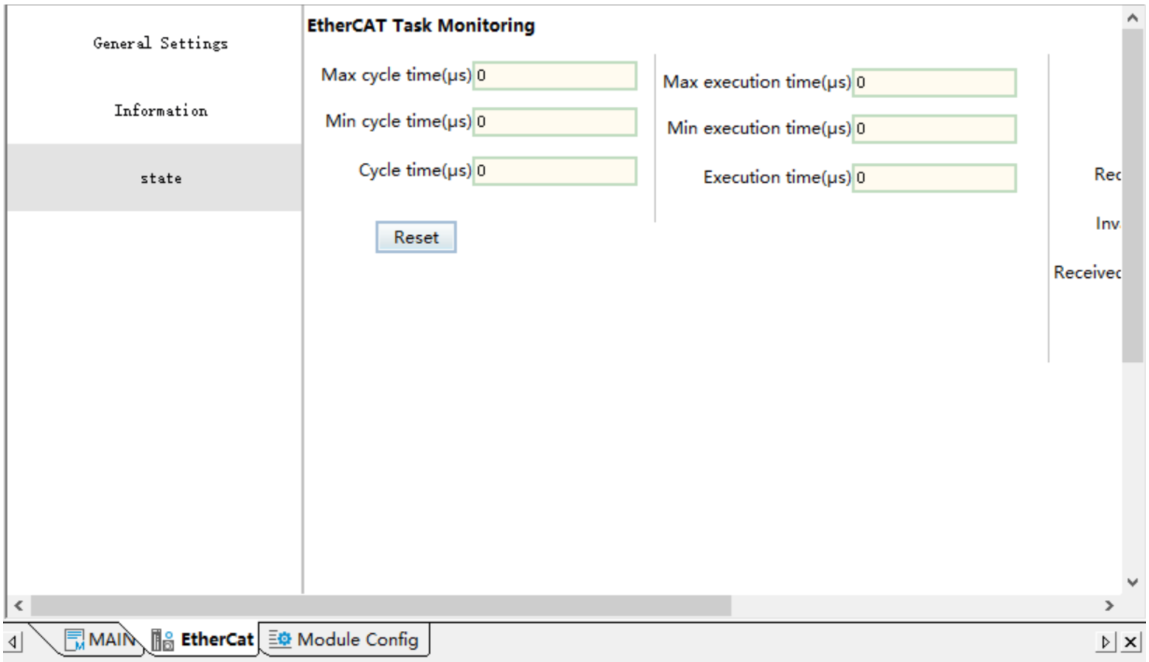



Caution

A disabled slave must be removed from the actual physical link. Otherwise, the slave will affect the startup of all subsequent slaves.

### 9.2.5 Master Status Monitoring

On the "Status" page, you can view the running information of the EtherCAT bus, as shown in the following figure.




- The left column displays the execution information of the EtherCAT task. The following table lists functions and corresponding system variables.

| System Variable | Data Type | Function |
|---|---|---|
| dMaxCycleTime | DINT | Maximum cycle time of the EtherCAT task |
| dMinCycleTime | DINT | Minimum cycle time of the EtherCAT task |
| dCycleTime | DINT | Cycle time of the EtherCAT task in the previous period |
| dMaxExeTime | DINT | Maximum execution time of the EtherCAT task |
| dMinExeTime | DINT | Minimum execution time of the EtherCAT task |
| dExeTime | DINT | Execution time of the EtherCAT task in the previous period |
| bResetTime | BOOL | Execution time and cycle time for resetting |

- The right column displays the data sending and receiving status of the EtherCAT bus.

| System Variable | Data Type | Function |
|---|---|---|
| dtx_error_cnt | DINT | Number of EtherCAT data frame sending errors |
| drx_timeout_cnt | DINT | Number of EtherCAT data frame receiving timeout times |
| drx_corrupt_cnt | DINT | Number of invalid frame receiving events by EtherCAT |
| drx_unmatch_cnt | DINT | Number of mismatched frame receiving events by EtherCAT |
| dLoss_frames | DINT | Number of lost data frames by EtherCAT |
| bClearFrameCounter | BOOL | Resetting of the EtherCAT data frame counter register |

- You can also use system variables to monitor the running, stop, or connection status of the master station.

| System Variable | Data Type | Function |
|---|---|---|
| bMasterRunState | BOOL | Running status of the EtherCAT master station<br>After the EtherCAT master station receives the RUN command and all slave stations are started, this variable becomes TRUE.<br>Note: If some slave stations are disconnected during EtherCAT running, this variable is still TRUE. |
| bLinkState | BOOL | Connection status of the master station<br>The variable is ON as long as one slave station is physically connected to the master station. The variable is OFF if no slave station is physically connected to the master station. |
| iSlavesState | INT | Online status of all slave stations<br>When all the configured slave stations are running, the value is 1. When any slave station is not running, the value is 0. |
| iFirstErrorSlave | INT | When a configured slave station fails (the state machine switches to a non-OP state or is offline), this variable displays the configuration location of the first disconnected slave station. |
| iSlavesLinkState | INT | Physical connection status of all slave stations<br>When the physical connections of all configured slave stations are normal, the value is 1; if the physical connection of any slave station is abnormal, the value is 0. |

### 9.2.6 Summary of System Variables

Table 9–2 System variables for EtherCAT communication

| System Variable | Data Type | Function |
|---|---|---|
| bMasterRunState | BOOL | Running status of the EtherCAT master station<br>After the EtherCAT master station receives the RUN command and all slave stations are started, this variable becomes TRUE.<br>Note: If some slave stations are disconnected during EtherCAT running, this variable is still TRUE. |
| bLinkState | BOOL | Connection status of the master station<br>The variable is ON as long as one slave station is physically connected to the master station. The variable is OFF if no slave station is physically connected to the master station. |
| bHeartBeat | BOOL | EtherCAT real-time task heartbeat<br>Flip once per EtherCAT real-time task cycle |
| bBolckHeartBeat | BOOL | EtherCAT non-real-time task heartbeat<br>Flip once per EtherCAT non-real-time task cycle |
| dMaxCycleTime | DINT | Maximum cycle time of the EtherCAT task |
| dMinCycleTime | DINT | Minimum cycle time of the EtherCAT task |
| dCycleTime | DINT | Cycle time of the EtherCAT task in the previous period |
| dMaxExeTime | DINT | Maximum execution time of the EtherCAT task |
| dMinExeTime | DINT | Minimum execution time of the EtherCAT task |
| dExeTime | DINT | Execution time of the EtherCAT task in the previous period |
| dtx_frames | DINT | Total number of sent frames |
| drx_frames | DINT | Total number of received frames |
| dtx_frames_rates | DINT | Frame sending rate (frames/s) |
| drx_frames_rates | DINT | Frame receiving rate (frames/s) |
| dtx_bytes_rate | DINT | Frame sending rate (bytes/s) |
| drx_bytes_rate | DINT | Frame receiving rate (bytes/s) |
| dloss_frames | DINT | Number of lost data frames by EtherCAT |
| bResetTime | BOOL | Execution time and cycle time for resetting |
| bStopMaster | BOOL | Stop of the EtherCAT master station<br>The EtherCAT master station stops at the rising edge of the variable input and then the variable is automatically reset. |
| bStartMaster | BOOL | Startup of the EtherCAT master station<br>When the EtherCAT bus fails or stops, the EtherCAT master station is restarted at the rising edge of the variable input and then the variable is automatically reset. |
| bClearFrameCounter | BOOL | Resetting of the EtherCAT data frame counter register |
| iSlavesState | INT | Online status of all slave stations<br>When all the configured slave stations are running, the value is 1. When any slave station is not running, the value is 0. |
| iFirstErrorSlave | INT | When a configured slave station fails (the state machine switches to a non-OP state or is offline), this variable displays the configuration location of the first disconnected slave station. |
| dLibVersion | DINT | Version of EtherCAT system library software |
| dMstVersion | DINT | Version of EtherCAT master station software |
| dDriveVersion | DINT | Version of EtherCAT network adapter drive board software |

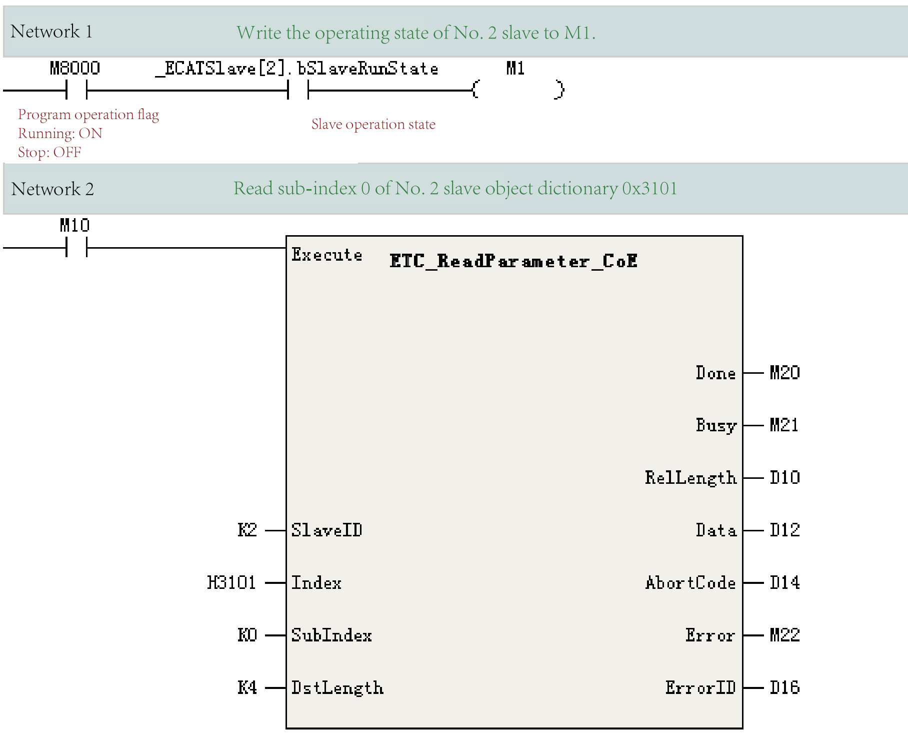
| System Variable | Data Type | Function |
|---|---|---|
| dtx_error_cnt | DINT | Number of EtherCAT data frame sending errors |
| drx_timeout_cnt | DINT | Number of EtherCAT data frame receiving timeout times |
| drx_corrupt_cnt | DINT | Number of invalid frame receiving events by EtherCAT |
| drx_unmatch_cnt | DINT | Number of mismatched frame receiving events by EtherCAT |
| dRxPDOLength | DINT | Total length of received PDOs in the configuration (bytes) |
| dTxPDOLength | DINT | Total length of send PDOs in the configuration (bytes) |
| dConfigureState | DINT | For internal use of configuration status |
| dDelay | DINT | Adjustment value of EtherCAT master station synchronization regulator |
| iSlavesLinkState | INT | Physical connection status of all slave stations<br>When the physical connections of all configured slave stations are normal, the value is 1; if the physical connection of any slave station is abnormal, the value is 0. |

# 9.3 Slave Configuration

## 9.3.1 General Settings

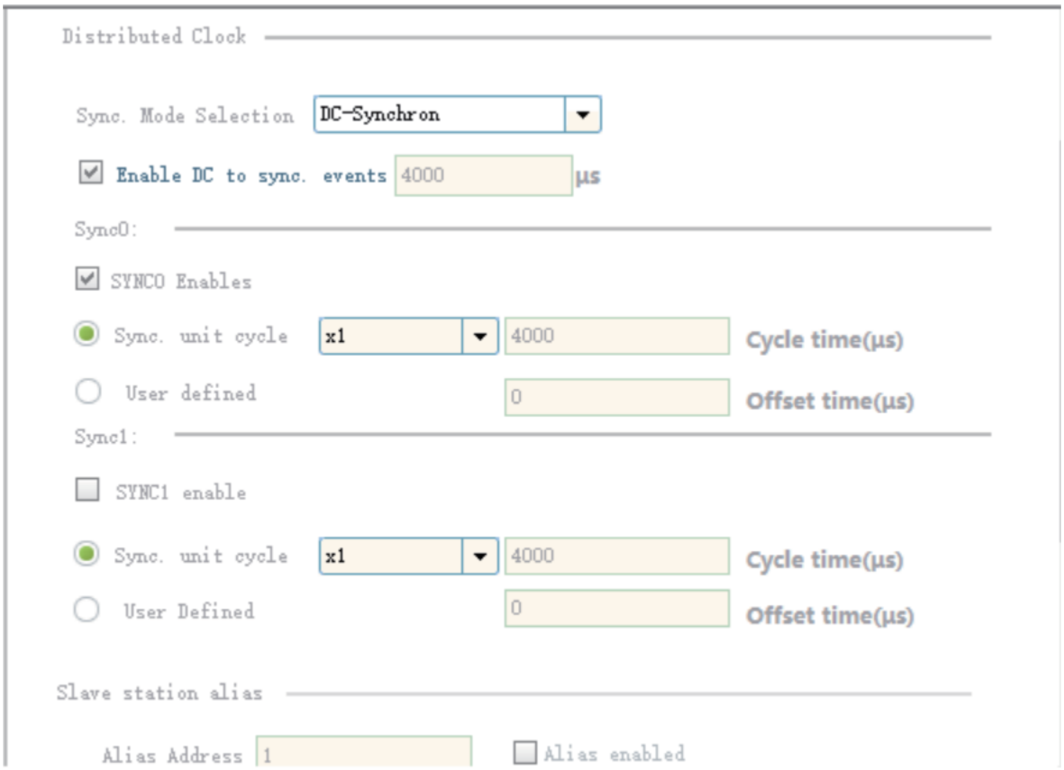
### Configuration address

Configuration addresses of slave stations are sequential addresses in the AutoShop device tree, which increase from 0. The configuration address can be used as a subscript of the slave system variable array or as the slave address for reading and writing SDO instructions.



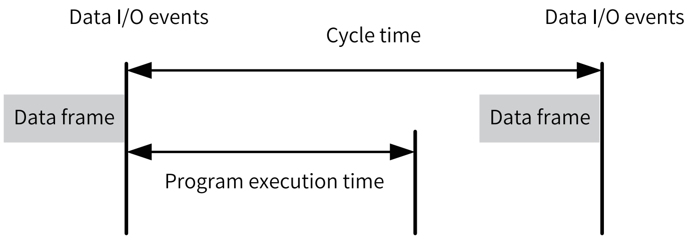
## Distributed clock (DC)

You can set the synchronization running mode for a slave station on the following page.

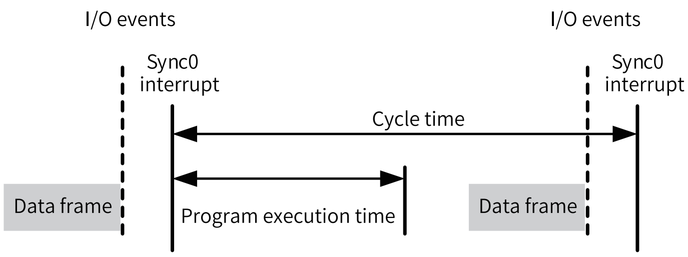



Synchronization mode selection: For an EtherCAT slave station, options are "FreeRun", "SM-Synchron", and "DC-Synchron". The available options vary with the selected slave station.

For example, the GL10-RTU-ECTA module only supports SM-Synchron, and does not support SYNC0 and SYNC1. There is only one interrupt for data input and output events inside the clock slave station, and the internal processing logic of the slave station is shown in the following figure.




Take the GR10-4PME module that supports only DC-Synchron as an example. In this mode, the Sync interrupt of the slave station can be configured. The DC Sync event is enabled by default, the SYNC0 interrupt is enabled, the period of the SYNC0 interrupt is the same as the cycle time of the EtherCAT master station, and the SYNC1 interrupt is not enabled.



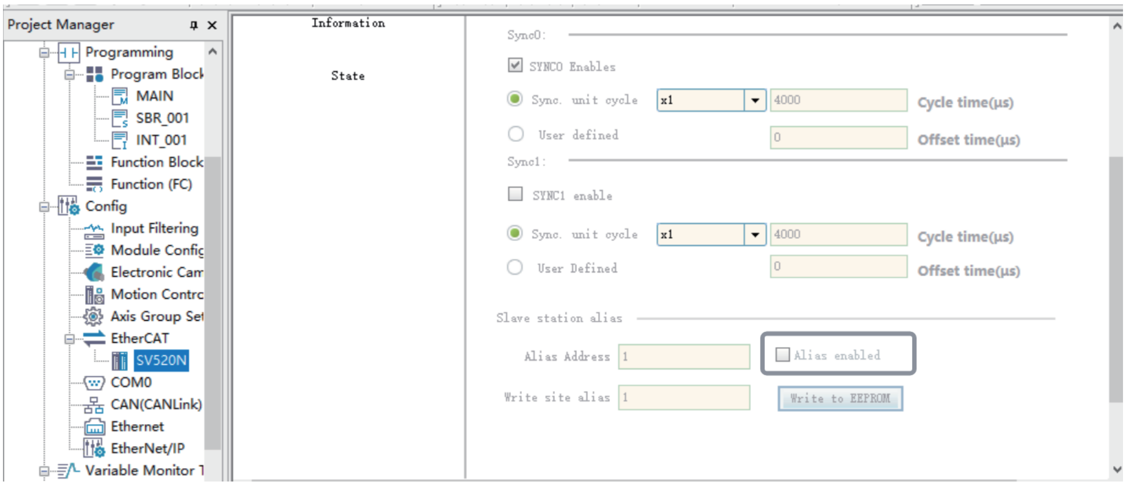
## Note

Users not familiar with the EtherCAT communication principles shall not modify the default configuration in DC-Synchron mode.

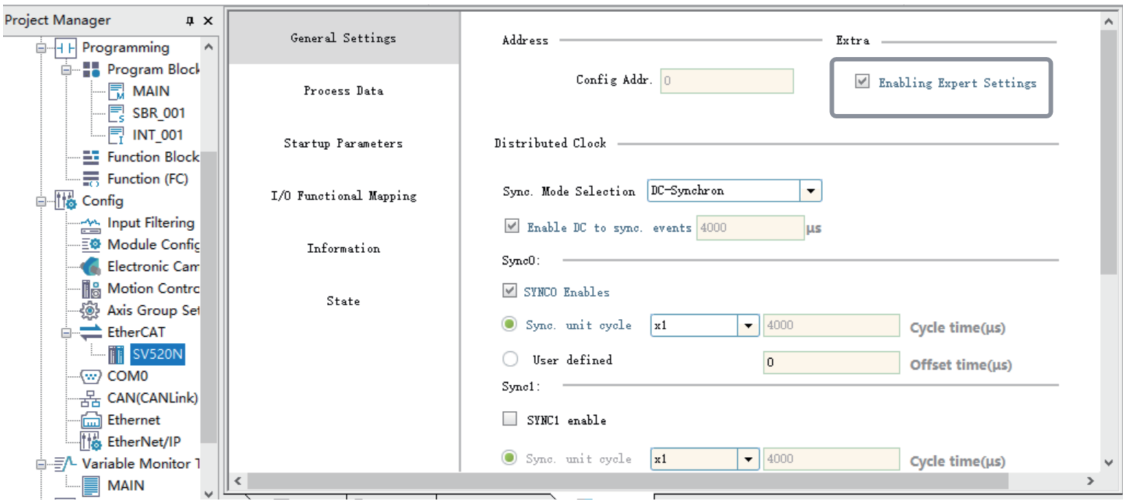
## Slave alias setting

An alias can be set for a slave station only when the expert mode is enabled. To enable the station alias function, you must set an alias for the slave station first. You can set parameters to set an alias for Inovance servo, use the DIP switch to set an alias for the GR10-0808ETNE module, and set the EtherCAT master station to set an alias for GL10-RTU-ECTA. Set an alias for an ECTA module as follows.

1. Create a configuration, do not select "Alias enable", download the program, and wait until the slave station is started.




2. Select "Enable Expert setting". In the "Write site alias" text box, input an alias, enter the monitoring status, and then click "Write EEPROM". Wait until the write operation is completed. The following takes writing 1 as an example.



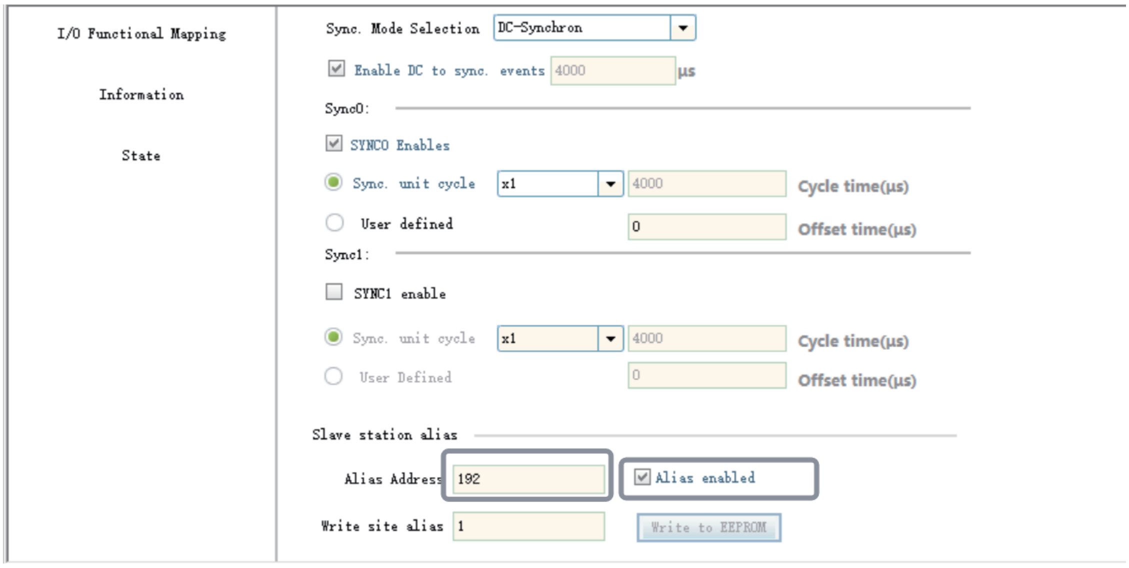

① Select "Enable Expert setting".

② Write an alias for the target station.

③ Click "Write EEPROM".

④ Click "OK" and restart the slave station.

3. Power on the slave station again. You can perform auto scanning to check whether the alias is written.
4. In the configuration, select "Alias enable". In the "Alias address" text box, input the actual alias of the current slave station, and then download the program.




① Select "Enable Expert setting".

② Select "Alias enable".

③ Write the alias address.

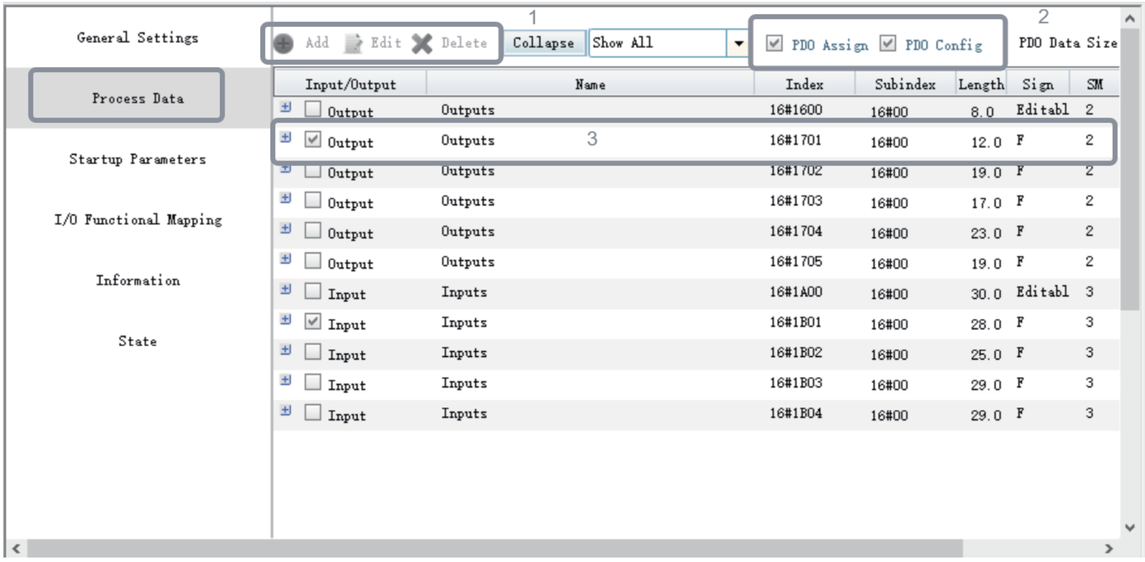
***Note***

- Avoid mixing the use of station alias and station names. Avoid alias conflicts when using aliases.
- It is recommended to enable the alias function for all slaves when setting up branch module networking.
- After the alias function is enabled for slaves, function blocks for reading and writing SDOs and system variables for accessing the slaves still use the configuration addresses.

## 9.3.2 Process Data

You can edit PDOs on the "Process data" page.

The "Process data" page is as follows.




① PDO editing button

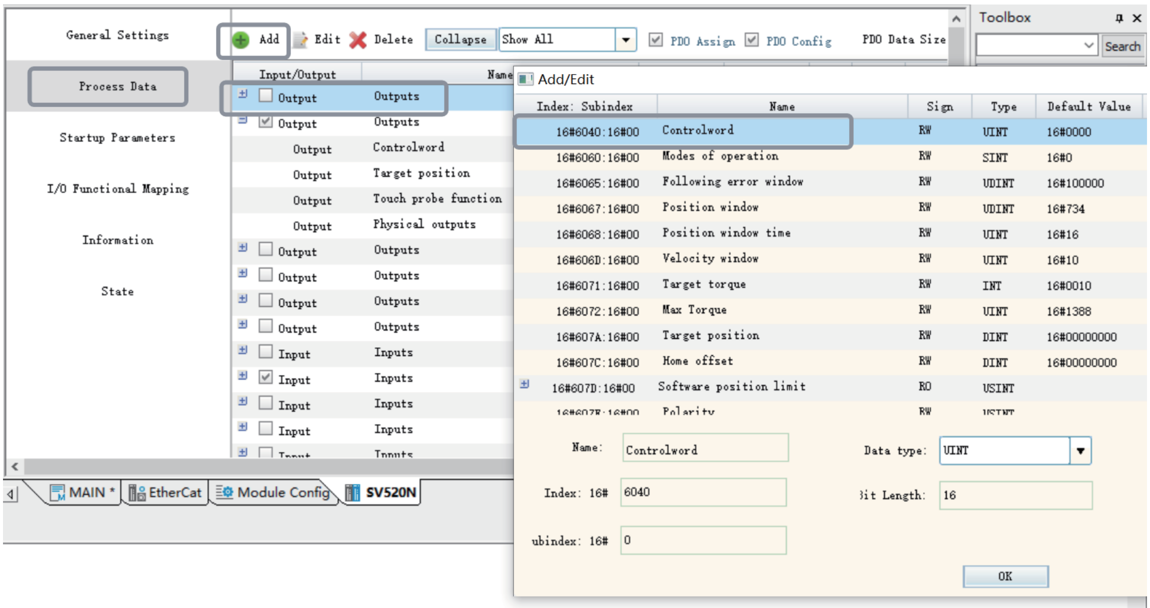
② PDO configuration downloading selection area

③ PDO display area

PDOs are divided into output PDOs and input PDOs by data flow direction. Output PDOs indicate process data sent from the EtherCAT master station to an EtherCAT slave station, such as the control word 0x6040. Input PDOs indicate process data sent from an EtherCAT slave station to the master station.

Each slave station may have one or more groups of PDOs. As shown in the preceding figure, the first group of input PDOs and the first group of output PDOs can be added, edited, or deleted.

The following describes how to add a PDO.



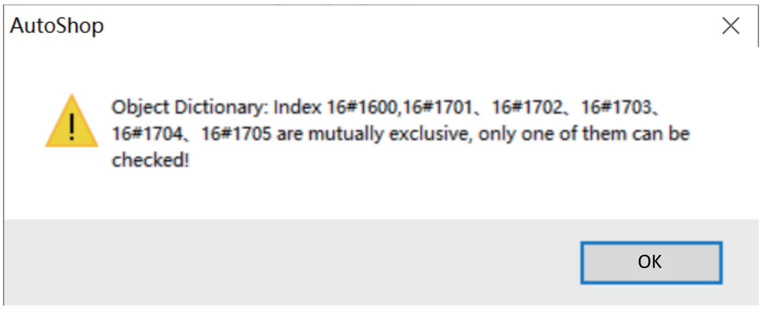

① Select a PDO in the first group.

② Click "Add".

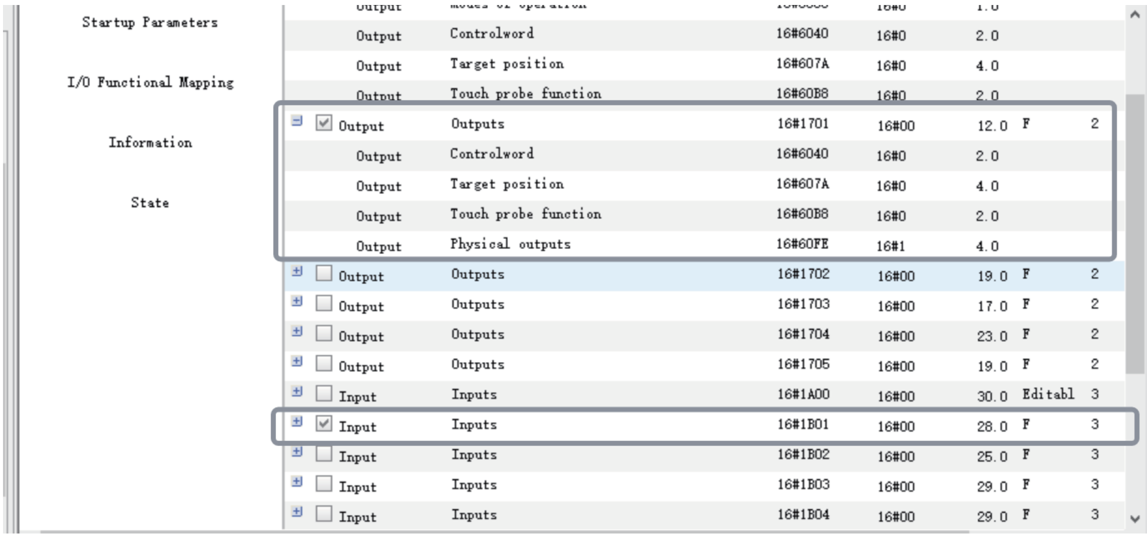
③ Select 6060.

④ Click "OK".

When a slave station has multiple groups of PDOs, such PDO groups are exclusive, such as IS660N. You can select one group each time.

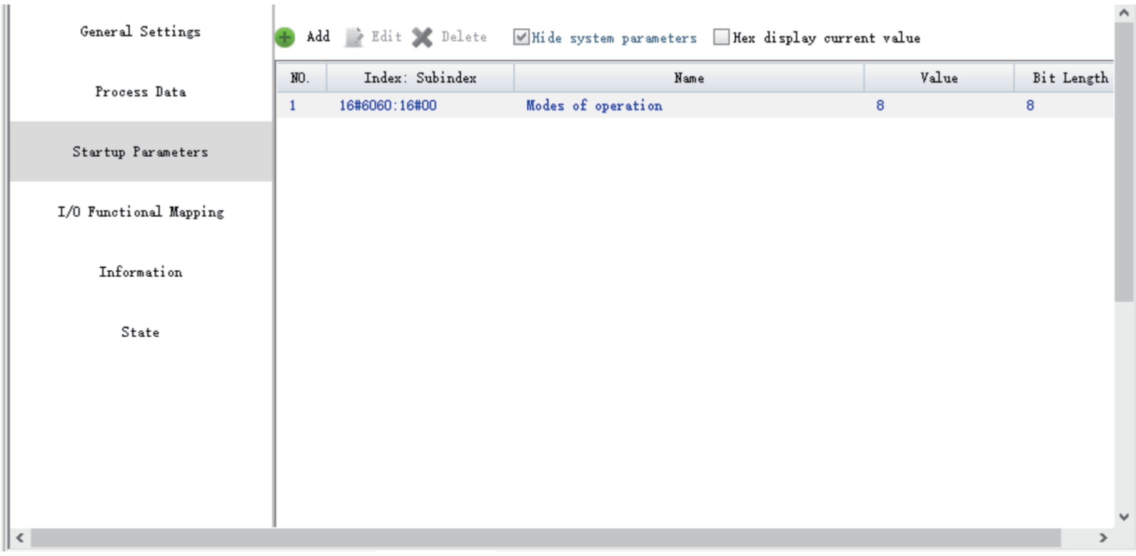



Such mutually exclusive relationship varies with the slave station. For example, you can select multiple PDO groups for GL10-RTU-ECTA.




The master station downloads the PDO configuration relationships to EtherCAT slave stations in the form of startup parameters through PDO allocation and PDO mapping.

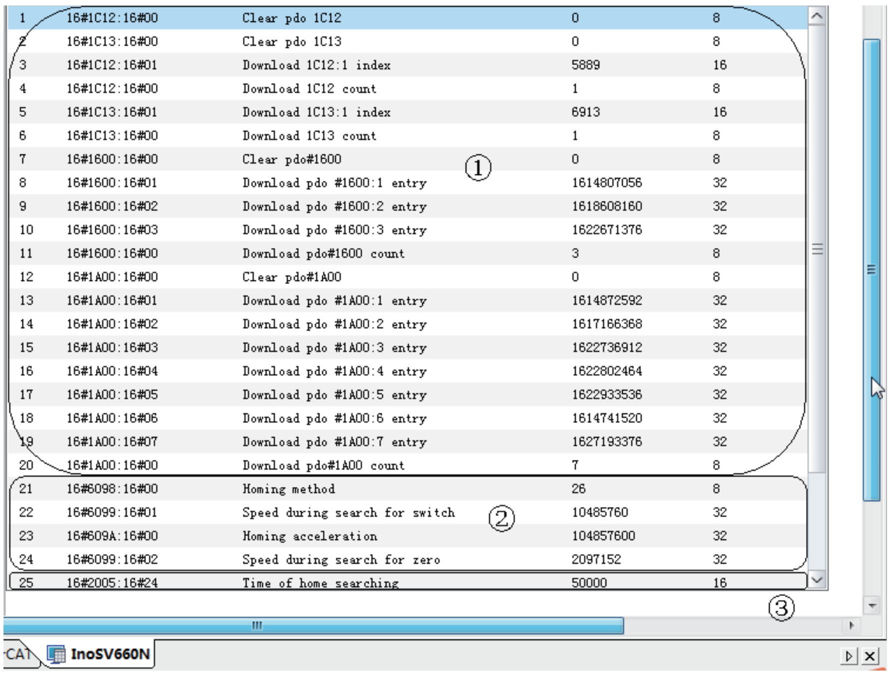
"PDO allocation" is used to download the selected PDO group number to the slave station, while "PDO allocation" is used to download editable PDOs of a group to the slave station. When PDOs are modified but "PDO allocation" and "PDO configuration" are not selected, the slave station may not be started. The configurations can be viewed in the startup parameter list.




### 9.3.3 Startup Parameters

Startup parameters are used to write slave station PDO configuration, factory settings, and parameters specified by some protocols (such as the 402 protocol) to the slave station through writing SDO when the slave station is in the PreOP state.

Take IS620N as an example:



| | | | | |
|---|---|---|---|---|
| 1 | 16#1C12:16#00 | Clear pdo 1C12 | 0 | 8 |
| 2 | 16#1C13:16#00 | Clear pdo 1C13 | 0 | 8 |
| 3 | 16#1C12:16#01 | Download 1C12:1 index | 5889 | 16 |
| 4 | 16#1C12:16#00 | Download 1C12 count | 1 | 8 |
| 5 | 16#1C13:16#01 | Download 1C13:1 index | 6913 | 16 |
| 6 | 16#1C13:16#00 | Download 1C13 count | 1 | 8 |
| 7 | 16#1600:16#00 | Clear pdo#1600 | 0 | 8 |
| 8 | 16#1600:16#01 | Download pdo #1600:1 entry | 1614807056 | 32 |
| 9 | 16#1600:16#02 | Download pdo #1600:2 entry | 1618608160 | 32 |
| 10 | 16#1600:16#03 | Download pdo #1600:3 entry | 1622671376 | 32 |
| 11 | 16#1600:16#00 | Download pdo#1600 count | 3 | 8 |
| 12 | 16#1A00:16#00 | Clear pdo#1A00 | 0 | 8 |
| 13 | 16#1A00:16#01 | Download pdo #1A00:1 entry | 1614872592 | 32 |
| 14 | 16#1A00:16#02 | Download pdo #1A00:2 entry | 1617166368 | 32 |
| 15 | 16#1A00:16#03 | Download pdo #1A00:3 entry | 1622736912 | 32 |
| 16 | 16#1A00:16#04 | Download pdo #1A00:4 entry | 1622802464 | 32 |
| 17 | 16#1A00:16#05 | Download pdo #1A00:5 entry | 1622933536 | 32 |
| 18 | 16#1A00:16#06 | Download pdo #1A00:6 entry | 1614741520 | 32 |
| 19 | 16#1A00:16#07 | Download pdo #1A00:7 entry | 1627193376 | 32 |
| 20 | 16#1A00:16#00 | Download pdo#1A00 count | 7 | 8 |
| 21 | 16#6098:16#00 | Homing method | 26 | 8 |
| 22 | 16#6099:16#01 | Speed during search for switch | 10485760 | 32 |
| 23 | 16#609A:16#00 | Homing acceleration | 104857600 | 32 |
| 24 | 16#6099:16#02 | Speed during search for zero | 2097152 | 32 |
| 25 | 16#2005:16#24 | Time of home searching | 50000 | 16 |

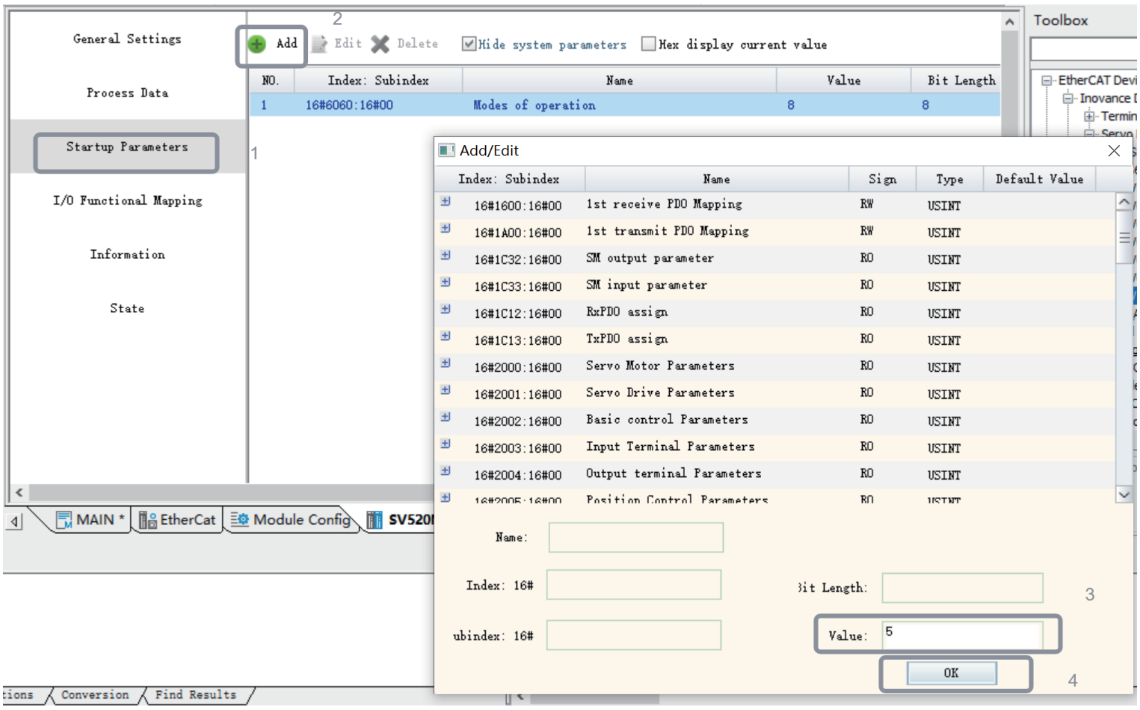


① PDO configuration parameters

② 402 protocol parameters

③ Factory parameters

On this page, you can add startup parameters as required. For example, you can add the object dictionary 0x605a and modify its value to 5 as follows.




① Click "Add".

② Select 605A.

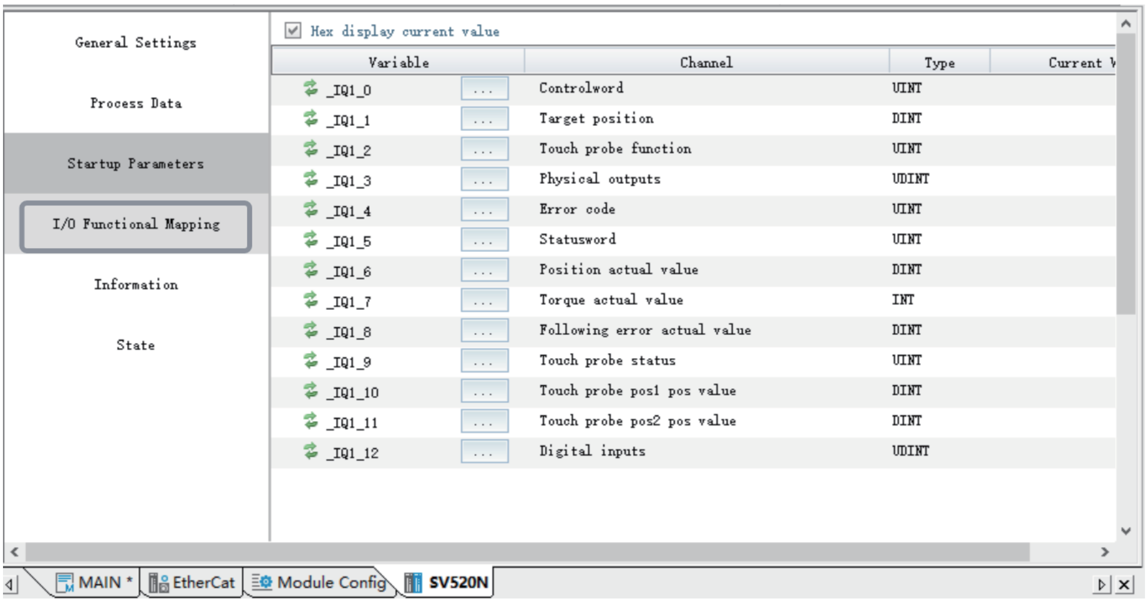
③ Modify its value to 5.

④ Click "OK".

## 9.3.4 I/O Function Mapping

You can control an EtherCAT slave station module by controlling the operation variables only after the PDO data is connected to the PLC.

The "IO Functional Mapping" page is as follows.




Each time a slave station is added, a group of internal variables are automatically created and connected to the PDO of the slave station, such as IQ2_0.

## *Note*

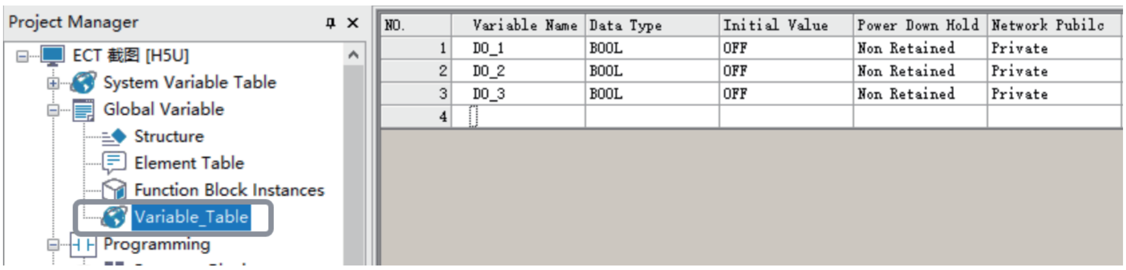
(1) The automatically generated variables change when the module position is changed or any PDO is added, deleted, or modified.

(2) If a slave is associated with a motion control axis, such as SV660N, these variables can only be controlled through axis instructions.

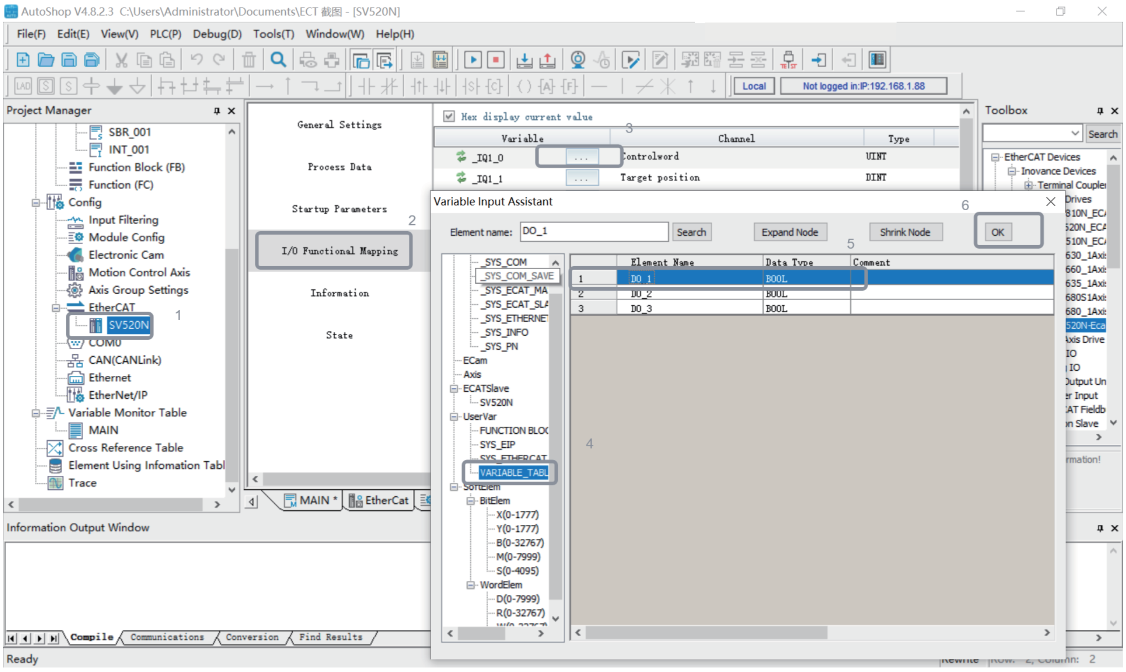
## Associated variables

To modify an associated variable, perform the following operations (taking the GR10-1616ETNE module as an example).

1. Open the variable table and add a variable.




2. Associate the variable on the "IO Functional Mapping" page.




① Open the slave station.

② Select "IO Functional Mapping".

③ Click the icon "...".

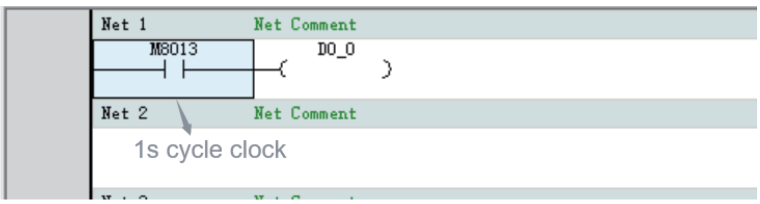
④ Select "Variable Table".

⑤ Select the variable and click "OK".

3. The following page is displayed.

| | | | |
|---|---|---|---|
| _IQ4_0 | ... | Device status | UINT |
| D1000 | ... | GL10-1600END_1 Digital input CH1-8bit | USINT |
| D1001 | ... | GL10-1600END_1 Digital input CH2-8bit | USINT |
| _IQ4_3 | ... | GL10-4AD_2 AD CH0 | INT |
| _IQ4_4 | ... | GL10-4AD_2 AD CH1 | INT |

4. The PLC program controls DO_0 to flash once every second.




## Mapping rules

Data types supported by customized variables are BOOL, BYTE, INT, DINT, and REAL. PDO variables of EtherCAT slave stations support more data types. The following table lists the mapping rules available on the "IO Functional Mapping" page.

| EtherCAT Slave Station Type | Bit Length | Mapping Rules |
|---|---|---|
| BOOL | 1 | BOOL |
| BYTE | 8 | INT: Low-order 8 bits are valid. High-order 8 bits are reserved.<br>BOOL[8]: An 8-bit BOOL-type array is used.<br>BYTE: 8-bit BYTE-type mapping is used. |
| SINT | 8 | INT: Low-order 8 bits are valid. High-order 8 bits are reserved.<br>BOOL[8]: An 8-bit BOOL-type array is used.<br>BYTE: 8-bit BYTE-type mapping is used. |
| USINT | 8 | INT: Low-order 8 bits are valid. High-order 8 bits are reserved.<br>BOOL[8]: An 8-bit BOOL-type array is used.<br>BYTE: 8-bit BYTE-type mapping is used. |
| BITARR8 | 8 | INT: Low-order 8 bits are valid. High-order 8 bits are reserved.<br>BOOL[8]: An 8-bit BOOL-type array is used.<br>BYTE: 8-bit BYTE-type mapping is used. |
| BIT8 | 8 | INT: Low-order 8 bits are valid. High-order 8 bits are reserved.<br>BOOL[8]: An 8-bit BOOL-type array is used.<br>BYTE: 8-bit BYTE-type mapping is used. |
| INT | 16 | INTBOOL[16]: A 16-bit BOOL-type array is used. |
| UINT | 16 | INTBOOL[16]: A 16-bit BOOL-type array is used. |
| WORD | 16 | INT<br>BOOL[16]: A 16-bit BOOL-type array is used. |
| BITARR16 | 16 | INT<br>BOOL[16]: A 16-bit BOOL-type array is used. |
| DINT | 32 | DINTBOOL[32]: A 32-bit BOOL-type array is used. |
| UDINT | 32 | DINTBOOL[32]: A 32-bit BOOL-type array is used. |
| DWORD | 32 | DINT<br>BOOL[32]: A 32-bit BOOL-type array is used. |
| BITARR32 | 32 | DINT<br>BOOL[32]: A 32-bit BOOL-type array is used. |
| REAL | 32 | REAL |

The following figure shows an example with the data type of USINT.

| | | | |
|---|---|---|---|
| _IQ4_0 | ... | Device status | UINT |
| _IQ4_1 | ... | GL10-1600END_1 Digital input CH1-8bit | USINT |
| _IQ4_2 | ... | GL10-1600END_1 Digital input CH2-8bit | USINT |
| _IQ4_3 | ... | GL10-4AD_2 AD CH0 | INT |
| _IQ4_4 | ... | GL10-4AD_2 AD CH1 | INT |
| _IQ4_5 | ... | GL10-4AD_2 AD CH2 | INT |
| _IQ4_6 | ... | GL10-4AD_2 AD CH3 | INT |
| _IQ4_7 | ... | GL10-8TC_3 TC CH0 | REAL |
| _IQ4_8 | ... | GL10-8TC_3 TC CH1 | REAL |
| _IQ4_9 | ... | GL10-8TC_3 TC CH2 | REAL |
| _IQ4_10 | ... | GL10-8TC_3 TC CH3 | REAL |
| _IQ4_11 | ... | GL10-8TC_3 TC CH4 | REAL |
| _IQ4_12 | ... | GL10-8TC_3 TC CH5 | REAL |
| _IQ4_13 | ... | GL10-8TC_3 TC CH6 | REAL |
| _IQ4_14 | ... | GL10-8TC_3 TC CH7 | REAL |

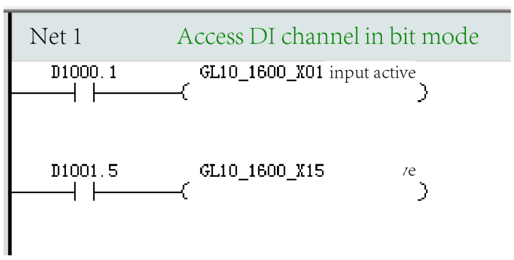
To detect the DI channel of the GL10-1600END module, you must allocate a variable to both GL10-1600END_1 Digital input CH1-8bit and GL10-1600END_1 Digital input CH2-8bit (you can also use the default variables IQ4_1 and IQ4_2, but they are not easy to expand and maintain). The configuration can be displayed in the following three ways.

**Solution 1: Associate the D element**

1. Create a mapping relationship

| | | | |
|---|---|---|---|
| _IQ4_0 | ... | Device status | UINT |
| D1000 | ... | GL10-1600END_1 Digital input CH1-8bit | USINT |
| D1001 | ... | GL10-1600END_1 Digital input CH2-8bit | USINT |
| _IQ4_3 | ... | GL10-4AD_2 AD CH0 | INT |
| _IQ4_4 | ... | GL10-4AD_2 AD CH1 | INT |

2. Call it in the program

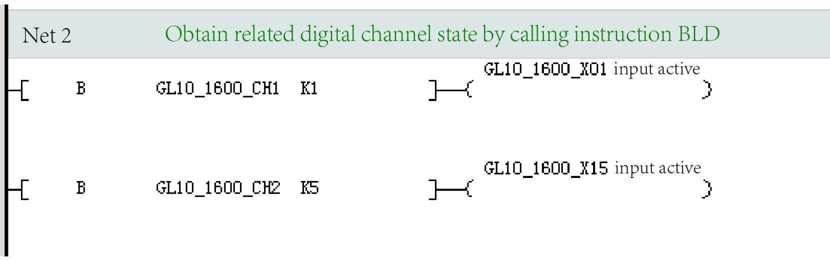



**Solution 2: Associate customized variable of the INT type**

1. Create a global variable
2. Create a mapping relationship

| | | | |
|---|---|---|---|
| _IQ4_0 | ... | Device status | UINT |
| GL10_1600_CH1 | ... | GL10-1600END_1 Digital input CH1-8bit | USINT |
| GL10_1600_CH2 | ... | GL10-1600END_1 Digital input CH2-8bit | USINT |
| _IQ4_3 | ... | GL10-4AD_2 AD CH0 | INT |
| _IQ4_4 | ... | GL10-4AD_2 AD CH1 | INT |

3. Call it in the program

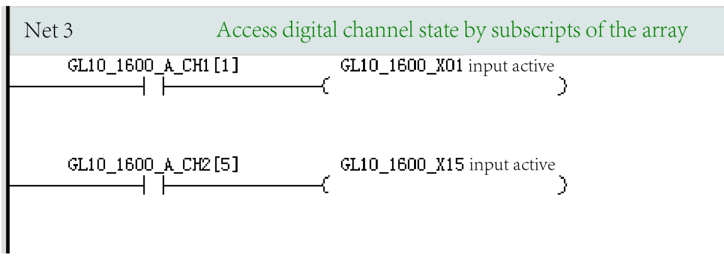



**Solution 3: Associate an array of the BOOL type**

1. Create a global variable array
2. Create a mapping relationship

| | | | |
|---|---|---|---|
| _IQ4_0 | ... | Device status | UINT |
| GL10_1600_A_CH1 | ... | GL10-1600END_1 Digital input CH1-8bit | USINT |
| GL10_1600_A_CH2 | ... | GL10-1600END_1 Digital input CH2-8bit | USINT |
| _IQ4_3 | ... | GL10-4AD_2 AD CH0 | INT |
| _IQ4_4 | ... | GL10-4AD_2 AD CH1 | INT |

3. Call it in the program



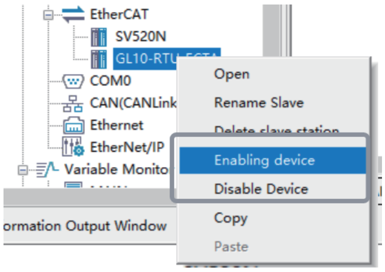

## 9.3.5 Start/Stop, Disable, and Enable

For AutoShop 4.0.0.0 matching PCB software of a version earlier than 3.0.0.0, you cannot start or stop a single slave station, but can only start or stop the entire EtherCAT bus.

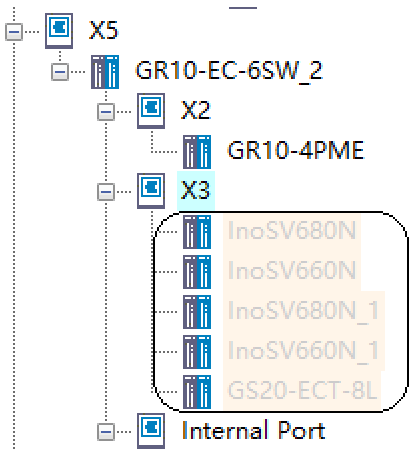
For AutoShop 4.0.0.0 matching PCB software of version 3.0.0.0 or later, you can select "Auto restart of slave" on the EtherCAT master station configuration page to automatically restart a slave station.

When the number of configured slave stations is greater than the number of connected ones, you can disable unavailable slave stations in the configuration.

To enable or disable a slave station, right-click the target slave station, and then select "Disable Device" or "Enabling device".




When the network contains branch modules, if a branch port is disabled, all slave stations mounted to this port are disabled.




## 9.3.6 Disabling Slaves Using Instructions

You can disable EtherCAT slave stations during programming by using the ETC_RestartMaster instruction and relevant system variables.

### System variables

- The following table lists system variables used to enable or disable specified EtherCAT slave stations.

| Name | Unit | Description | Retentive upon Power Failure |
|---|---|---|---|
| bDisableEnable | BOOL | Disable/Enable<br>OFF: Enabled<br>ON: Disabled | No |
| wDisableState | INT | Configuration status<br>0: Reserved<br>1: Enabled<br>2: Disabled | No |

- The following table lists system variables of EtherCAT slave stations used to enable or disable the entire EtherCAT bus.

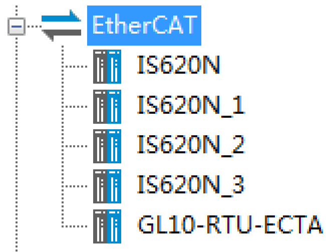
| Name | Unit | Description | Retentive upon Power Failure |
|---|---|---|---|
| bDisableMaster | BOOL | Disable/Enable<br>OFF: Enabled<br>ON: Disabled | No |
| iDisableState | INT | Configuration status<br>0: Reserved<br>1: Enabled<br>2: Disabled | No |

## Usage

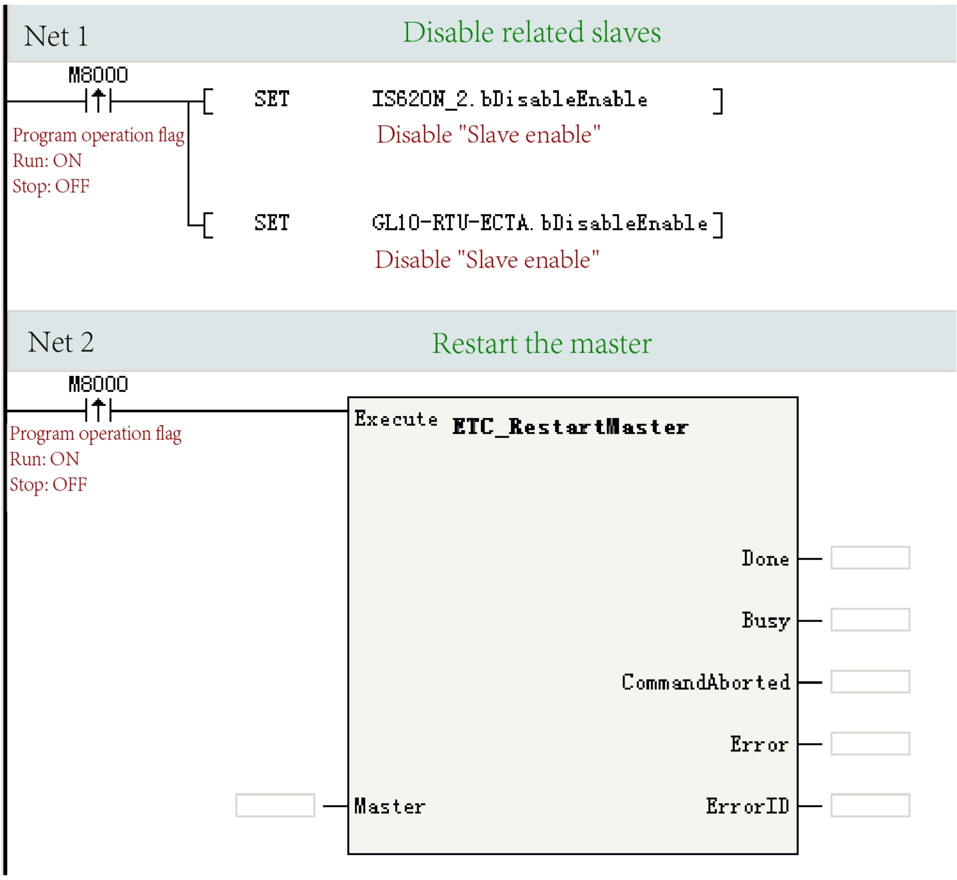
1. After power-on, the PLC initializes the bDisableEnable variable based on the background configuration, updates the configuration list based on the value of the bDisableEnable variable, starts the master station, and then writes the disabling status of the slave station to the wDisableState variable.
2. Wait until the PLC parses the program configuration.
3. Use the PLC program to set the value of the bDisableEnable variable.
4. Use the ETC_RestartMaster instruction to restart the EtherCAT master station.
5. After the master station is restarted, use the bDisableEnable variable to update the configuration list and write the disabling status of the slave station to wDisableState.

## Example

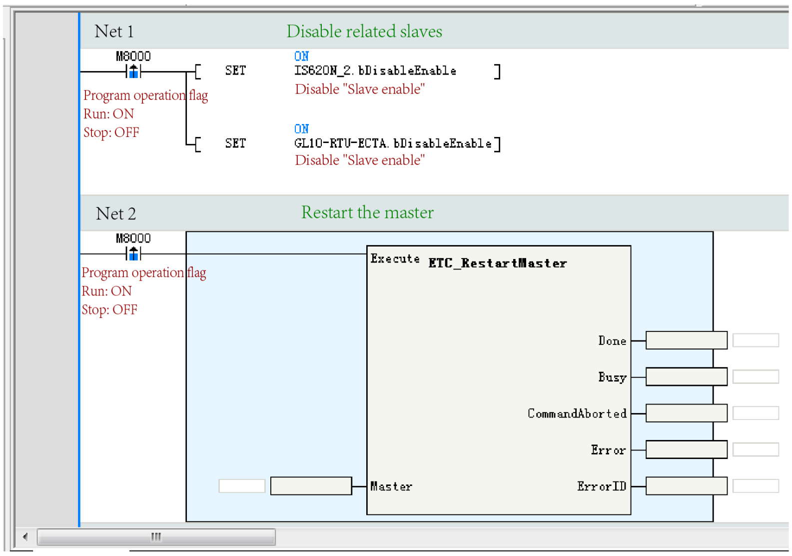
1. Create a configuration by using the background software, enable the EtherCAT communication, and configure four IS620N slave stations and one AM600-RTU-ECTA slave station.




2. Set the system variables _DisableEnable and bDisableEnable to disable the slave stations IS620N_2 and AM600-RTU-ECTA, and then use the ETC_RestartMaster instruction to restart the master station.




3. Download the project to the controller. The slave stations IS620N_2 and AM600-RTU-ECTA are disabled after start.




## 9.3.7 System Variables

The following table lists system variables of EtherCAT slave stations.

| System Variable | Data Type | Function |
| --- | --- | --- |
| bDisableEnable | BOOL | Disable/Enable<br>OFF: Enabled<br>ON: Disabled |
| wDisableState | INT | Configuration status<br>0: Reserved<br>1: Enabled<br>2: Disabled |
| bSlaveRunState | BOOL | Running status of slave station<br>The value is TRUE when the slave station is in the OP state; otherwise, the value is FALSE. |
| bSetAliasState | BOOL | Set the alias status (for the use of the background only)<br>TRUE: Busy<br>FALSE: Idle or setting completed |
| bSetAliasError | BOOL | Failed to set the alias status (for the use of the background only)<br>TRUE: Failed to set the alias status<br>FALSE: No fault |
| bSetAlias | BOOL | Set the station alias (for the use of the background only)<br>The value of wTarAlias is written to the slave station at the rising edge of the variable. |
| wALState | INT | Status of the EtherCAT slave station state machine<br>1: INIT<br>2: PreOP<br>4: SafeOP<br>8: OP |
| wAlCode | INT | Code of failure to convert the slave station state machine. For details, see the slave station guide. |
| wActAlias | INT | Actual alias of the slave station. Initialization is performed once upon power-on, and the modification does not take effect. |
| wTarAlias | INT | Station alias to be written (for the use of the background only) |
| wStationAddress | INT | Sequential address of the slave station. Initialization is performed once upon power-on, and the modification does not take effect. |

# 9.4 Faults and Diagnosis

## 9.4.1 Learning Faults

The BF indicator indicates the fault status of the EtherCAT bus. The following table lists the statuses and solutions.

| LED Indicator | Definition | Solution |
|---|---|---|
| Off | No fault | / |
| Flashing | The EtherCAT bus is abnormal. | Troubleshoot the problem based on the fault code displayed. For details, see *"9.4.2 Fault Codes" on page 329*. |
| On | Failed to request for the master station. | Troubleshoot the problem based on the fault code displayed. For details, see *"9.4.2 Fault Codes" on page 329*. |

You can obtain the code of an EtherCAT instruction fault based on the ErrorID in the instruction.

You can view the EtherCAT bus faults on the "Fault Diagnosis" page.

## 9.4.2 Fault Codes

| Fault Code | Cause | Solution |
|---|---|---|
| 8001 | Failed to request for the master station. | 1. Check whether the PCB software version matches the background version.<br>2. Restart the PLC. |
| 8002 | Failed to obtain the slave station configuration parameters. | Check whether the PCB software version matches the background version. |
| 8003 | Master station startup timed out. | Check the network connection. |
| 8004 | Failed to request for the master station. | 1 Restart the PLC.<br>2 An error occurred while loading ECAT. Upgrade the firmware to the correct version. |
| ... | - | - |
| 8200 | Failed to write startup parameters. | 1. Check whether the startup parameter list contains any object dictionary that is not supported by the slave station.<br>2. Check whether the value of the object dictionary exceeds the range. |
| 8201 | The slave station is lost during running. | 1. Check whether the slave station is disconnected from the network.<br>2. Check whether the slave station is powered off. |
| 8202 | The slave station enters a non-OP state during running. | 1. Check whether the slave station is disconnected from the network.<br>2. Check whether the slave station is powered off. |
| 8203 | Reserved | - |
| 8204 | The slave station type does not match. | 1. Check whether the network cable is inversely connected.<br>2. Check whether the configured device matches the connected device. |
| 8205 | The PDO address is incorrect. | 1. Check whether the memory is used up.<br>2. Check whether the background version matches the PCB software version.<br>3. Power off and then on the device. |
| 8206 | The PDO length is incorrect. | Check whether the background version matches the PCB software version. |
| 8301 | Failed to switch to the INIT status. | Check whether the slave station state machine supports status conversion. |
| 8302 | Failed to switch to the PerOP status. | Check whether the slave station supports the CoE protocol. |
| 8304 | Failed to switch to the SafeOP status. | Check whether the PDO communication configuration is correct. |

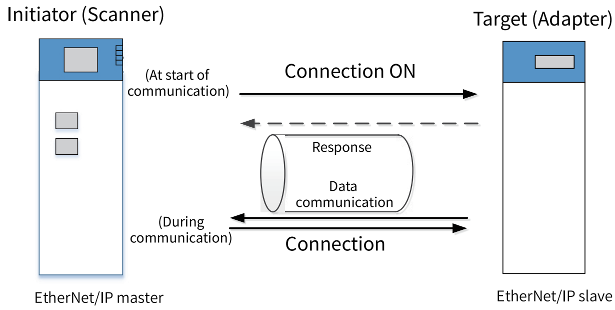
| Fault Code | Cause | Solution |
|---|---|---|
| 8308 | Failed to switch to the OP status. | 1. Check the network communication quality.<br>2. Check whether the EtherCAT task cycle is set appropriately. |
| 8310 | Configuration of the FMMU unit is incorrect. | Check whether the slave station supports the FMMU unit. |
| 8311 | The email configuration is incorrect. | Check whether the slave station supports the SM unit. |
| 8400 | The ECTA configuration is incorrect. | Check whether the configured extension module is the connected extension module. |
| 8401 | An ECTA hardware error occurred. | 1. Check whether the connection between ECTA and the extension module is loose.<br>2. Replace ECTA. |
| 8402 | The extension module mounted to ECTA is incorrect. | Check the fault type of the extension module based on the ECTA guide. |
| 1280 | No master station. | Check whether EtherCAT bus communication is enabled. |
| 1281 | No slave station. | Check whether this slave station is configured. |
| 1282 | The SDO length to be read or written is greater than 4 or equal to 0. | Check whether the read or written SDO length is correct. |
| 1283 | No master station. | Check whether the configuration parameters of the master station are correct. |
| 1284 | Read or write operation failed.<br>• SDO read/write timed out.<br>• SDO does not exist.<br>• SDO read/write is not supported due to the status of the slave station.<br>• The SDO length to be read or written is incorrect. | Check whether the SDO operation is supported by the slave station state machine.<br>Check whether the SDO to be read or written exists.<br>Check whether the SDO length to be read or written is correct. |
| 1285 | Memory request failed. | 1. Check whether the PLC memory is used up.<br>2. Contact Inovance. |
| 1286 | The master station stops. | This instruction cannot be called when the master station stops. |

When an EtherCAT bus fault occurs, the fault status indicator in the lower-right corner of AutoShop turns to yellow. If you double-click this area, the "Fault Diagnosis" dialog box is displayed, in which you can view the configuration of the failed slave station, the fault code, and the fault details.

# 10 EtherNet/IP Communication

## 10.1 Overview

The open connected end is the EtherNet/IP master station, and the opened end is the EtherNet/IP slave station, as shown in the following figure.




The small PLC background AutoShop V4.4.0.5 and later versions support the EtherNet/IP function. The communication specifications are as follows.

- H5U and Easy320/Easy52X series PLCs support one EtherNet/IP master station.
- The minimum cycle communication period (RPI) is 5 ms.
- The maximum data volume of single connection communication is 1400 bytes for Easy, and 500 bytes for H5U.
- A maximum of 32 connections (consumer tags + server tags + slave connections) are supported.
- A maximum of 32 tags (producer tags + server tags) can be created.

### *Note*

- When EtherCAT and EtherNet/IP networks both exist in a networking project, the real-time communication performance of EtherNet/IP network is reduced because EtherCAT has the highest priority by default.
- For protocol details, see the official standard documents EIP-CIP-V1-1.0 and EIP-CIP-V2-1.0.
- The firmware version must be V5.66.0.0 or later, and the software version must be AutoShop V4.8.0.0 or later.

## 10.2 Technical Data

### 10.2.1 EtherNet/IP Transmission Specifications

Table 10–1 Transmission specifications

| Item | Technical Specifications | |
|---|---|---|
| | 10BASE-T | 100BASE-TX |
| Transmission rate | 10 Mbps | 100 Mbps |
| Transmission media | STP or UTP above Cat3[1] | STP or UTP above Cat5[1] |
| Max. cable length[2] | 100 m | 100 m |

Meet the standard IEEE802.3.

- [1]: STP: shielded twisted pair. UTP: unshielded twisted pair.
- [2]: The maximum cable length is the distance between an EtherNet/IP unit and a network device.

## 10.2.2 EtherNet/IP Communication Specifications

| Item | | | | H5U Series | Easy32x Series | Easy52x Series |
|---|---|---|---|---|---|---|
| CIP service | Implicit message communication | Number of I/O connections at the originator[1] | | 32 | 32 | 32 |
| | | Number of I/O connections at the target end[2] | | 32 | 32 | 32 |
| | | RPI (communication cycle) | | 5 ms to 50000 ms | | |
| | | Bandwidth allowable for implicit (I/O) message communication | (@4 bytes) | 12800 pps[3] | 12800 pps[3] | 12800 pps[3] |
| | | | (@250 bytes) | 6400 pps[3] | 12800 pps[3] | 12800 pps[3] |
| | | | (@500 bytes) | 3200 pps[3] | 12800 pps[3] | 12800 pps[3] |
| | | | (@1400 bytes) | - | 8000 pps[3] | 12800 pps[3] |
| | | Maximum data size per connection[4] | | 500 bytes | 1400 bytes | 1400 bytes |
| | | Multicast filter[5] | | Supported (IGMP client function) | | |
| | Explicit message communication | Number of Class3 tags at the originator[6] | | 32 | 32 | 32 |
| | | Number of Class3 tags at the target end[6] | | 32 | 32 | 32 |
| | | Number of UCMM tags at the initiator[6] | | Number of simultaneous executions: 32 | Number of simultaneous executions: 32 | Number of simultaneous executions: 32 |
| | | Number of UCMM tags at the target end[6] | | Number of simultaneous executions: 32 | Number of simultaneous executions: 32 | Number of simultaneous executions: 32 |

[1] I/O connections at the originator include:

- Consumer tags: Connections requested by the originator with the name of the producer tag as the connection path.
- Originator generic I/O connections: Connections requested by the originator with the instance ID of the generic I/O connections of the target end as the connection path.

[2] I/O connections at the target end include:

- Consumer tags: Responses from the target end to the connection requests with the name of the producer tag as the connection path.
- Target end generic I/O connections: Responses from the target end to connection requests with the instance ID of the generic I/O connections of the target end as the connection path.

[3] pps refers to Packet Per Second. pps is the unit of network throughput rate. Here, it means the sum of the number of grouping packets sent and received that can be processed in one second. It is calculated according to the following formula: Communication bandwidth pps = 1000 ms/RPI x Number of connections x 2.

[4] Data simultaneity within a connection is guaranteed. The device used supports Large Forward Open (CIP option specification) when the data size is greater than 509 bytes.

[5] The EtherNet/IP unit supports the IGMP client function, so the use of an Ethernet switch that supports IGMP Snooping allows filtering out unattended multicast packets.

[6] The number of tags is as follows:

- Initiator tags include the consumer tags, initiator generic I/O connections, Class3 tags at the originator, and UCMM tags at the initiator. The maximum number is 32.
- Target end tags include the producer tags, target end generic I/O connections, Class3 tags at the target end, and UCMM tags at the target end. The maximum number is 32. The maximum number of target end generic I/O connections is 16.

### 10.2.3 Quick Reference Table of EtherNet/IP Solutions

The quick reference table of EtherNet/IP solutions lists typical values generated based on the bandwidth allowable for implicit (I/O) message communication provided in *"10.2.2 EtherNet/IP Communication Specifications" on page 332*. It strictly adheres to the relevant communication bandwidth regulations and is designed to help customers to quickly find a solution. When user requirements do not match the solution quick reference table, the bandwidth allowable for implicit (I/O) message communication provided in *"10.2.2 EtherNet/IP Communication Specifications" on page 332* shall be used as a design constraint.

Table 10–2 Solution quick reference table for the H5U series

| Specification No. | Data Size | Number of Connections | RPI | Communication Bandwidth |
|---|---|---|---|---|
| SPEC.001 | (0,4] bytes | 32 | 5 ms | 12800 pps |
| SPEC.002 | (4,250] bytes | 32 | 10 ms | 6400 pps |
| SPEC.003 | (4,250] bytes | 16 | 5 ms | 6400 pps |
| SPEC.004 | (250,500] bytes | 32 | 20 ms | 3200 pps |
| SPEC.005 | (250,500] bytes | 16 | 10 ms | 3200 pps |
| SPEC.006 | (250,500] bytes | 8 | 5 ms | 3200 pps |

1. You are recommended to set the user program scan cycle to RPI x 2.

2. "(a,b] bytes" means an integer value greater than a but equal to or less than b.

3. When user requirements match the data in the table, but the connection number and scan cycle do not match, balance them to meet the communication bandwidth requirements.

For example, when the data size of user requirement REQ.X does not match the data size of SPEC.Y in the table, REQ.X must meet the following condition:

REQ.X RPI/REQ.X connection number = SPEC.Y RPI/SPEC.Y connection number

Table 10–3 Solution quick reference table for Easy32X

| Specification No. | Data Size | Number of Connections | RPI | Communication Bandwidth |
|---|---|---|---|---|
| SPEC.001 | (0,4] bytes | 32 | 5 ms | 128000 pps |
| SPEC.002 | (4,250] bytes | 32 | 5 ms | 128000 pps |
| SPEC.003 | (250,500] bytes | 32 | 5 ms | 128000 pps |
| SPEC.004 | (500,1400] bytes | 32 | 8 ms | 8000 pps |

1. You are recommended to set the user program scan cycle to RPI x 2.

2. "(a,b] bytes" means an integer value greater than a but equal to or less than b.

3. When user requirements match the data in the table, but the connection number and scan cycle do not match, balance them to meet the communication bandwidth requirements.

For example, when the data size of user requirement REQ.X does not match the data size of SPEC.Y in the table, REQ.X must meet the following condition:

REQ.X RPI/REQ.X connection number = SPEC.Y RPI/SPEC.Y connection number

Table 10–4 Solution quick reference table for Easy52X

| Specification No. | Data Size | Number of Connections | RPI | Communication Bandwidth |
|---|---|---|---|---|
| SPEC.001 | (0,4] bytes | 32 | 5 ms | 128000 pps |
| SPEC.002 | (4,250] bytes | 32 | 5 ms | 128000 pps |
| SPEC.003 | (250,500] bytes | 32 | 5 ms | 128000 pps |
| SPEC.004 | (500,1400] bytes | 32 | 5 ms | 128000 pps |

1. You are recommended to set the user program scan cycle to RPI x 2.

2. "(a,b] bytes" means an integer value greater than a but equal to or less than b.

3. When user requirements match the data in the table, but the connection number and scan cycle do not match, balance them to meet the communication bandwidth requirements.

For example, when the data size of user requirement REQ.X does not match the data size of SPEC.Y in the table, REQ.X must meet the following condition:

REQ.X RPI/REQ.X connection number = SPEC.Y RPI/SPEC.Y connection number

## 10.2.4 EtherNet/IP Solution Selection Example

### Taking REQ.A as an example to describe how to use the solution quick reference table

**User requirement REQ.A**

One H5U connects to 32 EtherNet/IP devices.

The data size of each connection is 500 bytes for both input data and output data.

RPI is 25 ms.

**Solution**

1. Use the data size and connection number of REQ.A as indexes and search for the specification in the "Solution quick reference table for the H5U series" of the section *"10.2.3 Quick Reference Table of EtherNet/IP Solutions" on page 333*. SPEC.004 matches.
2. The scan cycle of REQ.A is 25 ms, greater than 20 ms of SPEC.004. In this case, you do not need to reduce the connection number and the recommended user program scan cycle is 50 ms.
3. Options:
   REQ.A communication bandwidth: 1000 ms/RPI x Connection number x 2 = 1000 ms/25 ms x 32 x 2 = 2560 pps.

The communication bandwidth provided in the "Solution quick reference table for the H5U series" of the section *"10.2.3 Quick Reference Table of EtherNet/IP Solutions" on page 333* is 3200 pps, greater than 2560 pps. Therefore, the solution is appropriate.

### Taking REQ.B as an example to describe how to use the solution quick reference table

**User requirement REQ.B**

One H5U connects to 32 EtherNet/IP devices.

The data size of each connection is 300 bytes for both input data and output data.

RPI is 10 ms.

**Solution 1**

1. Use the data size and connection number of REQ.B as indexes and search for the specification in the "Solution quick reference table for the H5U series" of the section *"10.2.3 Quick Reference Table of EtherNet/IP Solutions" on page 333*. SPEC.004 matches.
2. RPI of REQ.B is 10 ms, less than 20 ms of SPEC.004.
3. Solution: Increase the RPI

RPI of REQ.B must be equal to or greater than 20 ms of SPEC.004. Therefore, you are recommended to set RPI to 20 ms.

**Solution 2**

1. Use the data size and RPI of REQ.B as indexes and search for the specification in the "Solution quick reference table for the H5U series" of the section *"10.2.3 Quick Reference Table of EtherNet/IP Solutions" on page 333*. SPEC.005 matches.
2. The connection number of REQ.B is 32, greater than 16 of SPEC.005.
3. Solution: Reduce the connection number

The connection number of REQ.B must be equal to or less than 16 of SPEC.005. Therefore, you are recommended to set the connection number to 16.

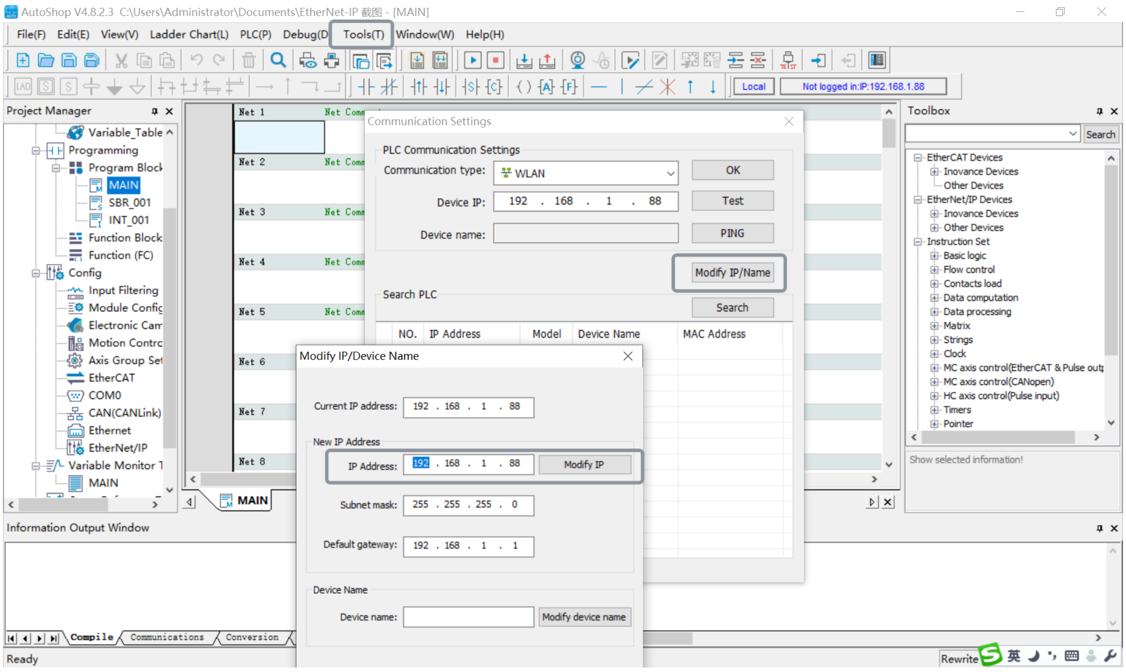
In general, both solution 1 and solution 2 are appropriate for REQ.B after adjustment.

# 10.3 Class 1 Communication

## 10.3.1 Master Configuration

### 10.3.1.1 EtherNet General Settings

1. Log in through the background, connect to the PLC, and configure the PLC gateway, including the IP address, mask, and gateway.

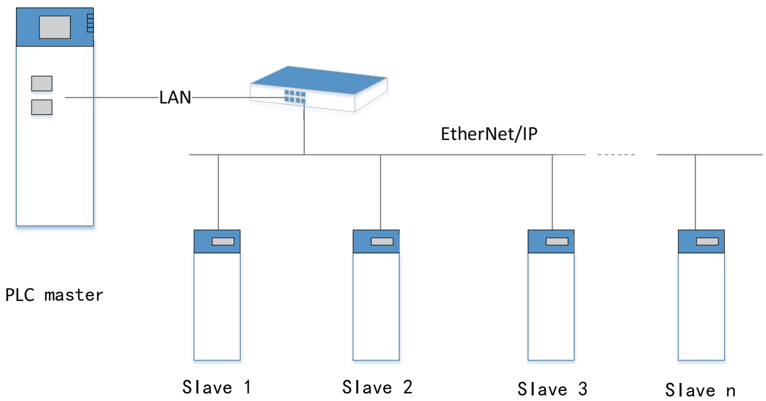


2. In the main menu, choose "Tools" > "Communication Settings".
3. In the "Communication Settings" dialog box displayed, click "Search" to search for PLCs in the current network, select the target PLC, and click "Test" to check whether the PLC can be connected.

### 10.3.1.2 EtherNet/IP Device IP Settings

EtherNet/IP supports bus topology, star topology, and bus-star topology. In a star topology, all nodes are connected to the network hub, and nodes are easily added, deleted, and maintained. Such topology is often used due to its cost-effectiveness, easy connection, and availability of required devices.

IP addresses of all devices must be unique and in the same EtherNet/IP network segment. The following figure shows a star topology.




IP address of the EtherNet/IP master station: 192.168.1.100

IP address of the EtherNet/IP slave station 1: 192.168.1.101

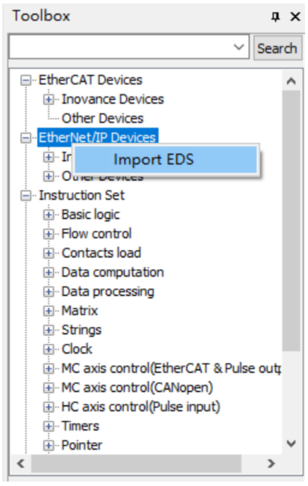
IP address of the EtherNet/IP slave station 2: 192.168.1.102

...

IP address of the EtherNet/IP slave station n: 192.168.1.XXX

#### 10.3.1.3 Adding EtherNet/IP Slaves

1. Import the EDS description file of the slave station.
   Create a master station project. Right-click "EtherNet/IP Devices" under "Toolbox". In the menu displayed, click "Import EDS". In the dialog box displayed, select the EDS file and then click "Open". The following figure takes importing the EDS file of KEYENCE N-L20 EtherNet/IP as an example.




### *Note*

To synchronize with the latest EDS file of a slave when there is any change to the EDS file, expand the "EtherNet/IP" menu, right-click the slave, and select "Update EDS" in the shortcut menu. In this process, select the option that the EDS file exported from the slave overwrites the original file in the directory. See *"10.3.1.4 Exporting EDS Files" on page 338* for details.

2. Create the configuration. You can create a configuration in AutoShop in two ways.
   ①: Locate the device file you want to import, and double-click the file. The device is added to the network configuration. You can add multiple EtherNet/IP slave stations one by one.

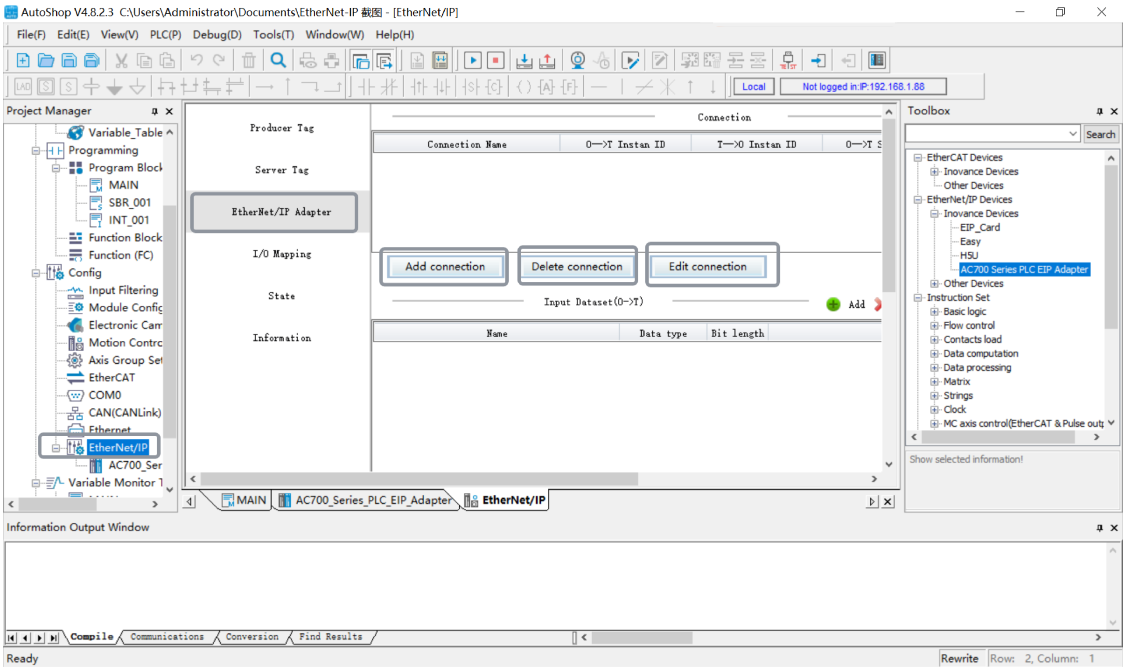
   ②: Scan a device to add it to the configuration. When AutoShop and PLC are connected, you can click "Auto Scan" to scan EtherNet/IP devices connected to the PLC. The procedure is as follows.

   a. Right-click "EtherNet/IP" in the project tree. In the menu displayed, click "Auto Scan".
   b. In the "Auto Scan" dialog box displayed, slave stations configured for the current project are displayed on the left. The names of the slave stations scanned out by the PLC after you click "Auto Scan" are displayed on the right. The slave stations in red are devices for which no matching EDS file is found in AutoShop, while configurations of slave stations in black can be updated.
   c. Click "Update Config". The system asks you to confirm whether to save the current configuration. After you select "Yes", slave stations whose configurations can be updated are added to the current configuration. If you select "No", all EtherNet/IP configurations are deleted and the slave stations whose configurations can be updated are added.

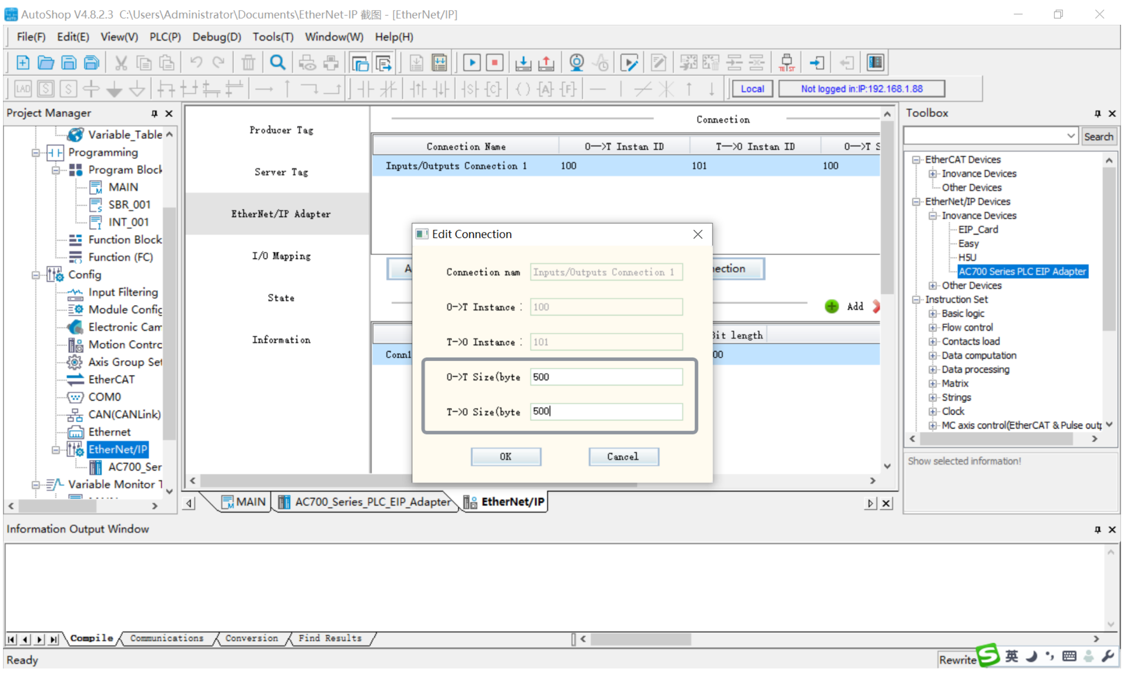
### 10.3.1.4 Exporting EDS Files

The way to export EDS files is basically the same for Easy and H5U. The main difference is that Easy supports a maximum of 1400 bytes while H5U supports a maximum of 500 bytes.

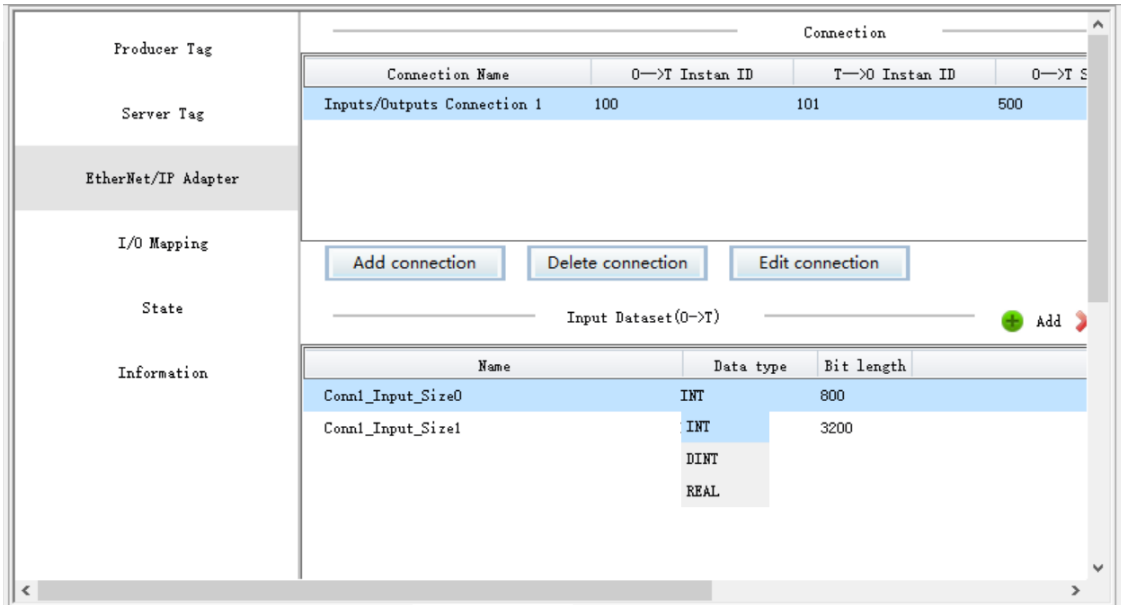
1. Double-click "EtherNet/IP", and then select "EIP Adapter". On the EIP slave station page displayed, you can add or delete connections (up to 16 connections are supported), as shown in the following figure.



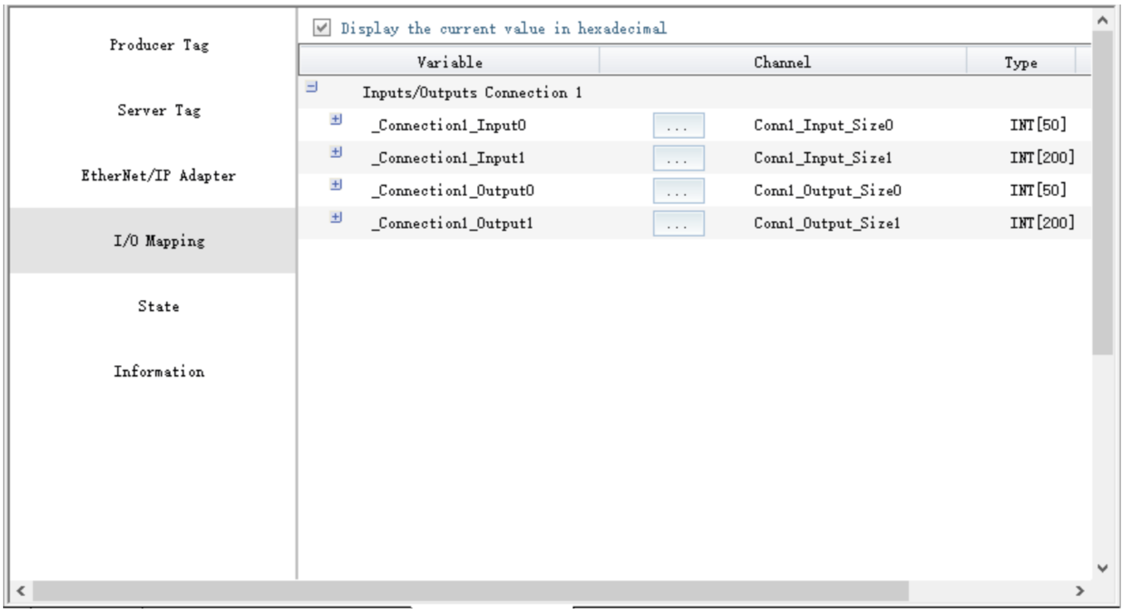
2. Click "Edit connection" to edit the O->T and T->O sizes for connections. The default value is 500 bytes.



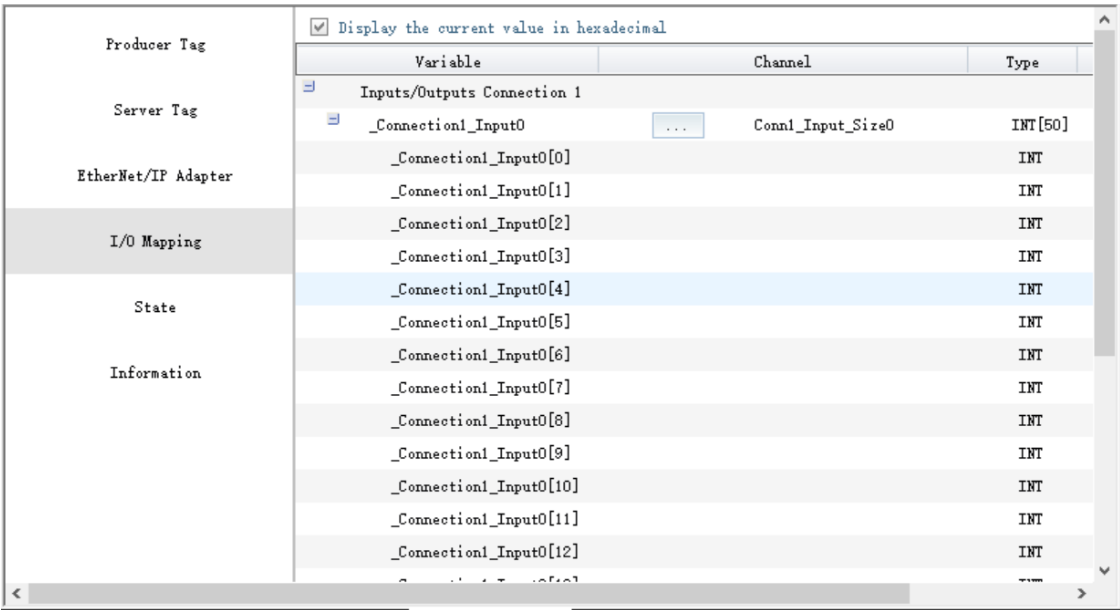
3. You can also split the size of bytes according to the data set of O->T and T->O, and split the total bytes into multiple variables of the required byte size for mapping. You can add or delete a data set to adjust the byte size, or move a data set up or down.



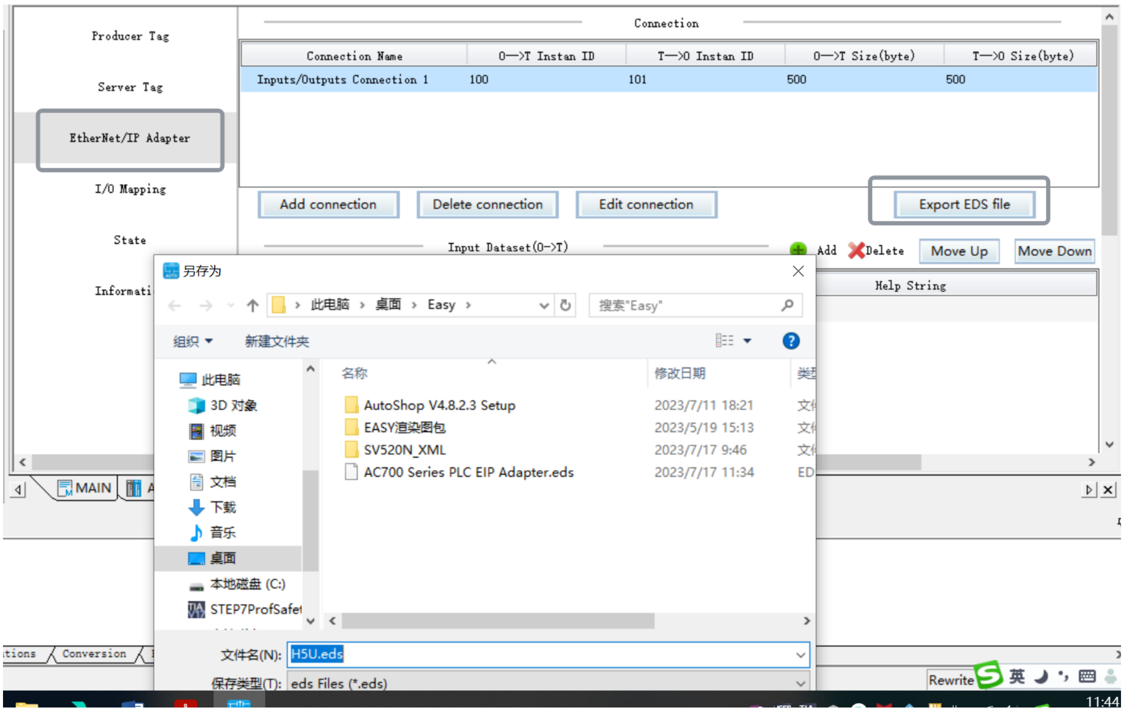

4. Split bytes will generate multiple corresponding variable which can be viewed on the "IO Mapping" page. The corresponding bytes will generate the corresponding variable numbers, and the byte size will be that of the connection.



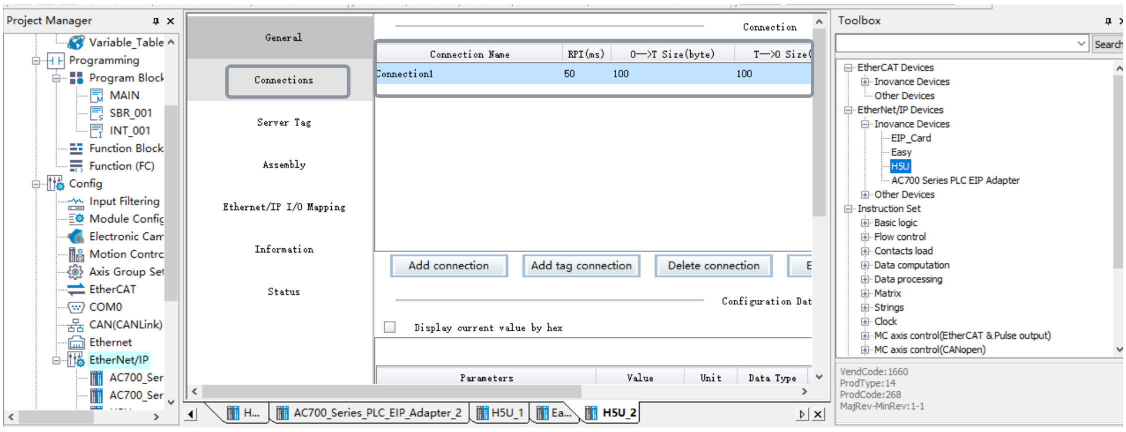

5. You can expand and view an array.



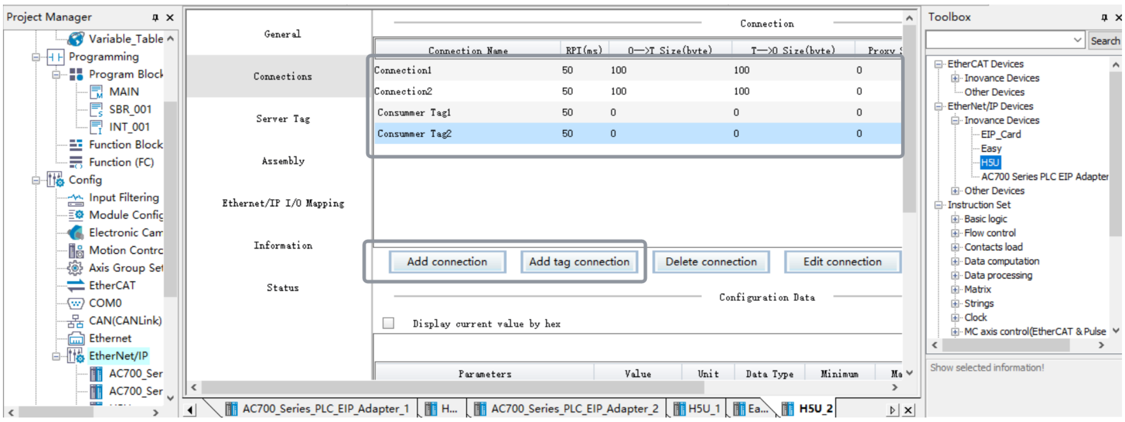
6. Select parameters, switch to the "EtherNet/IP" page, and click "Export EDS file" to export the EDS file to any folder.



7. To import the exported EDS file to the background, choose "EtherNet/IP Devices" under "Toolbox", and double-click the H5U.eds file. On the following page displayed, select the I/O connection from the drop-down list of "Connection name"。



8. You can click "Add connection" or "Add label connection" to add the required connection. "Add connection" is used to add an I/O connection while "Add label connection" is used to add a consumer connection.

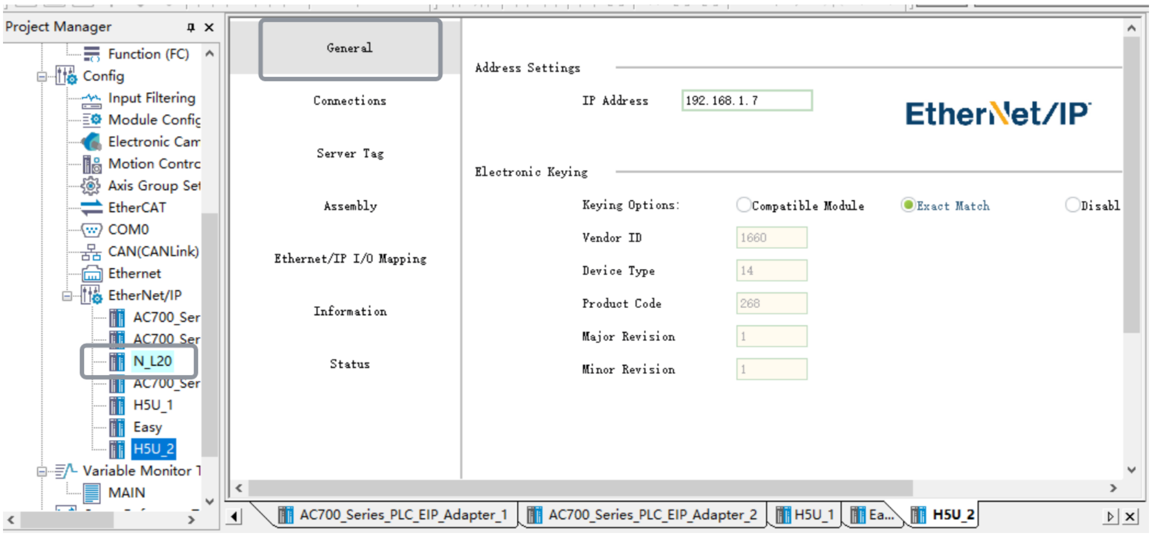


## 10.3.2 Slave Configuration

### 10.3.2.1 General Settings

**Modifying the configuration of a single slave station**

Double-click the EtherNet/IP slave station "N-L20" you want to set. On the page displayed, set the IP address and matching options for the slave station.




Electronic match: The EtherNet/IP master station checks whether the following fields of the EtherNet/IP slave station match those in the EDS file: supplier code, device type, product code, major version, and minor version. The following table lists the matching options.

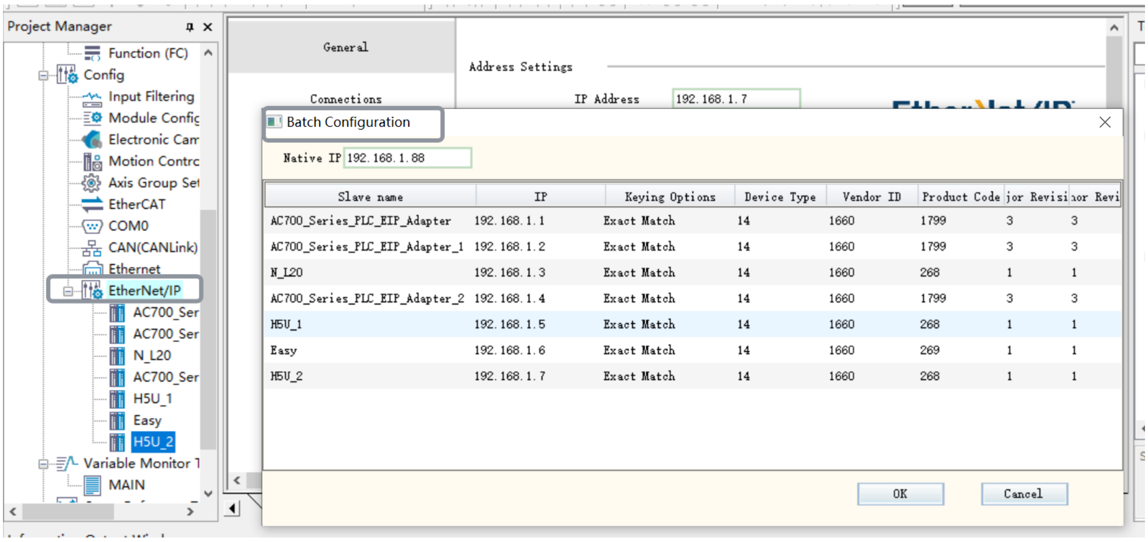
| Parameter Name | Description |
|---|---|
| Compatible Module | Conditional matching. The communication is established only when the supplier code, device type, and product code are identical and the major version and minor version of the slave station are equal to or later than those in the EDS file (the version of the slave station is equal to or later than the version in the EDS file, and the slave station is compatible with EDS files of earlier versions). |
| Exact Match | Communication can be established between EtherNet/IP master and slave stations only when all of such fields are exactly matched. |
| Stop check[1] | Communication is directly established between EtherNet/IP master and slave stations without checking whether such fields are matched. |

Warning

[1]: Exercise special caution when selecting "Stop check". Improper use of this option may cause physical injury, property damage, or economic loss. It is strongly advised against using the "Stop check" option.

### Modifying configurations of multiple slave stations

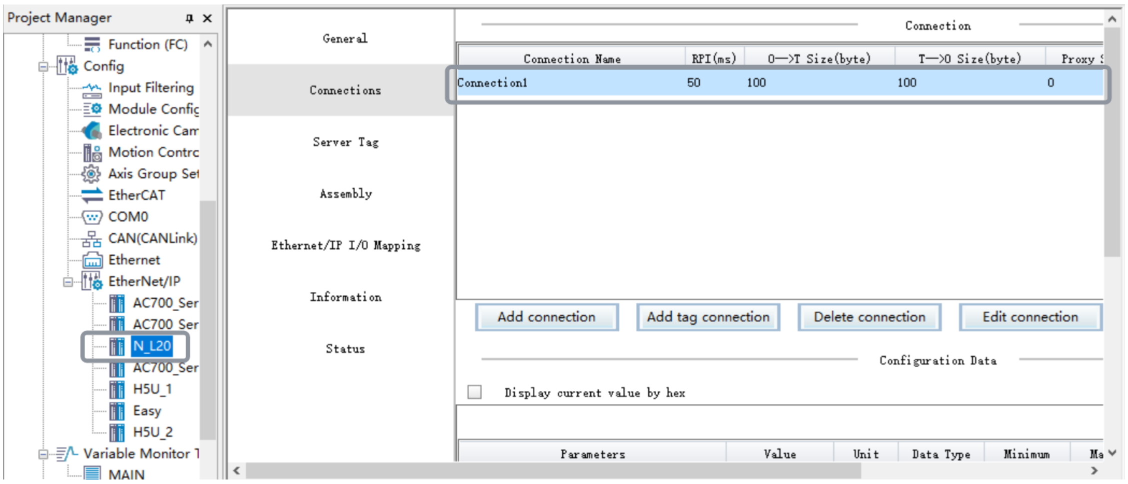
When multiple slave stations are configured, right-click "EtherNet/IP" in the "Project Manager" section. In the menu displayed, select "Batch Configuration". In the "Batch Configuration" dialog box, modify the IP addresses and matching options of slave stations in a batch.



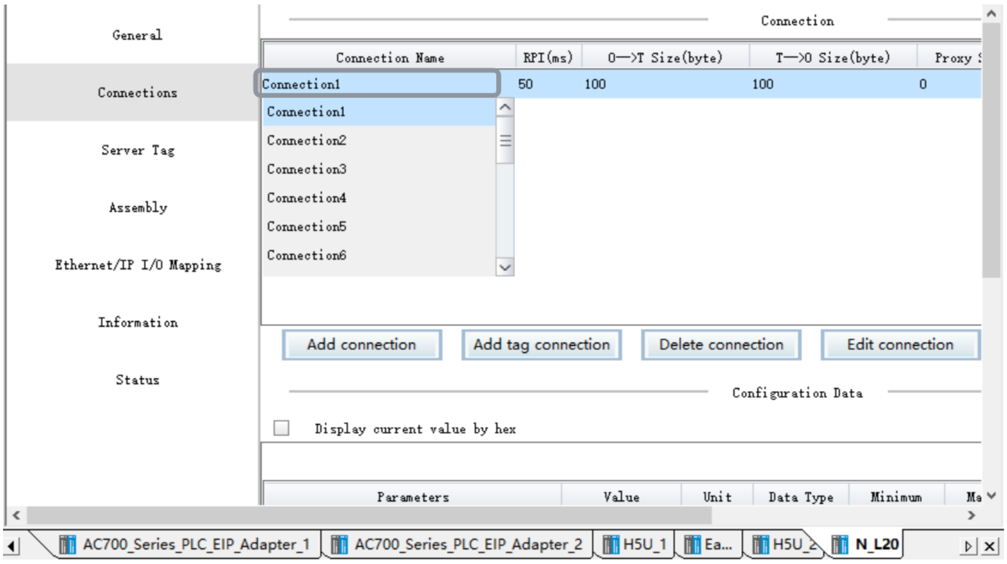
#### 10.3.2.2 Connection Settings

1. Add a connection.

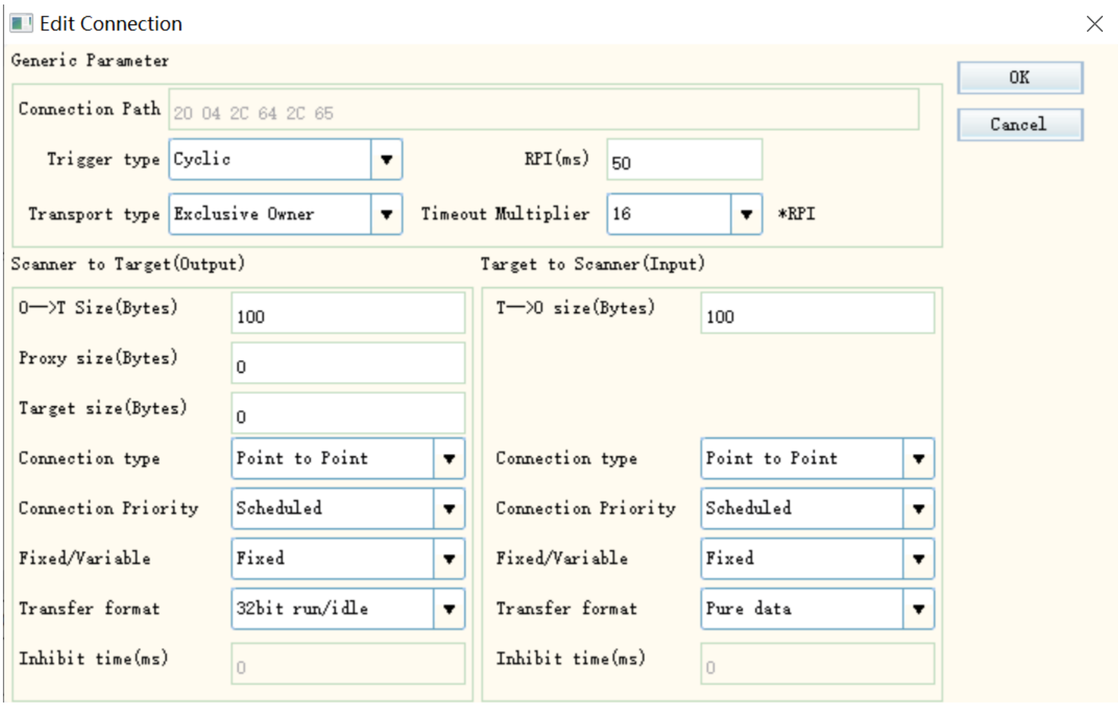
   The EDS description file of an EtherNet/IP slave station contains a default connection path. After the EtherNet/IP network configuration is added, the background connection page loads the default connection path, as shown in the following figure.



   You can also click the connection name and set the connection path pre-defined in the EDS file, as shown in the following figure.




On the preceding page, click "Edit connection" to enter the connection setting page. Generally, all parameters other than RPI (communication cycle) of the connection must use the default values.




2. Configure the general parameters.

- Connection path: Specifies the format and connection instance of a byte stream frame.
  For example, 20 04 2C C6 2C 68 (for details, see EIP-CIP-V1-1.0, Appendix C: Data Management).

  20: Logical Segment, ClassID, 8-bit logical address

  04: Assembly Object (04H)

  2C: Logical Segment, Connection Point, 8-bit logical address

  C6: ID-C6H of the Assembly Object instance

  2C: Logical Segment, Connection Point, 8-bit logical address

  68: ID-68H of the Assembly Object instance

Note: The connection path must be configured based on the guide of the specific slave station. The connection path varies with the manufacturer.

- RPI (MS): Requested Packet Interval. It indicates the communication transmission interval in ms. The RPI of each node can be set individually without affecting each other.

3. Scan the target.

- Transmission byte size
  1) O->T Size (Bytes): Indicates the amount of data transferred from the producer (scanner) to the consumer (target device), in bytes.

  2) T->O Size (Bytes): Indicates the amount of data transferred from the consumer (target device) to the producer (scanner), in bytes.

- Transport Type
  Exclusive Owner: Allows users to set both data sending from the initiator to the target device and data receiving from the target device to the initiator.

  Redundant Owner: Allows multiple initiators to create independent and identical connections to the same target device.

  Input Only: This connection can only be used to set data receiving from the target device to the initiator.

  Listen Only: EtherNet/IP devices apply this type of connections to listen to multicast data without providing configuration or scheduling information.

- Trigger Type
  Cyclic: Periodically triggers data transmission.

  Change-Of-State: Transmits data when a change in the state of the application object is detected.

  Application Object: Transmits data when the application object is triggered.

- Connection Type
  Multicast: Multiple scanners receive data from one target device at the same time.

  Point-to-Point: One scanner can receive data from only one target device.

---

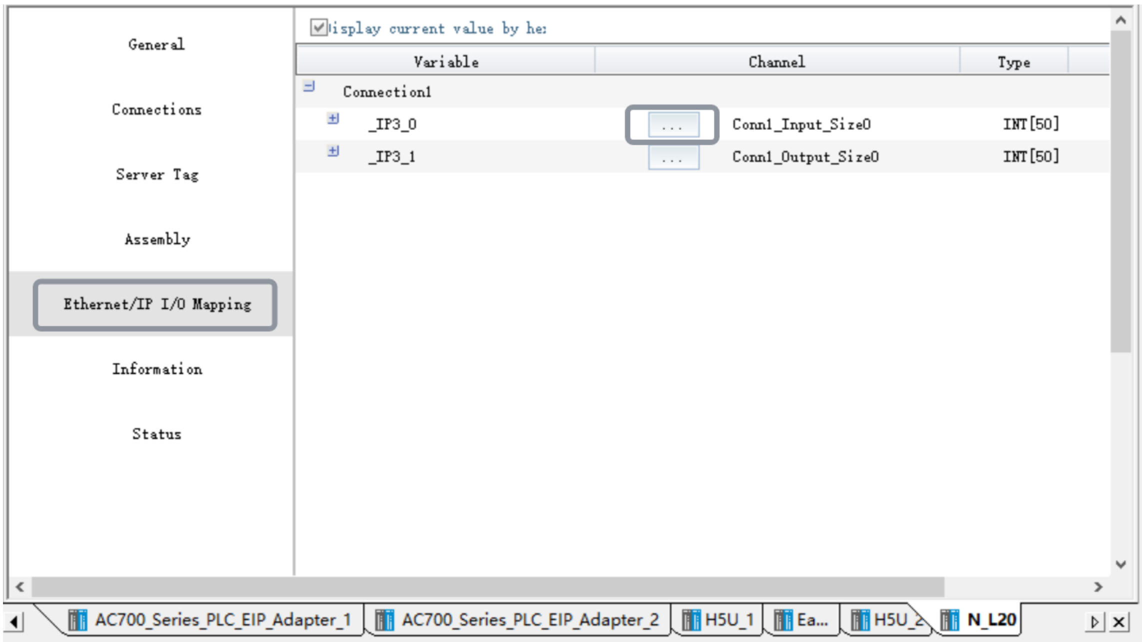
***Note***

Click "Add connection" to open the connection setting interface and select "Universal connection" to customize a connection as needed. This requires knowledge of the CIP protocol. For users without such knowledge, it is recommended to use the default connection configuration.

---

#### 10.3.2.3 Configuring I/O Variable Mapping

You can expand an array when modifying a variable mapping. For example, to create a connection, of which the O->T size of the consumer tag is 10 bytes, the number of server tags is 5, and _IP2_0 and _IP2_1 are variables of the default mapping, click "..." and input the variables at the variable name position to modify the mapping.




Only three data types are displayed: INT, DINT, and RAL. If you have modified the data type of the consumer tag through the data set, the data type is converted to any of these three types. The correspondence is as follows.

INT: BYTE, INT, UINT, SINT, and USINT are all displayed as INT.

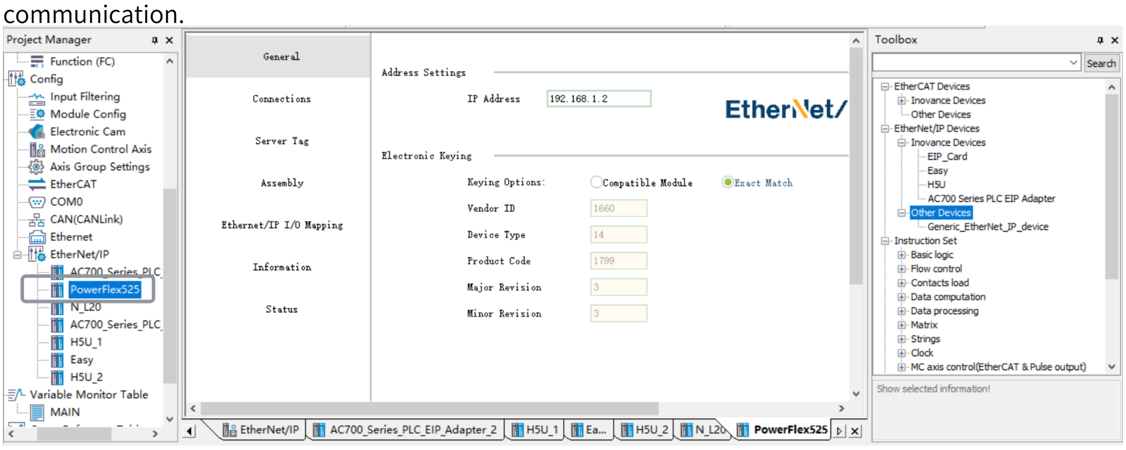
DINT: DINT, UDINT, LINT, ULINT, LWORD, DWORD, and WORD are all displayed as DINT.

REAL: REAL and LREAL are displayed as REAL.

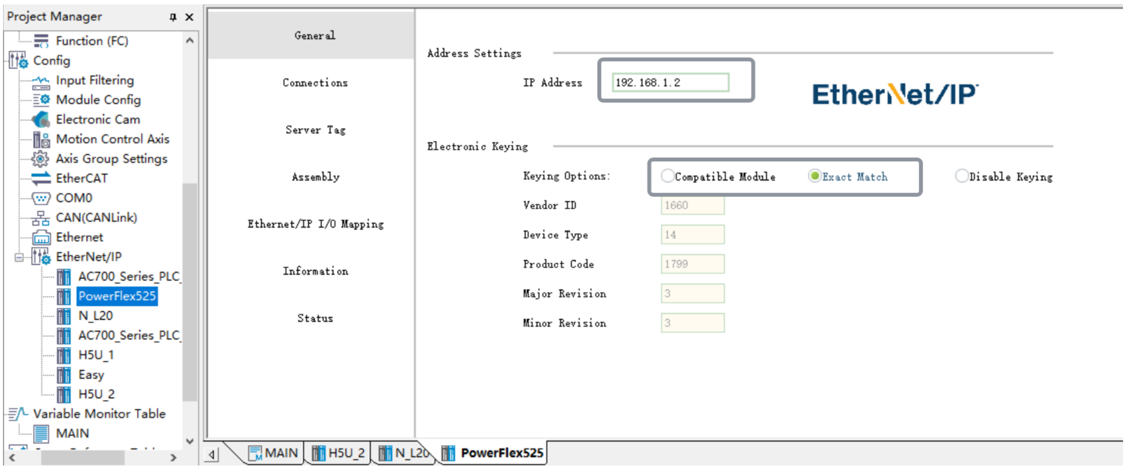
## 10.3.3 EtherNet/IP Master Application Example

This project describes how to create an EtherNet/IP network in which H5U serves as the master station. In this example, the slave station is the Tockwell PowerFlex 525 AC drive.

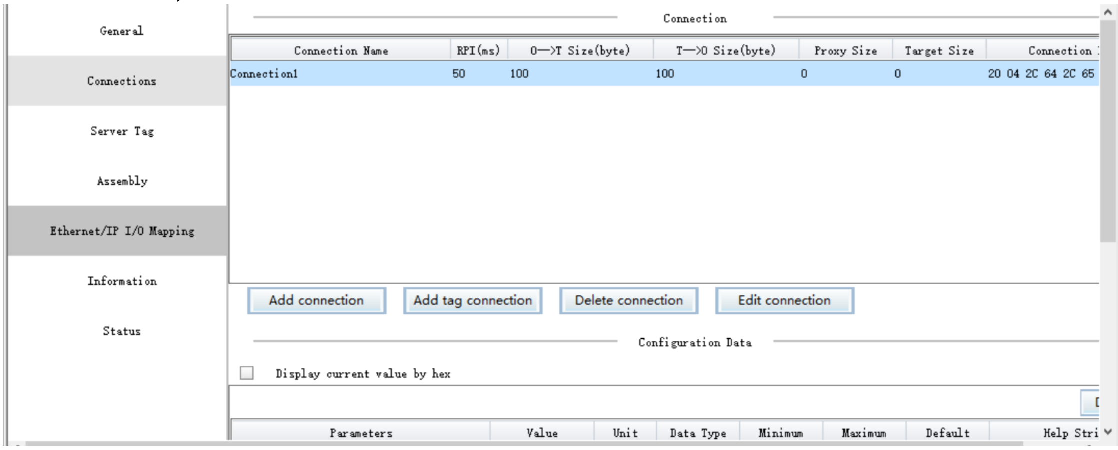
1. Under "EtherNet/IP Devices" of "Toolbox", select the corresponding slave station for I/O communication.




2. Set the IP address of the slave station you want to connect.




3. Set the connection parameters. The PowerFlex 525 AC drive supports only the default connection and therefore only one connection is listed under "Connection name". You can directly change the RPI. In this case, RPI is 50 ms and cannot be modified.

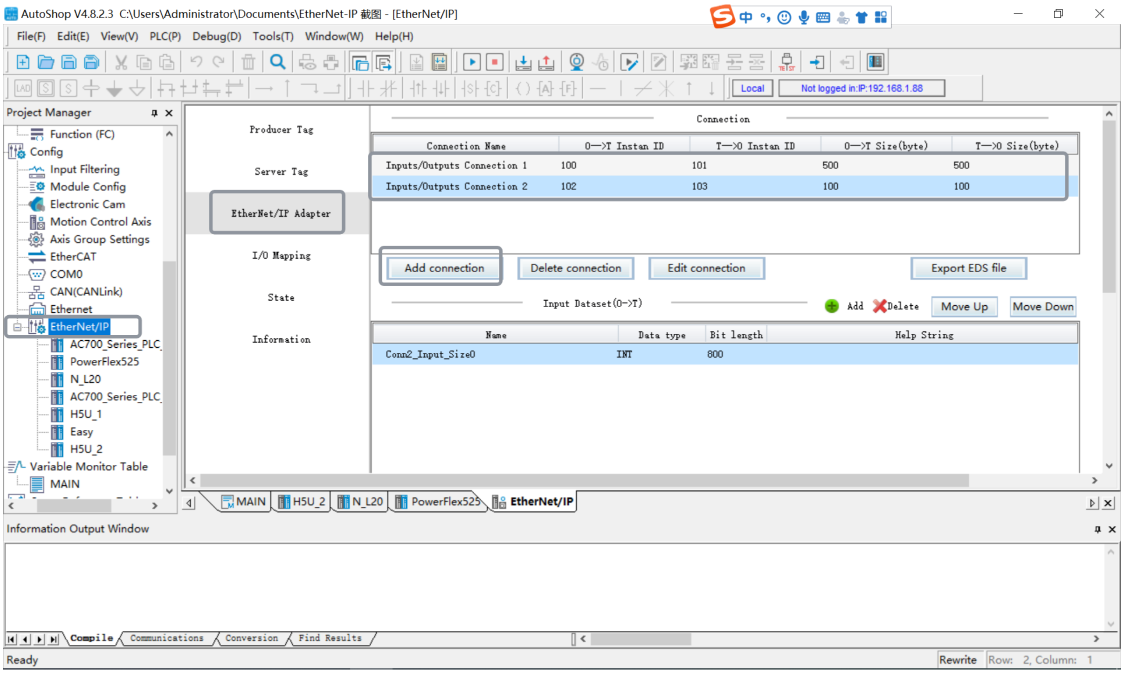



4. After making the configuration, download the program, run the PLC, and monitor the communication status.

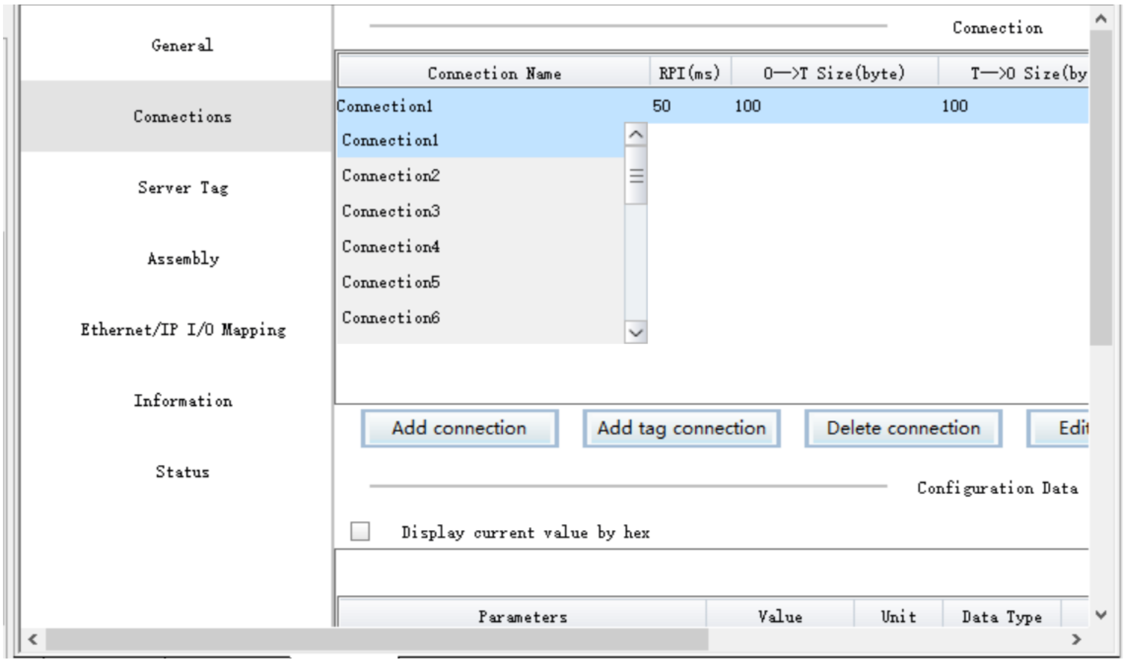
The communication details can be viewed on the status page.

## 10.3.4 EtherNet/IP Slave Application Example

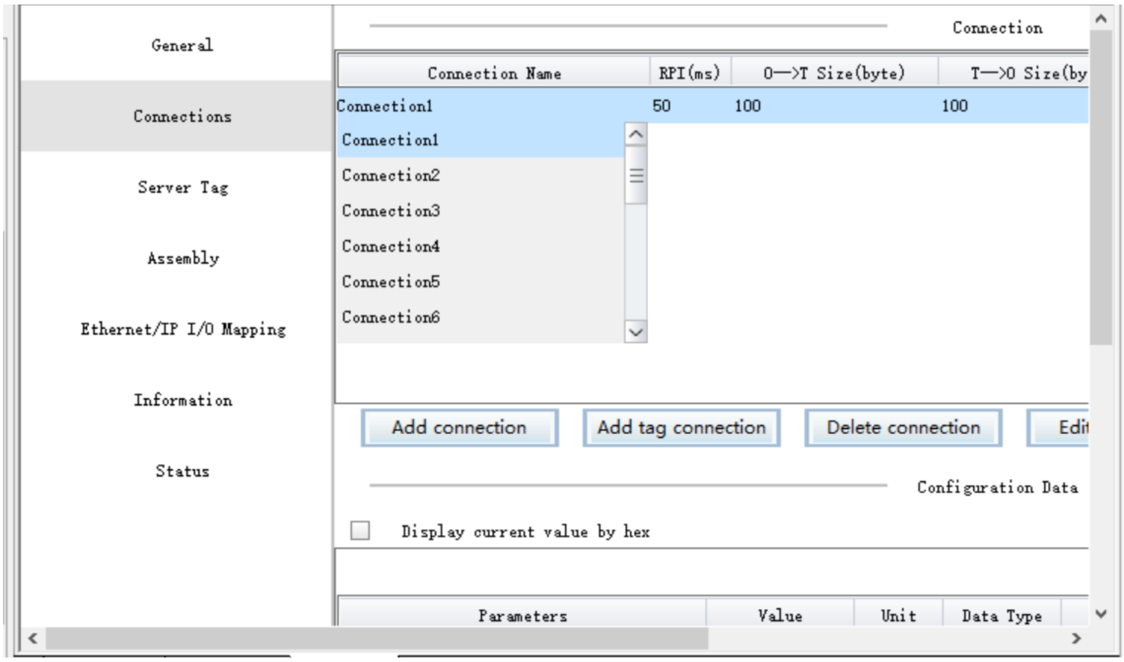
1. Add two connections, and modify their O->T size to 100 bytes and T->O size to 100 bytes. Export the EDS file, set the IP address of the connected PLC to 10.45.124.150, compile the project, and then download and run the project.



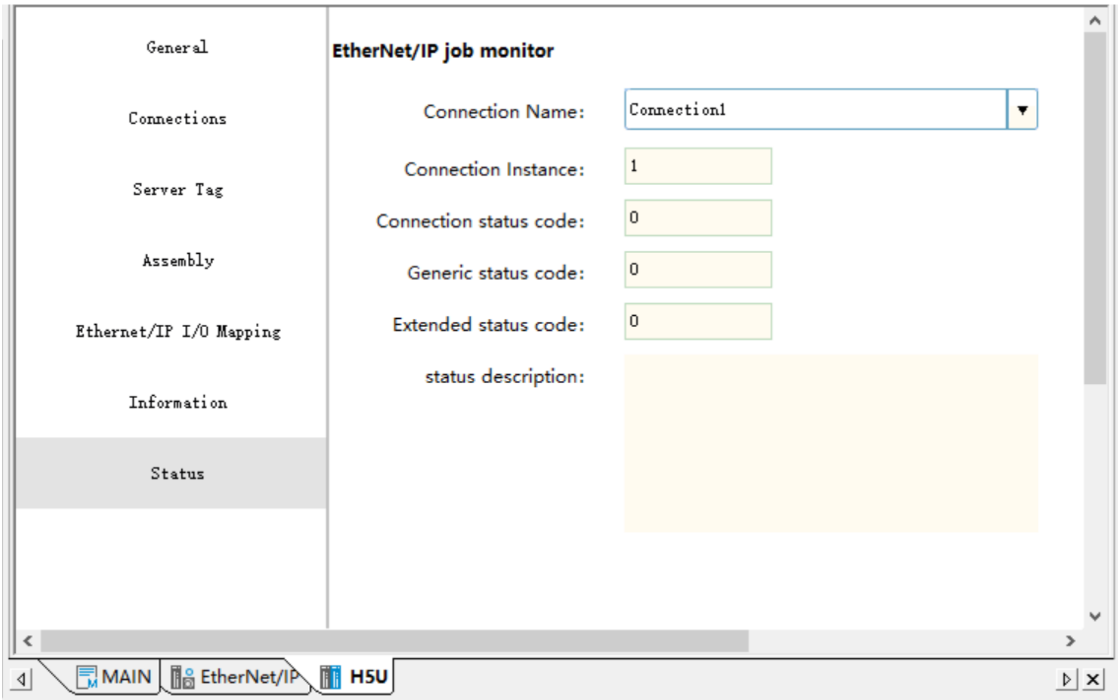
2. Import the exported EDS file. Double-click "H5U" under "EtherNet/IP" in the "Toolbox" section, add a slave station, and set the IP address of the connected PLC to 10.45.124.77.



3. After the file is imported, "Connection1" is selected by default, whose O->T and T->O sizes are those you set when creating the connection.
   You can click "Add connection" to add a custom I/O connection or click "Add label connection" to add a consumer tag connection. You can click "Connection name" to unfold the drop-down list which displays connections defined in the EDS file. You can switch, edit, and delete connections in the drop-down list.




4. On the "General" tab page, set the IP address to 10.45.124.150, and then export and run the project.




5. If a green icon is displayed for the H5U node in the project tree, the node is connected. On the status page on which the connection status of "Connection1" is successful.

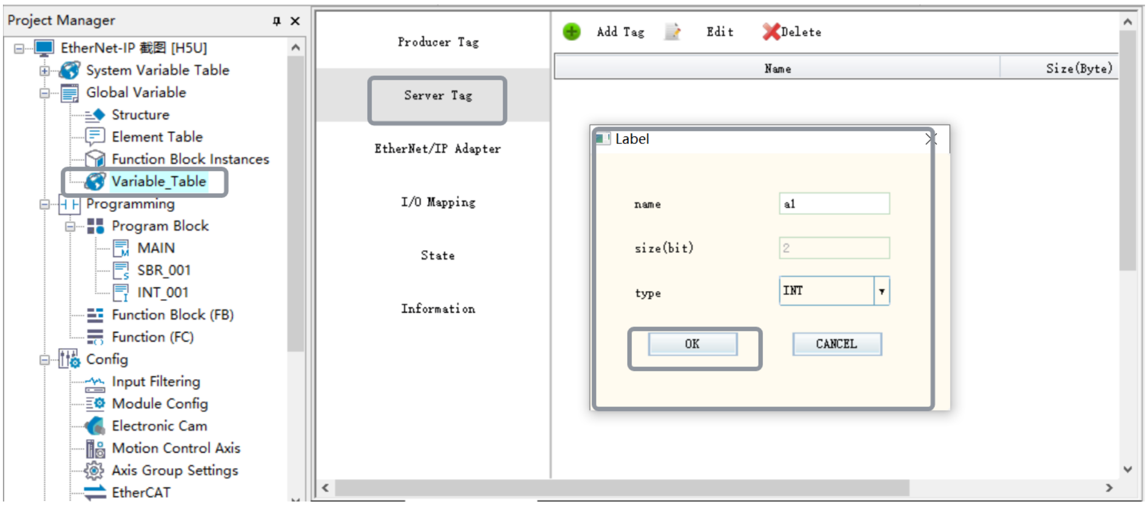
## 10.3.5 Tag Communication

### 10.3.5.1 Configuring Producer Tag Data

**Configuring the producer tag data on the "Producer label" page**

1. In the "Project Manager" section, unfold "Config", and double-click "EtherNet/IP" to open the "Producer label" page. Supported producer tag types are INT, DINT, REAL, and array.
2. To create a producer tag, create a variable in the variable table. On the "Producer label" page, click "Add label", input the created variable, and then click "OK".

For data of the type INT, DINT, or REAL, you can input a name to create a tag on the "Producer label" page. Then, AutoShop automatically displays the variable creation dialog box, on which you can create the variable, as shown in the following figure.




**Directly configuring the producer tag data in the variable table**

In the variable table, modify the "Network Public" property of the variable to "IN/OUT". Then, the variable is configured as a producer tag.

### 10.3.5.2 EtherNet/IP Consumer Tag Connection

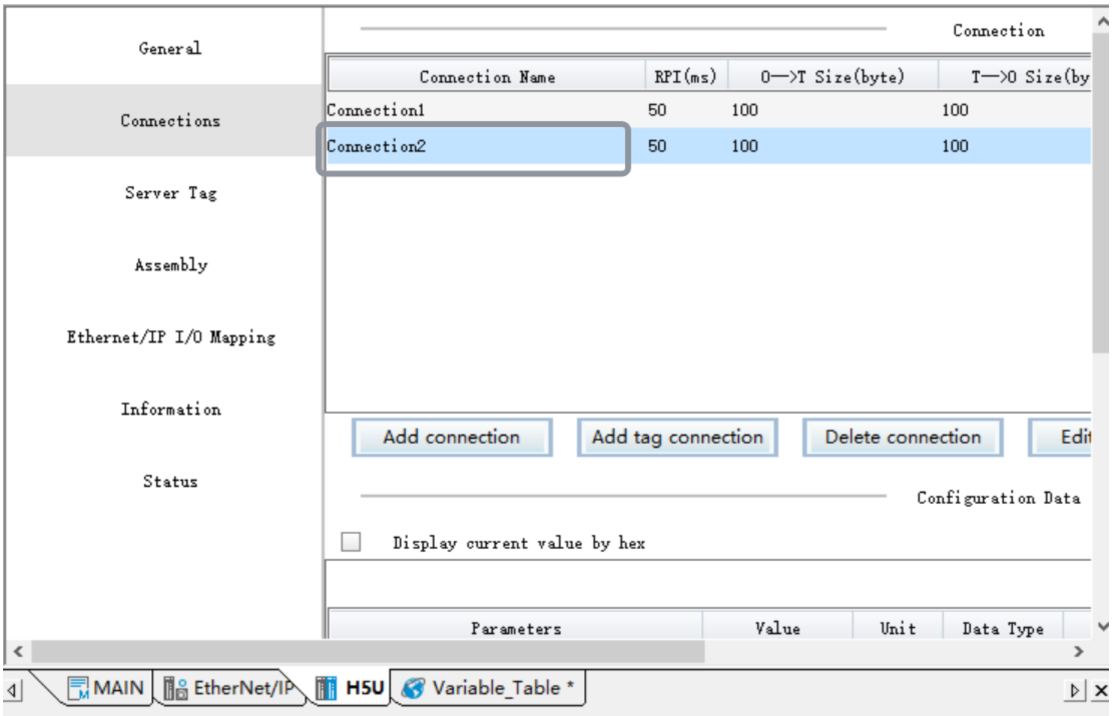
## Configuring an EtherNet/IP consumer tag connection

***Note***

Before configuring a consumer or producer, add a slave and select a tag from the slave.

Take the EDS file of the Inovance slave station as an example. In the toolbox, import the AM600_400 Series PLC EIP Adapter.eds file, add the configuration, modify the IP address, and then access the "Connection" page, on which a connection is loaded from the EDS file by default.

If the connection is a consumer tag connection, the "Add connection" button is activated and can be used to add a custom consumer tag connection. You can also click "Edit connection" to modify the RPI, T->O size, and connection path, wherein the connection path is the consumer tag name.

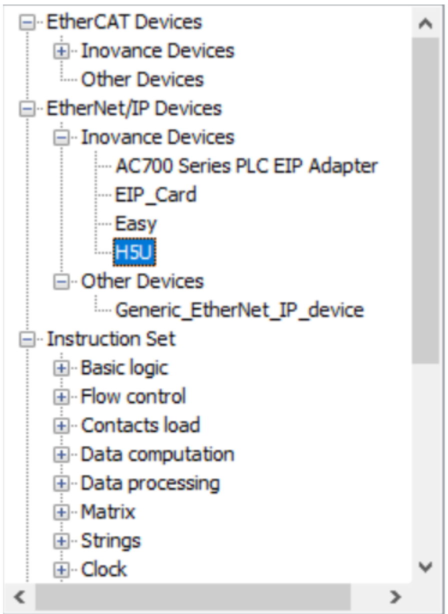



## Methods for adding a slave station

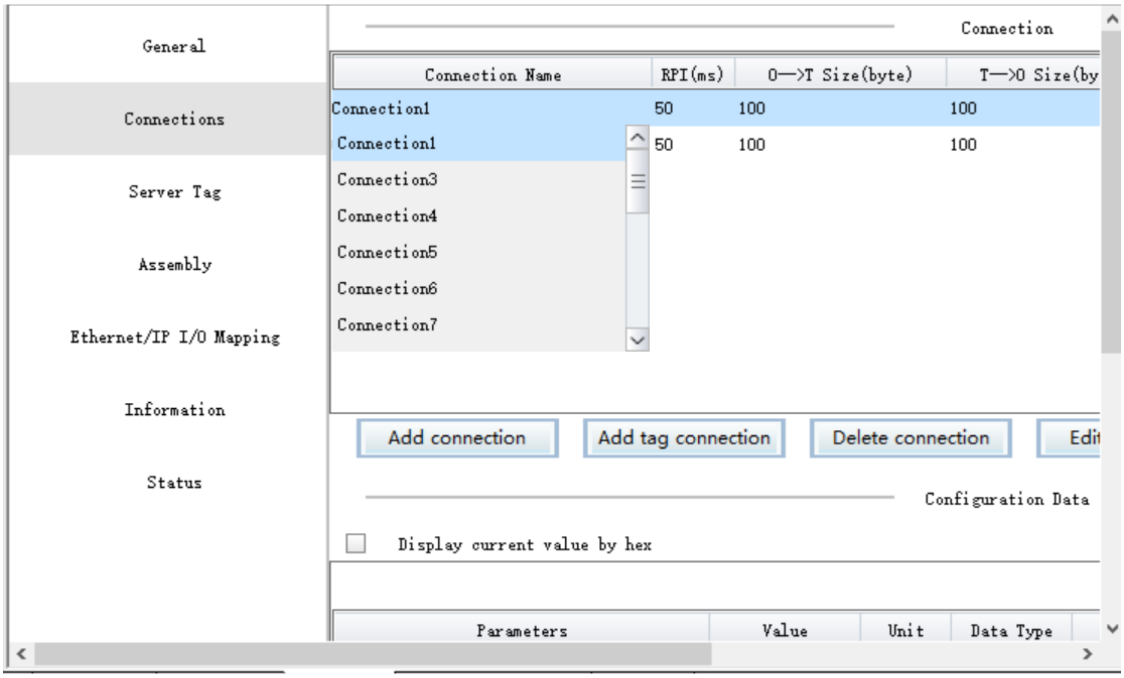
### 1. Import the EDS file

The following describes how to add a slave station by taking the EDS file of the Inovance slave station as an example.

1. Right-click "EtherNet/IP Devices" in the "Toolbox" section, click "Import EDS file", and select the corresponding EDS file.
2. After the EDS file is imported, double-click the EDS file, and add the slave station corresponding to EIP.

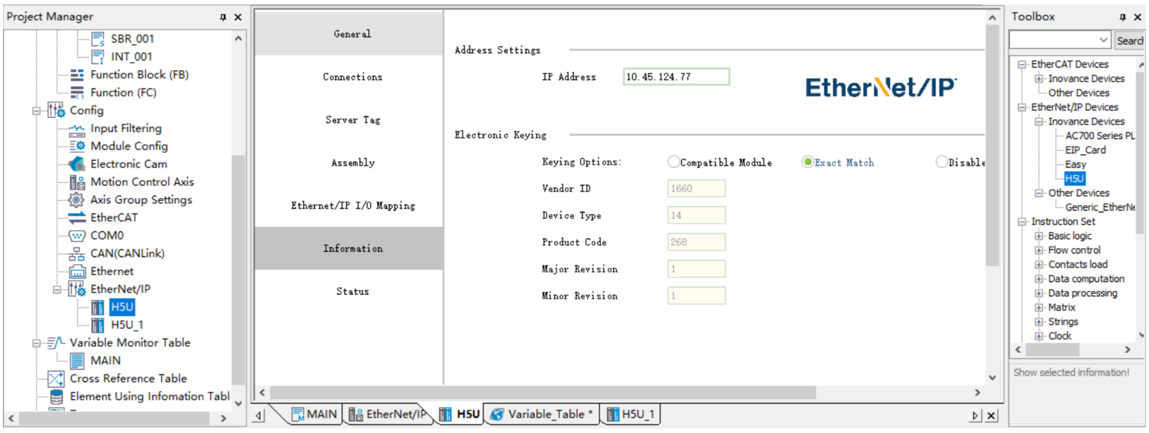



3. Select "Connection" and click the corresponding connection.



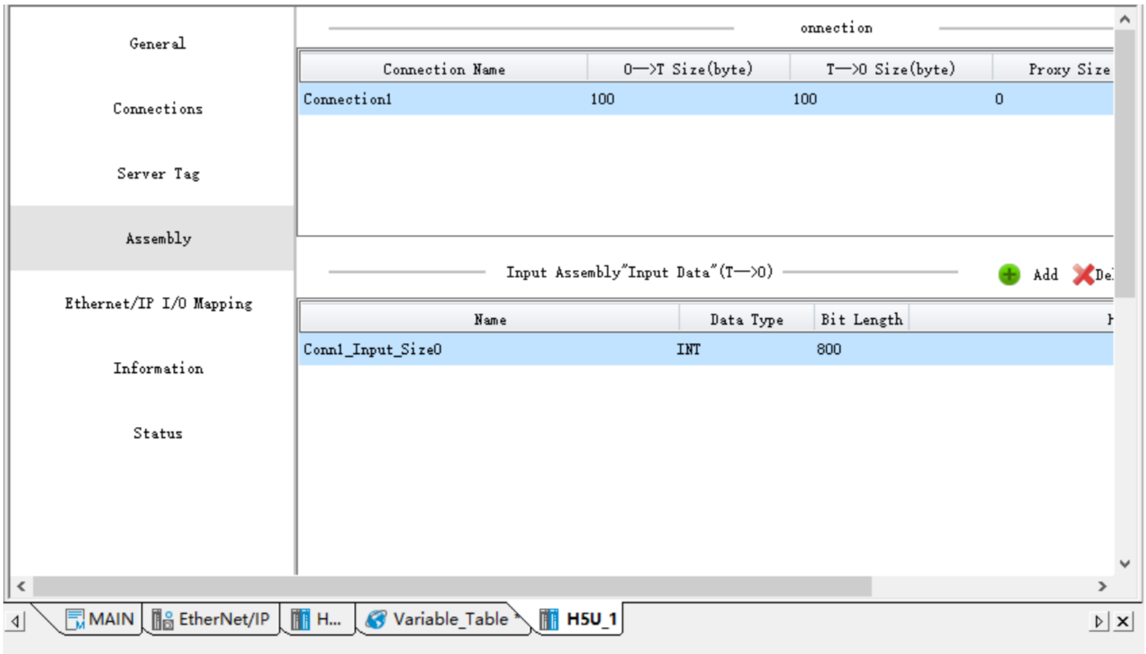

**2. Use the generic template Generic_EtherNet_IP_device**

When no EDS file is provided for third-party device tag communication or the product ID of the current device does not match that in the EDS file, you can add this device and manually configure the device. On the "General setting" page, set all items of electronic matching to 0 and select "Stop check", as shown in the following figure.




### 10.3.5.3 Setting Tag Data Set

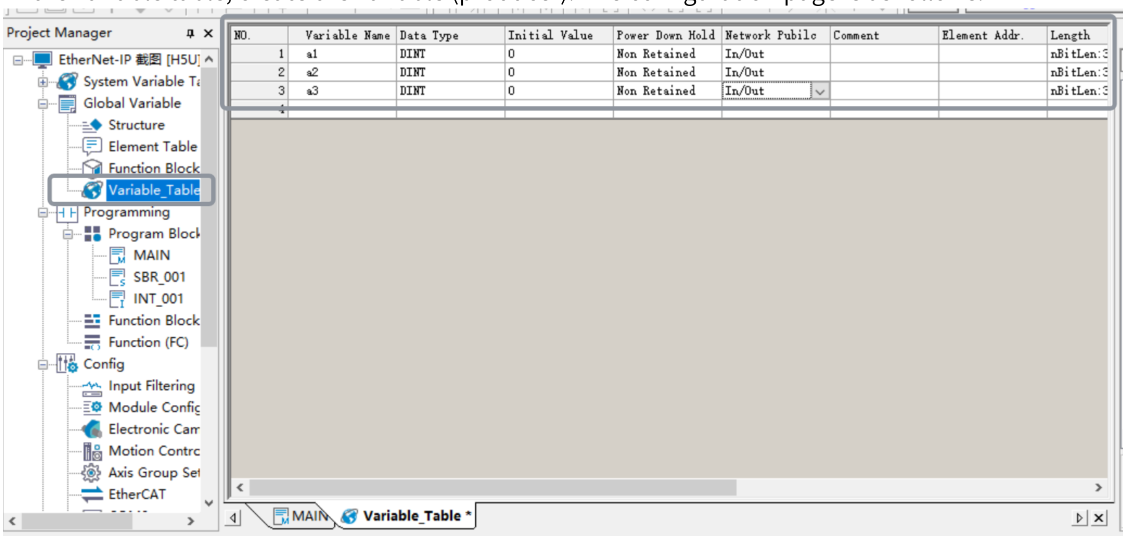
In the data area of tag communication, the parameter data types can be classified based on the T->O size. You can combine structure variable members to generate the corresponding I/O mapping.




## 10.3.6 Tag Communication Example

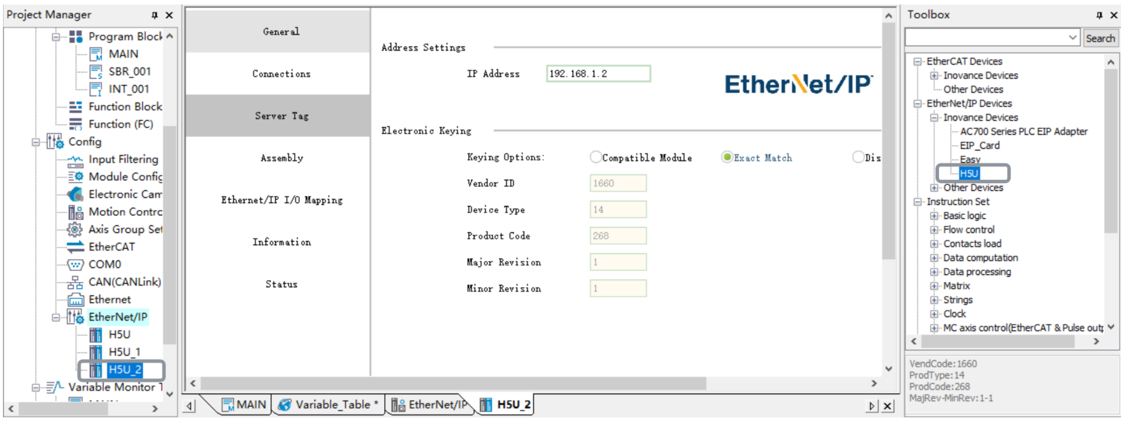
The following takes the example of one H5U consuming tags a1, a2, and a3 created by another H5U to describe how to make the configuration.

1. In the variable table, create the variable (producer). The configuration page is as follows.

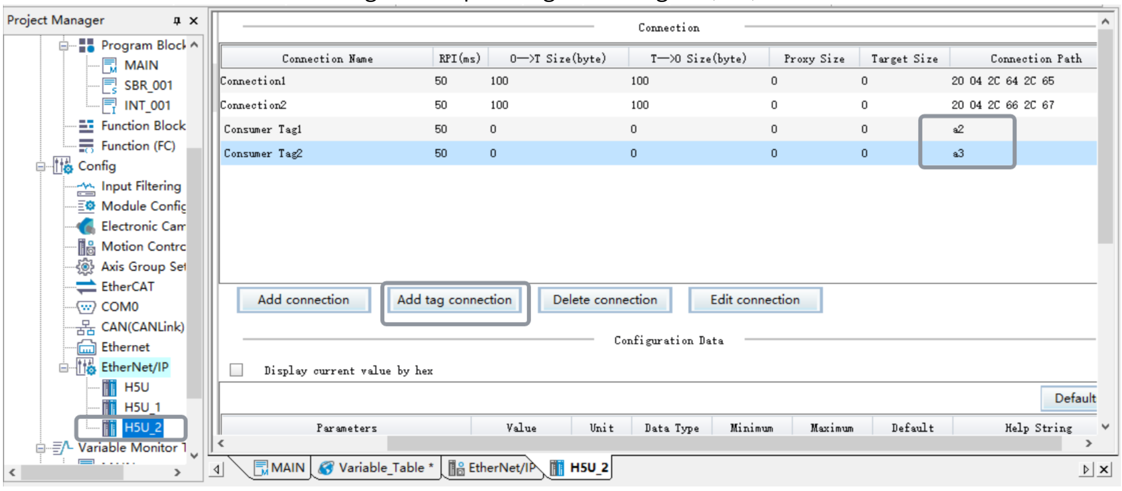



2. Associate the variable with the tag (producer).

3. Access the configuration page (consumer).




4. Add connections to consumer tags corresponding to the tags a1, a2, and a3 of H5U.




After configuration, download the projects to the PLC to monitor their communication states.

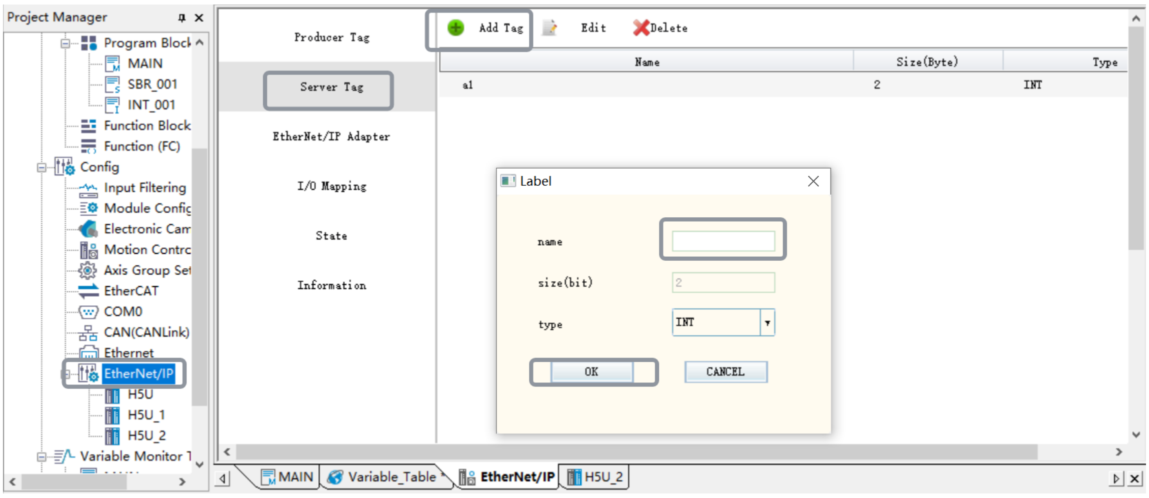
# 10.4 Service Message Tag Communication

## 10.4.1 Configuring Service Message Tags on Server

**Configuration on the "Service message label" page**

1. In the "Project Manager" section, unfold "Config", and double-click "EtherNet/IP" to open the "Service message label" page. Data types supported by service message tags are INT, DINT, REAL, and array.
2. To create a service message tag, you can create a variable in the variable table. On the "Service message label" page, click "Add label", input the created variable, and then click "OK".

You can also click "Add label" and input a name to create a tag on the "Service message label" page. Then, AutoShop automatically displays the variable creation dialog box, as shown in the following figure. (*If you modify the variable of a created server tag in the variable table, an error is reported when you compile the variable directly. In this case, you can click "Edit" to refresh the data type of the variable associated with the tag.*)




**Directly configuring the tag in the variable table**

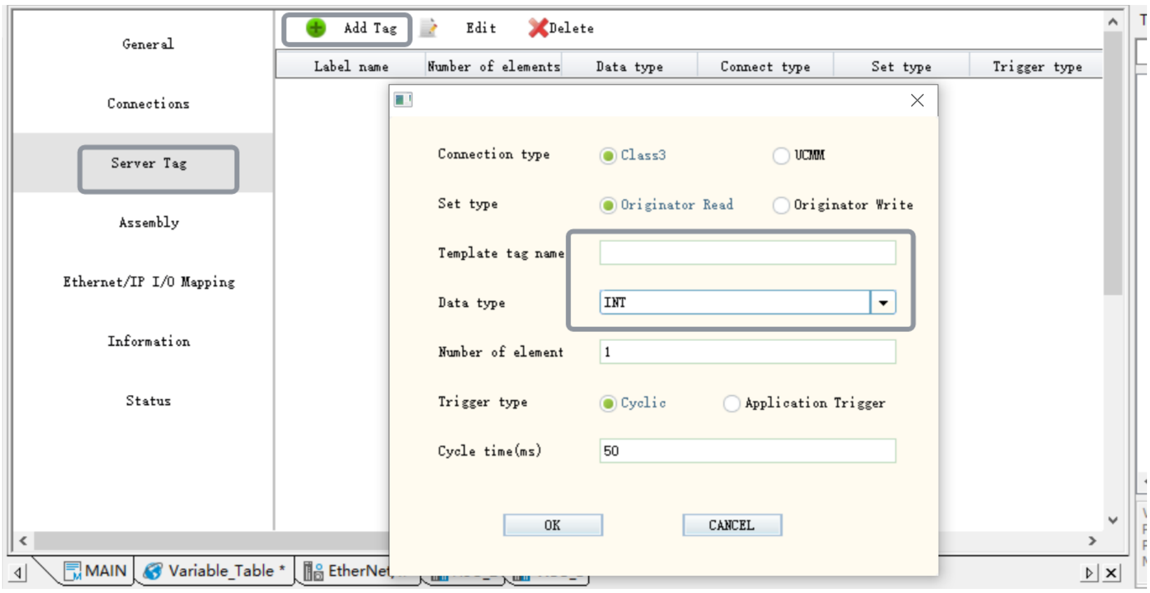
In the variable table, modify the "Network Public" property of the variable to "Public". Then, the variable is configured as a service message tag.

| NO. | Variable Name | Data Type | Initial Value | Power Down Hold | Network Public | Comment | Element Addr. | Length |
|---|---|---|---|---|---|---|---|---|
| 1 | a1 | DINT | 0 | Non Retained | Public | | | nBitLen:32 |
| 2 | a2 | DINT | 0 | Non Retained | In/Out | | | nBitLen:32 |
| 3 | a3 | DINT | 0 | Non Retained | In/Out | | | nBitLen:32 |
| 4 | | | | | | | | |

## 10.4.2 Configuring Service Message Tags on Client

The following takes service message tag communication between Inovance H5Us as an example to describe how to configure service message tags.

1. In the "Toolbox" section, double-click the EDS file of H5U, add the configuration, modify the IP address, and access the "Service message label" page.
2. Click "Add label", and specify the name and data size of the service message tag you want to request, that is, the response service message tag created by the peer device to be connected.



You can click "Edit" to modify an added service message tag or double-click a tag in the list to edit the tag.

You can click "Delete" to delete an added service message tag.

The following section describes terms on the page of adding service message tag configuration.

- **Connection type**

  ① Class3 means a CIP connection is required for communication, that is, a connection-type tag communication.

  ② UCMM means a CIP connection is not required for communication, that is, connection-free tag communication.

- **Setting type**

  ① Originator Read means reading the data of the target tag.

  ② Originator Write means writing data to the target tag.

- **Target label name**: Indicates the name of the service message tag created by the requested device. The sum of the tag name size and the data size cannot exceed 487 bytes.
- **Data type**: Indicates the data type of the requested service message tag. Supported data types are INT, DINT, and REAL.
- **Element number**: Indicates the number of arrays of the requested service message tag. When the number of elements is N (N is greater than 1), an array whose size is N and type is basic data is created.
- **Trigger type**

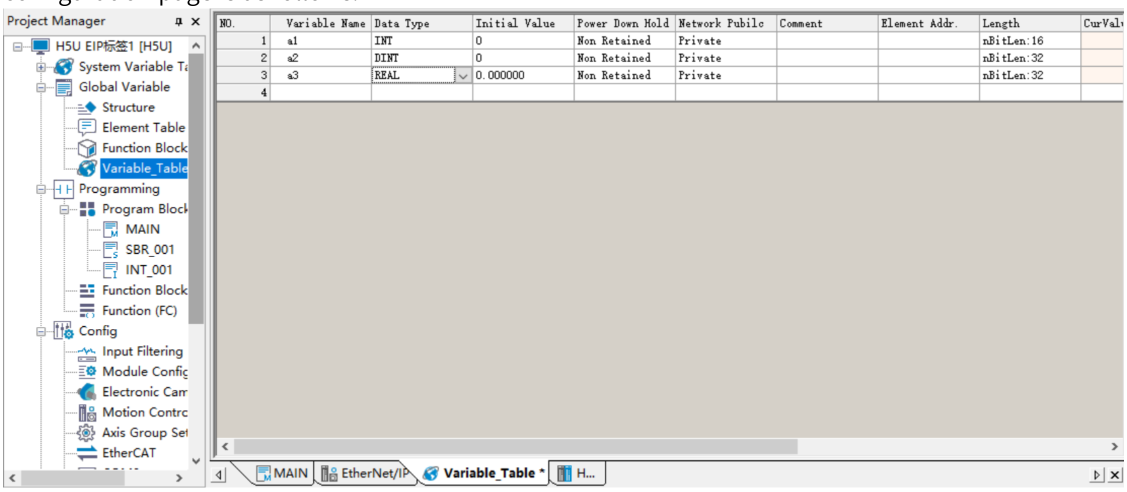
  ① Cyclic means data is requested periodically. The valid range of "**Cycle time**" is 5 ms to 1000 ms, and the default value is 50 ms.

  ② Application Trigger indicates the status trigger and corresponds to **Input variable**. The request is triggered by the BOOL-type variables.

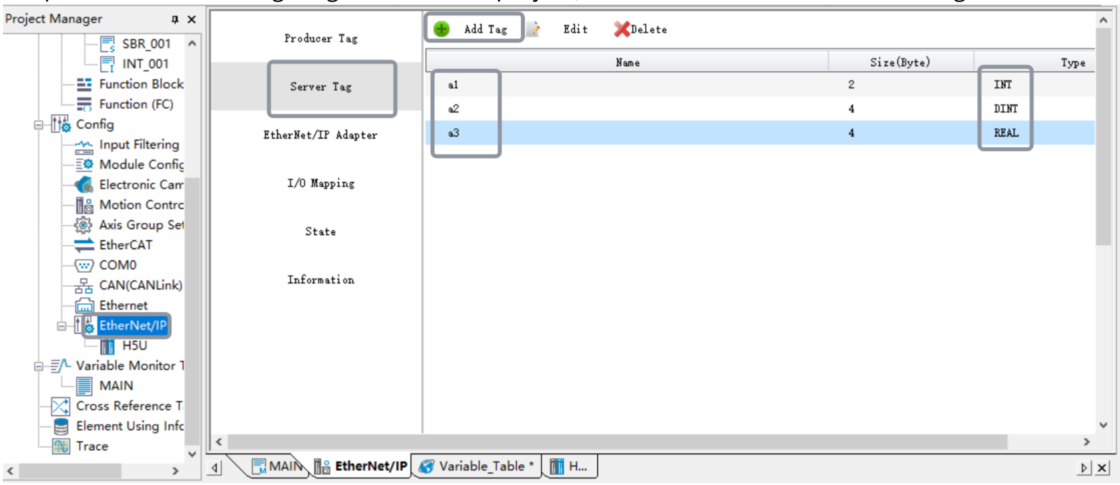
## 10.4.3 Application Example

The following takes the example of H5U-1 consuming tags a1, a2, and a3 created by H5U-2.

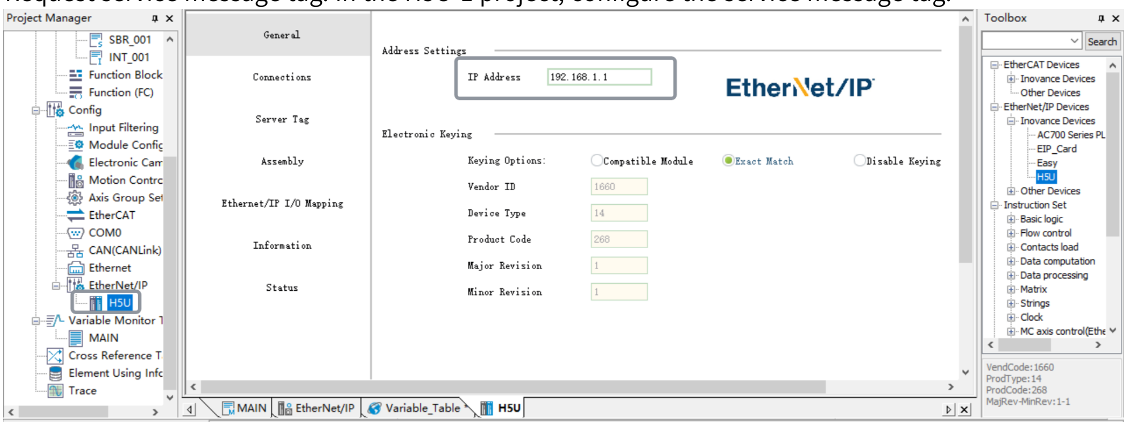
1. Response service message tag: In the variable table, create the variable (producer). The H5U-2 configuration page is as follows.

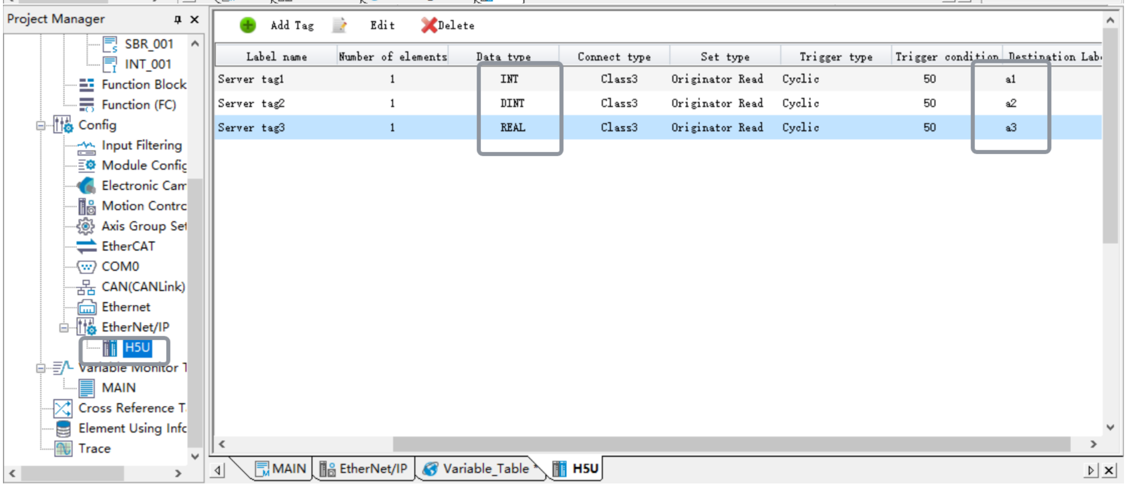


2. Response service message tag: In the H5U-2 project, associate the variable with the tag.




3. Request service message tag: In the H5U-1 project, configure the service message tag.




4. After configuration, download the projects to the PLC to monitor their communication states, and monitor the request data in the H5U-1 project.

# 11 PROFINET Communication

## 11.1 Overview

### About PROFINET

PROFINET, launched by PROFIBUS International (PI), is a new generation of automation bus standards based on the industrial Ethernet technology.

PROFINET provides a complete network solution for automation communication, encompassing hot topics in automation such as real-time Ethernet, motion control, distributed automation, fail-safe and network security. As a cross-supplier technology, it is fully compatible with industrial Ethernet and existing fieldbus (such as PROFIBUS) technologies, protecting existing investments.

### Extension modules supported by H5U as PROFINET slave station

H5U supports connection to Siemens PLCs through the PROFINET protocol. Extension modules of H5U are operated through the TIA Portal software and data is mapped to H5U. The following table lists supported extension table.

| Module Name | Input (Bytes) | Output (Bytes) | Description |
|---|---|---|---|
| 0016ETN | - | 2 | A module with 16 DO terminals (transistor NPN output) |
| 0016ETP | - | 2 | A module with 16 DO terminals (transistor PNP output) |
| 0016ER | - | 2 | A module with 16 DO terminals (relay output) |
| 1600END | 2 | - | A module with 16 DI terminals |
| 3200END | 4 | - | An input module with 32 channels |
| 0032ETN | - | 4 | An input module with 32 channels |
| 4DA | - | 8 | A module with 4 DA terminals, supporting voltage and current output |
| 4AD | 8 | - | A module with 4 AD terminals, supporting voltage and current input |
| 8TC | 16 | - | A temperature module with 8 channels |
| 4TC | 8 | - | A temperature module with 4 channels |
| 4PT | 8 | - | A temperature module with 4 channels |
| Share IN2 BOOL | 2 | - | Remote module input data area |
| Share IN32 DINT | 32 | - | Remote module input data area |
| Share IN32 INT | 32 | - | Remote module input data area |
| Share IN32 REAL | 32 | - | Remote module input data area |
| Share IN64 DINT | 64 | - | Remote module input data area |
| Share IN64 INT | 64 | - | Remote module input data area |
| Share IN64 REAL | 64 | - | Remote module input data area |
| Share OUT2 BOOL | - | 2 | Remote module output data area |
| Share OUT32 DINT | - | 32 | Remote module output data area |
| Share OUT32 INT | - | 32 | Remote module output data area |
| Share OUT32 REAL | - | 32 | Remote module output data area |

| Module Name | Input (Bytes) | Output (Bytes) | Description |
|---|---|---|---|
| Share OUT64 DINT | - | 64 | Remote module output data area |
| Share OUT64 INT | - | 64 | Remote module output data area |
| Share OUT64 REAL | - | 64 | Remote module output data area |

Caution

H5U devices can only be used as PROFINET slaves, and only support the reading and writing of process data of extension modules.

## Data mapping relationship

- TIA Portal page
  The directory tree "Module" on the right shows all currently supported extension modules, as well as shared modules Share INXX and Share OUTXX. All modules can be added to the slots under H5U in the "Device overview" area in any order. A maximum of 16 modules can be added to the 16 slots (except Share INXX/Share OUTXX, a maximum of 15 Share IN64XX/Share OUT64XX modules or a maximum of 20 other modules can be added). In the TIA Portal software, you can operate the I or Q address of each module, map the final data to H5U, and view the data of the module in AutoShop.
- AutoShop page
  AutoShop uses the system variable "_SYS_PN" to obtain mapped data in the TIA Portal software.

  In the TIA Portal software, data areas of all H5U modules are mapped to corresponding variables to the variable table "_SYS_PN" in AutoShop. The following table lists the mapping relationship.

  - Mapping relationship of H5U extension modules

| TIA Portal Module Name | AutoShop Variable Name |
|---|---|
| 0016ETN | MOD1600ETN |
| 0016ETP | MOD3200ETP |
| 0016ER | MOD0016ER |
| 1600END | MOD1600END |
| 3200END | MOD3200END |
| 0032ETN | MOD0032ETN |
| 4DA | MOD4DA |
| 4AD | MOD4AD |
| 8TC | MOD8TC |
| 4TC | MOD4TC |
| 4PT | MOD4PT |

When there are multiple identical modules, these modules will be mapped to the data areas of the corresponding indexes in the order they are added in the TIA Portal software. For example, three 3200END modules are added in the Portal software, and they are mapped to "MOD3200 [0]", "MOD3200[1]", and "MOD3200[2]", respectively.

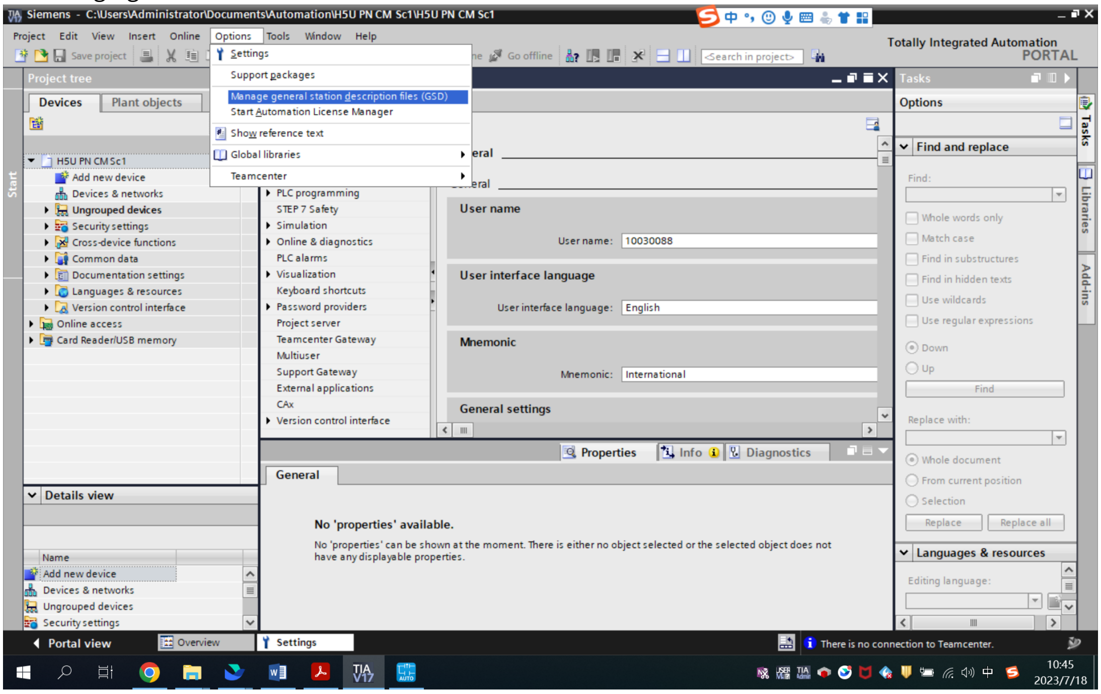
  - "Share IN*XX*" and "Share OUT*XX*" modules are mapped to variables "_share_in*XX*" and "_share_out*XX*", respectively. These modules can be used as data mapping variables for remote modules (Share IN*XX* mapped to _share_in*XX*, and Share OUT*XX* mapped to _share_out*XX*).

# 11.2 Configuration Process

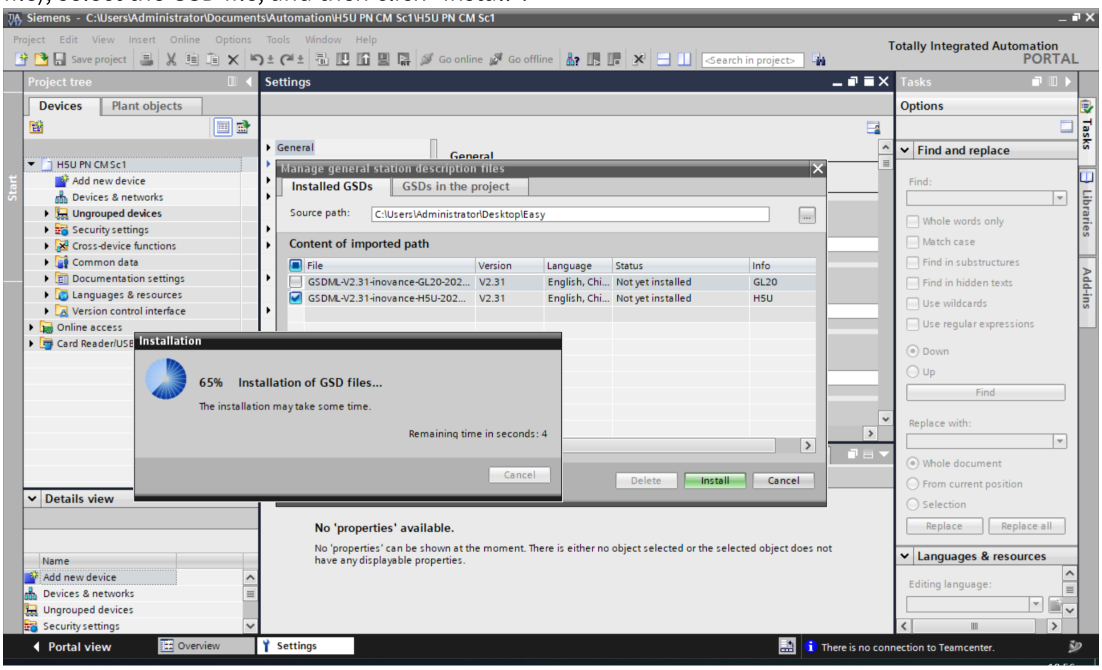
## 11.2.1 TIA Portal Configuration

1. Import and install the GSD file.

a. In the menu bar, choose "Option > Manage general station description file (GSD)", as shown in the following figure.

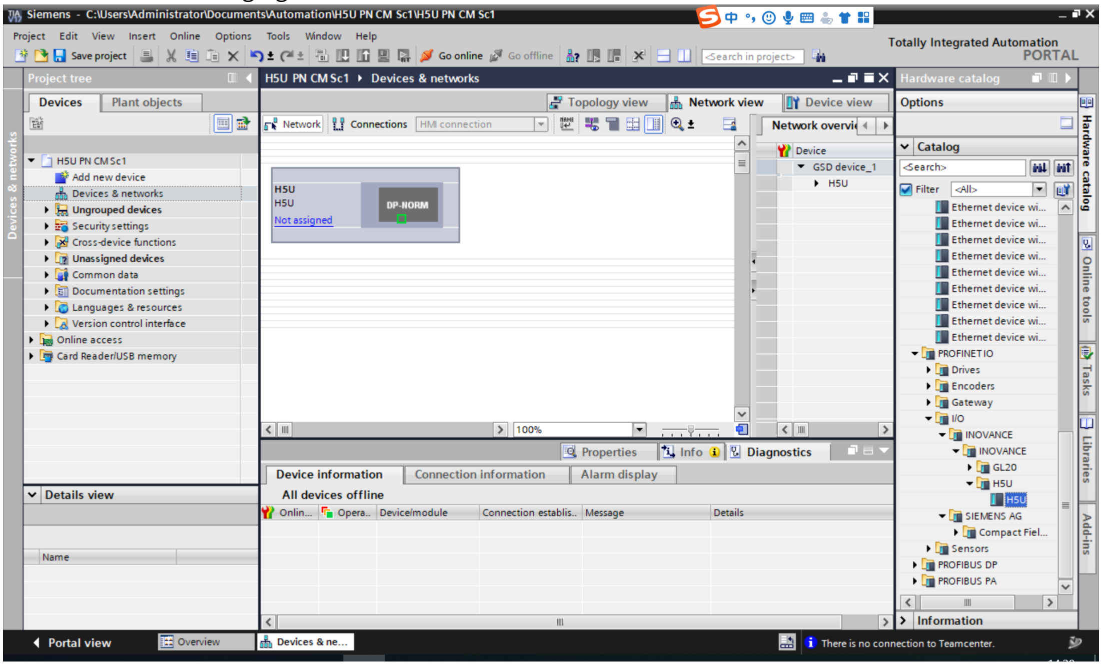



b. In the dialog box displayed, click ..., locate the GSD file (the software automatically indexes the file), select the GSD file, and then click "Install".

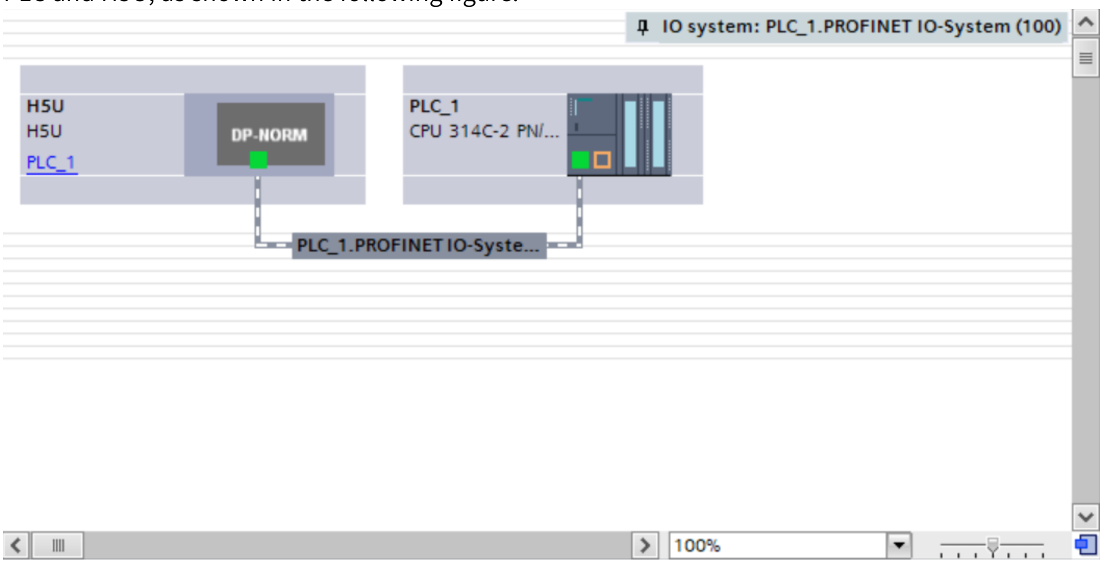



2. Configure H5U.

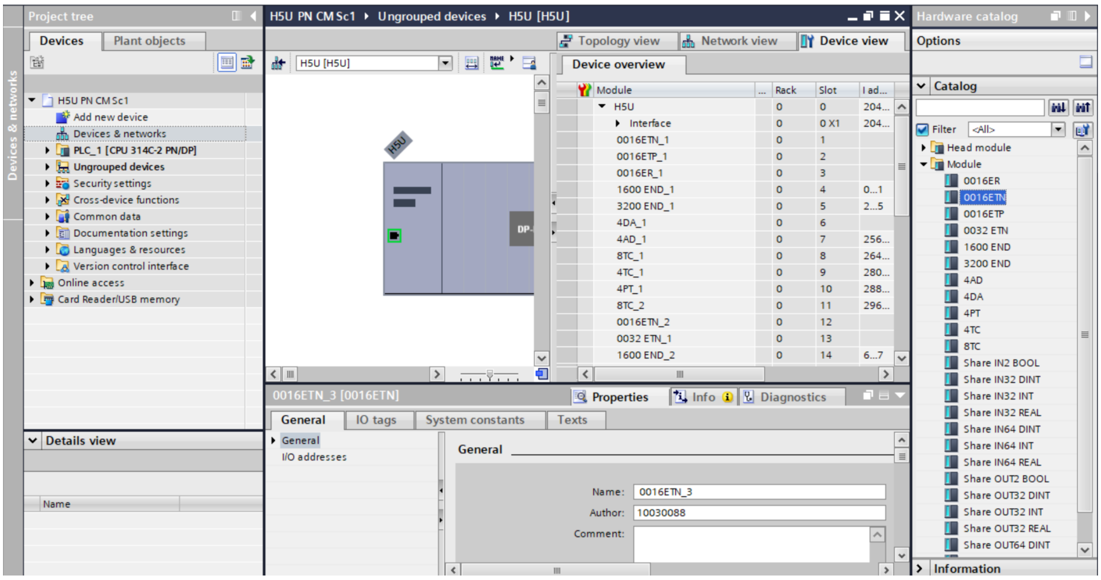
a. Double-click "H5U" in the hardware directory or drag "H5U" to the "Network view" section, as shown in the following figure.



b. Hold down the left mouse button and drag the PLC green box to the H5U green box to connect the PLC and H5U, as shown in the following figure.




c. Double-click a module in the hardware directory tree on the right to add the module and assign the address, as shown in the following figure.

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## *Note*

It is recommended to keep the order of added modules and slots consistent with the AutoShop interface.

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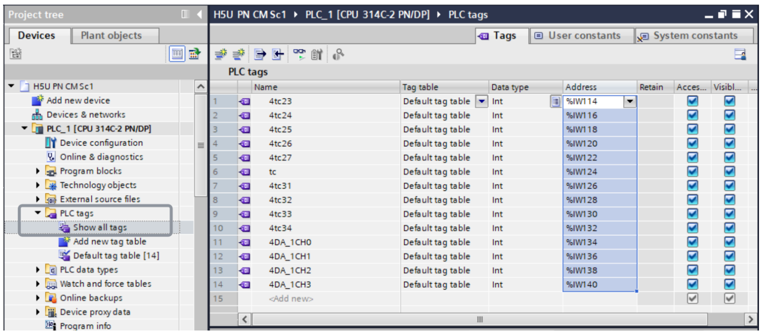
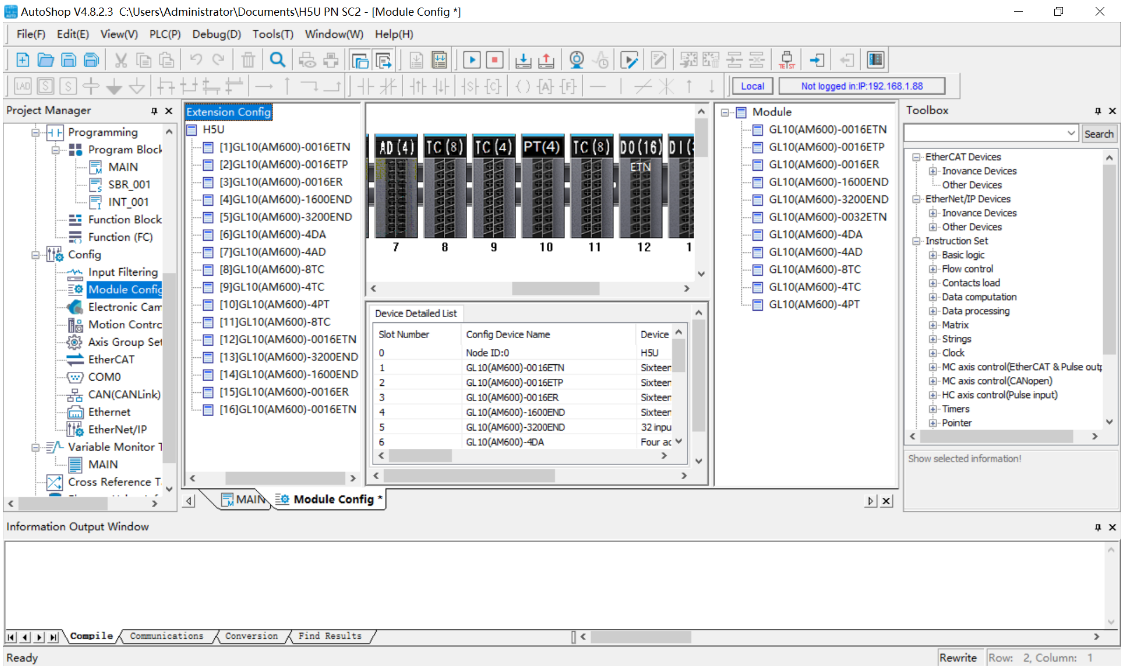
d. Click "Display all variables". On the "PLC variable" page displayed, define the specific address variable of the module, as shown in the following figure.




## 11.2.2 AutoShop Configuration

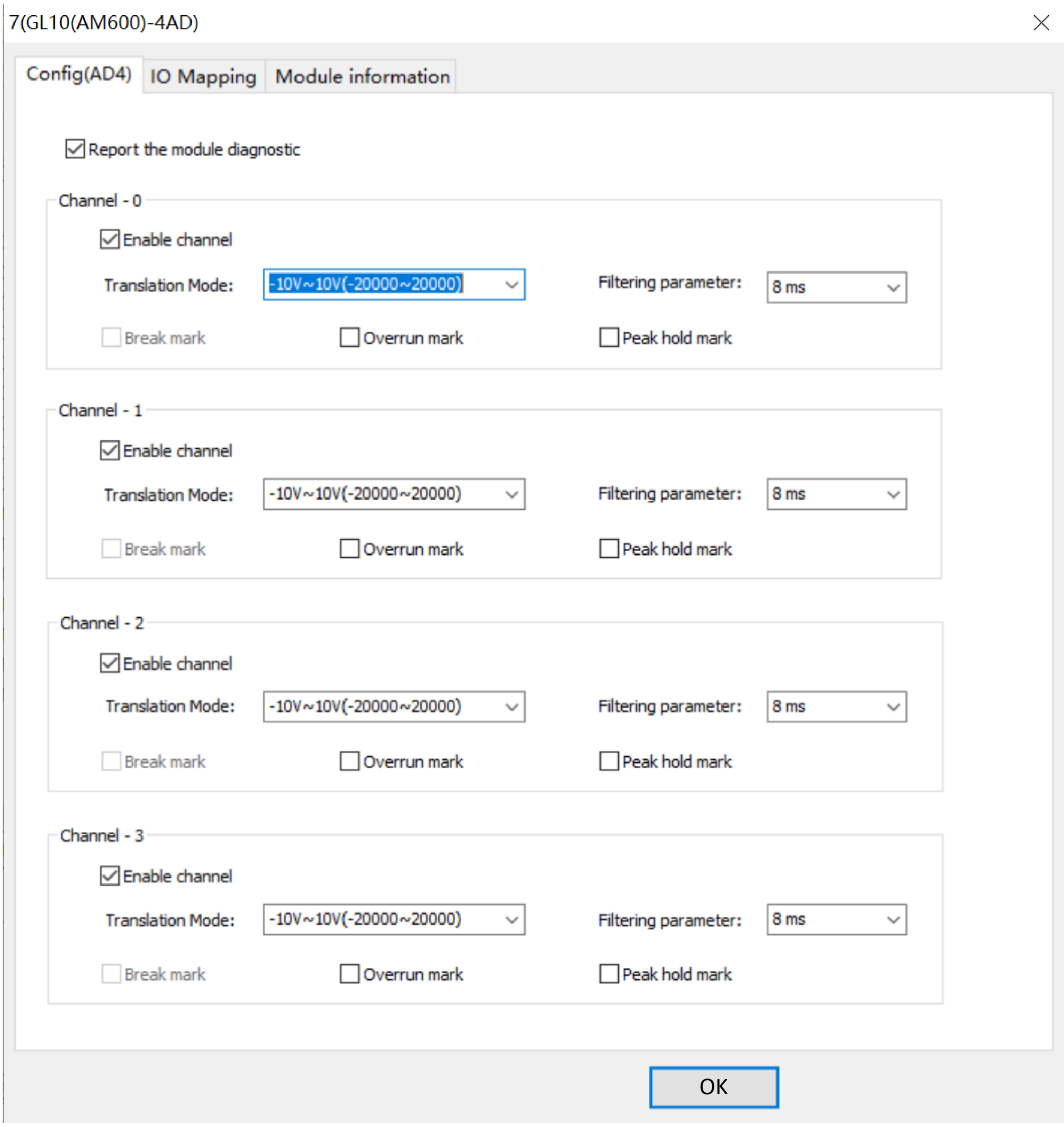
1. Under "Config" in the "Project Manager" section, double-click "Module Config". In the "Module" section, double-click the module you want to add, as shown in the following figure.



## Note

It is recommended to keep the order of added modules and slot numbers consistent with the TIA Portal interface.

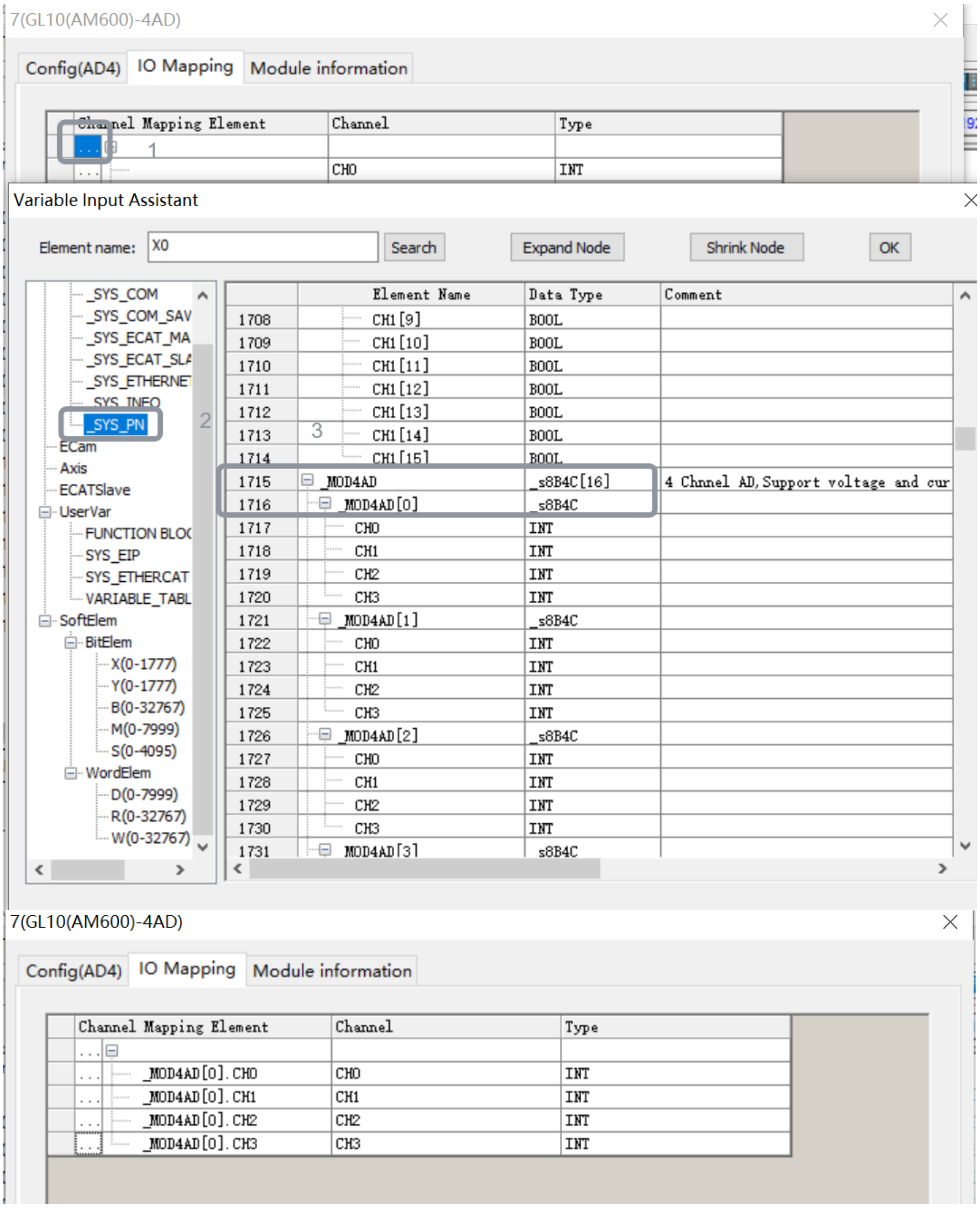
2. In the "Device Detailed List" section, double-click the module (taking GL10-4AD as an example) for which you want to configure parameters, configure the module parameters, and then click "OK", as shown in the following figure.




3. Map the module I/O to the corresponding variable in the system variable "_SYS_PN".

   a. In the "Device Detailed List" section, double-click the module (taking GL10-4AD as an example) for which you want to perform I/O mapping, as shown in the preceding figure.

   b. Click "IO Mapping", and map the module to the variable "MOD4AD[0]", as shown in the following figure.



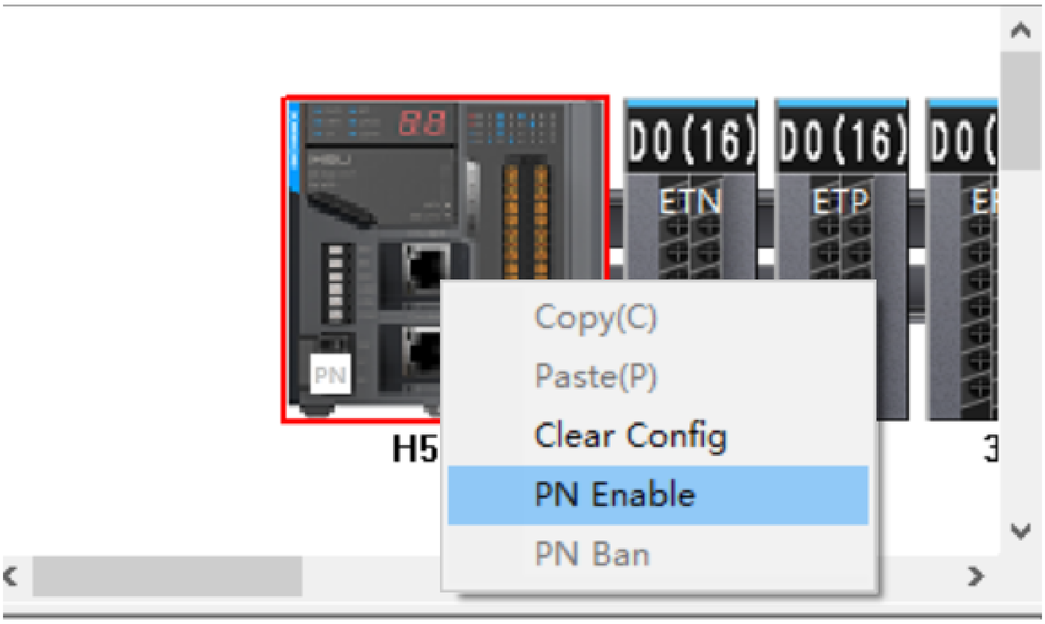
c. Click "OK", and then "OK".

## 11.3 Enable and Disable

PROFINET is disabled for H5U by default. To enable this function, perform the following operations.

### Enable

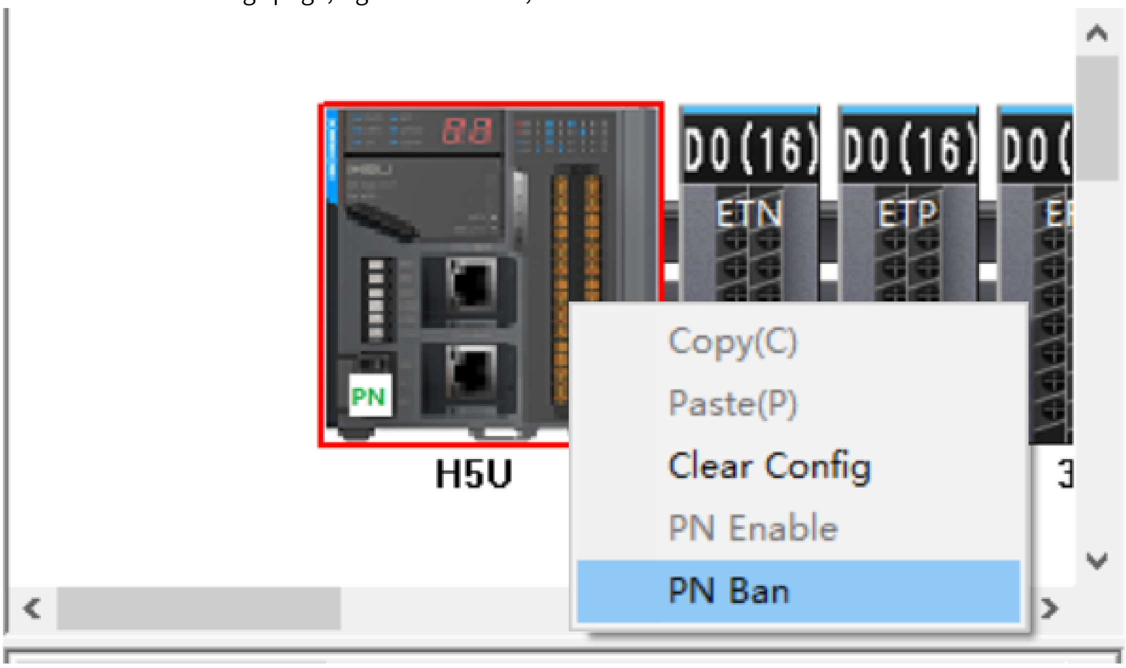
1. On the "Module Config" page, right-click "H5U", and select "PN Enable".




2. Download the program to H5U.
3. Restart H5U. Then, the function is enabled.

## Disable

1. On the "Module Config" page, right-click "H5U", and select "PN Ban".




2. Download the program to H5U.
3. Restart H5U. Then, the function is disabled.

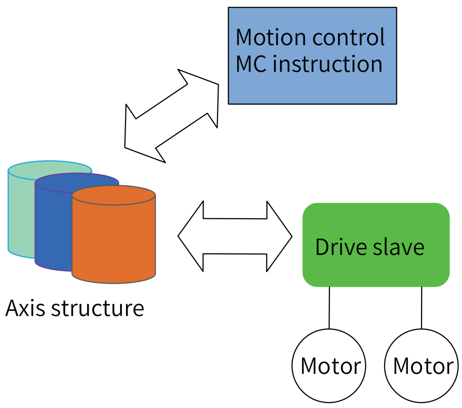
# 12 Motion Control

## 12.1 Introduction to Motion Control Axes

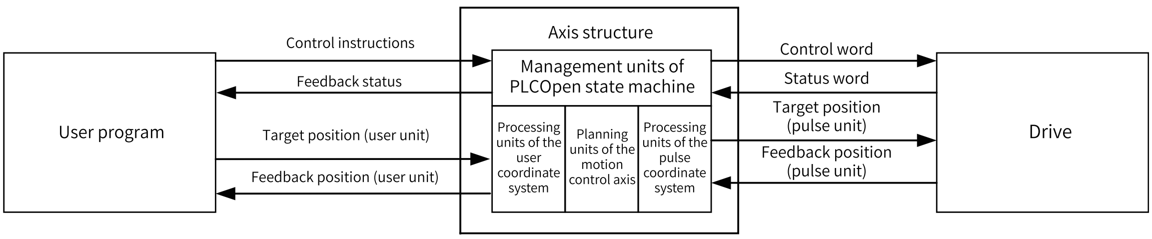
### 12.1.1 Overview

#### Basic composition and control logic

In a motion control system, the objects of motion control are called axes. The axes are the bridge between a drive and the PLC instructions. The motion control axes are used to control EtherCAT bus drive that is compliant with the CiA 402 protocol, as well as local high-speed pulse outputs and high-speed pulse inputs.




The following figure shows the basic composition and processing logic of an axis in the PLC.




#### Scheduling mechanism of motion control instructions

Main programs, subprograms, and interrupt subprograms are provided for users to write programs. However, motion control instructions can only be called in the main programs or subprograms, not in the interrupt subprograms.

The EtherCAT tasks are hidden tasks that are not open to users, so programming of the EtherCAT tasks is not supported.

As shown in the following figure, in a main program, the PLC scans all the motion control instructions written in the program in turn, and stores the final result in the motion control parameter buffer according to the interrupt rules of the program. The PLC updates the motion control instruction when a EtherCAT task is executed. After the execution is completed, the execution result is put into the buffer, and the motion control instruction in the main program updates the instruction status according to the execution result.

For example, there are two MC_MoveAbsolute instructions in the program. The target position of the first instruction is 100, the target position of the second instruction is 200, and both instructions are triggered by the soft element M1000 at the same time. When the PLC scans the program, the PLC first scans the first absolute positioning instruction, obtaining the target position 100, and then scans the second instruction, updating the target position to 200. At the end of the main task, the PLC finally writes the target position 200 to the motion control buffer and implements the instruction according to the second absolute positioning parameter, interrupting the first instruction. After obtaining the target position 200, the EtherCAT task starts to execute the absolute positioning algorithm, and sets the completion flag when the positioning is completed. After the second absolute positioning instruction in the main program obtains the completion flag, the Done signal is activated.

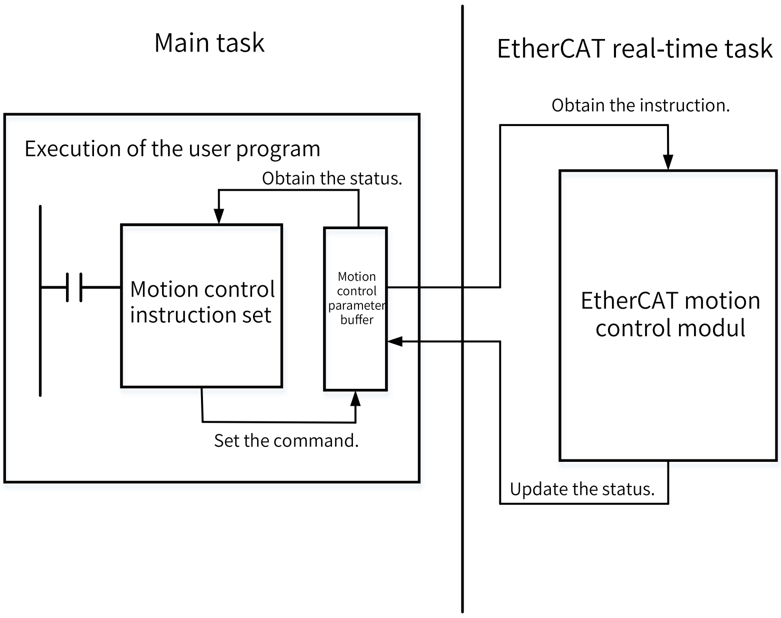



Figure 12-1 EtherCAT instruction execution

## Axis types

Supported axis types include bus servo axis, local pulse axis, bus encoder axis, and local encoder axis.

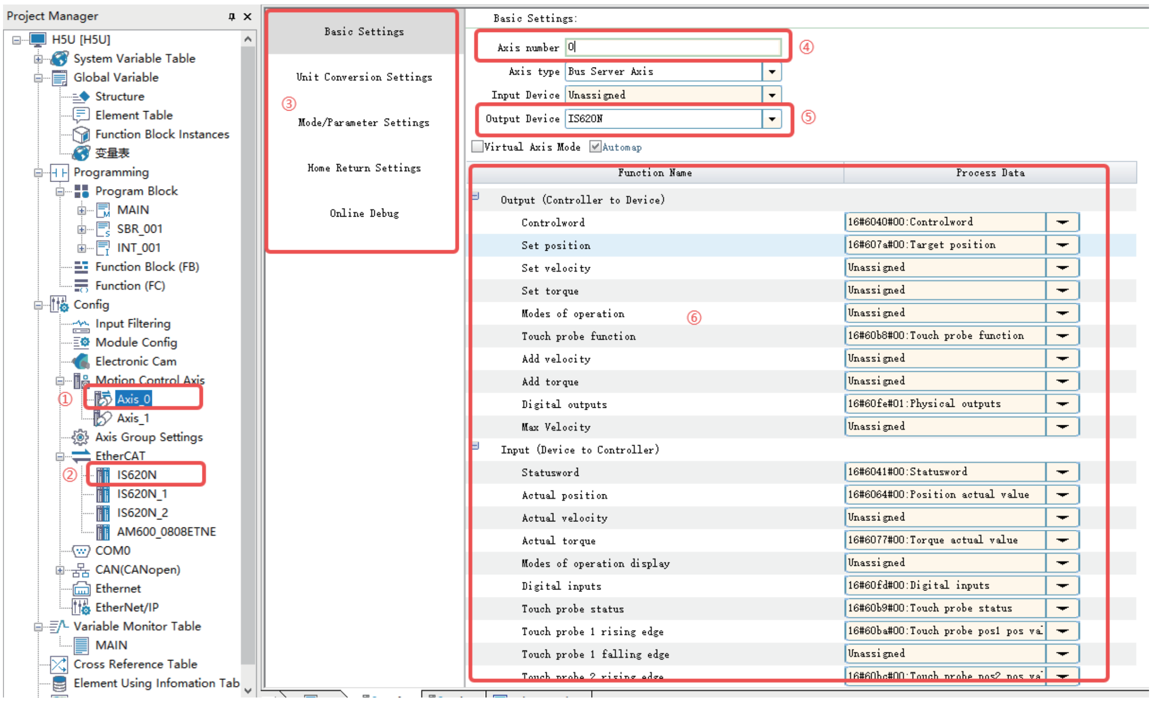
| Axis Type | Content |
|---|---|
| Bus servo axis | Bus servo axis is controlled using EtherCAT slave servo drives.<br>When virtual axis mode is disabled, the bus servo axis is assigned to the actual servo drive for use.<br>The bus servo axis supports the control of several basic modes such as torque, point, velocity, and homing modes. |
| Local pulse axis | Local pulse axis is controlled using a pulse drive controlled by local high-speed I/O.<br>Four local pulse axes can be set: Y0/Y1, Y2/Y3, Y4/Y5, and Y6/Y7.<br>Each pulse output channel can be set to pulse+direction or CW/CCW.<br>Up to two probe terminals can be set per pulse output channel.<br>The local pulse axis supports control in several basic modes such as point, velocity, and homing modes. Torque mode is not supported. |
| Bus encoder axis | Reserved |
| Local encoder axis | See *"13.1 Introduction to High-speed Counter Axes" on page 427*. |

To fully describe the attributes of an axis, monitor the axis status, and control the axis motion, each axis is divided into three parts.

| Axis Structure | Function |
|---|---|
| Axis configuration parameter | Configures parameters of an axis, such as gear ratio, homing type, and encoder mode. |
| Axis system variable | Monitors the operating status and abnormal information of an axis, such as the current position and axis error code. |
| Axis control instruction | In a user program, axis motion control is performed using MC motion control instructions.<br>Axis control instructions are divided into management (such as MC_Power), motion (such as MC_Jog), and status (MC_ReadStatus). |

## Configuration interface

In the project, the axis configuration interface is as follows:




① Motion control axis

② EtherCAT bus drive

③ List of axis configuration and monitoring options

④ Axis number (unique access ID for an axis)

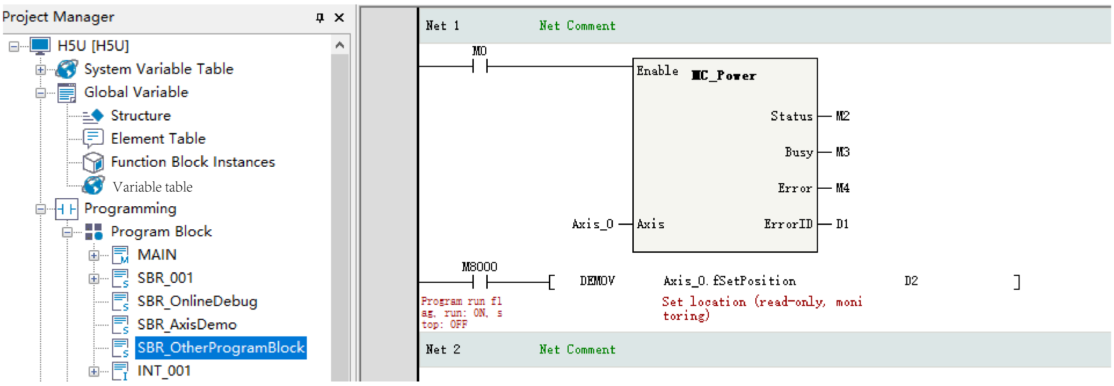
⑤ Associated physical drive

⑥ Detailed parameter settings

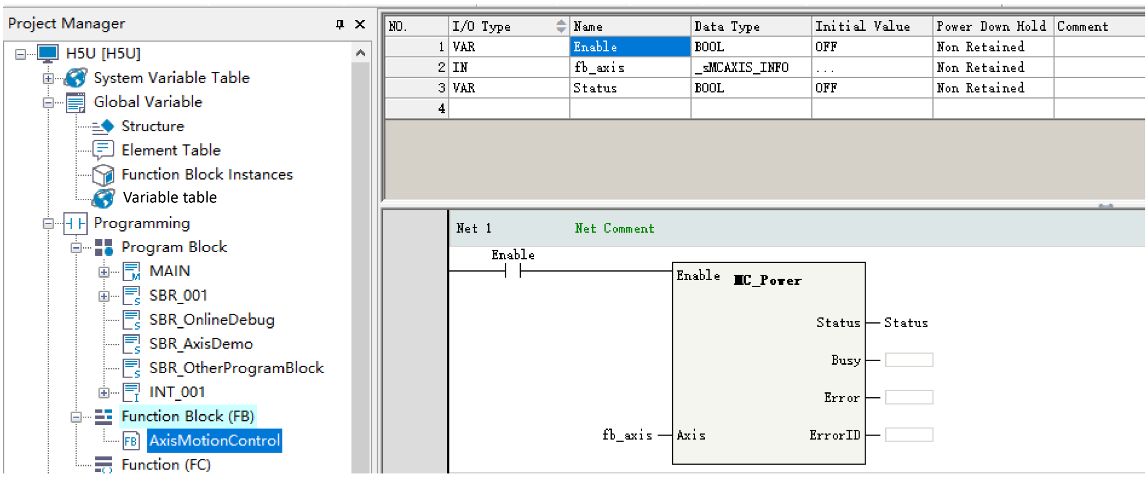
## Motion control axis access modes

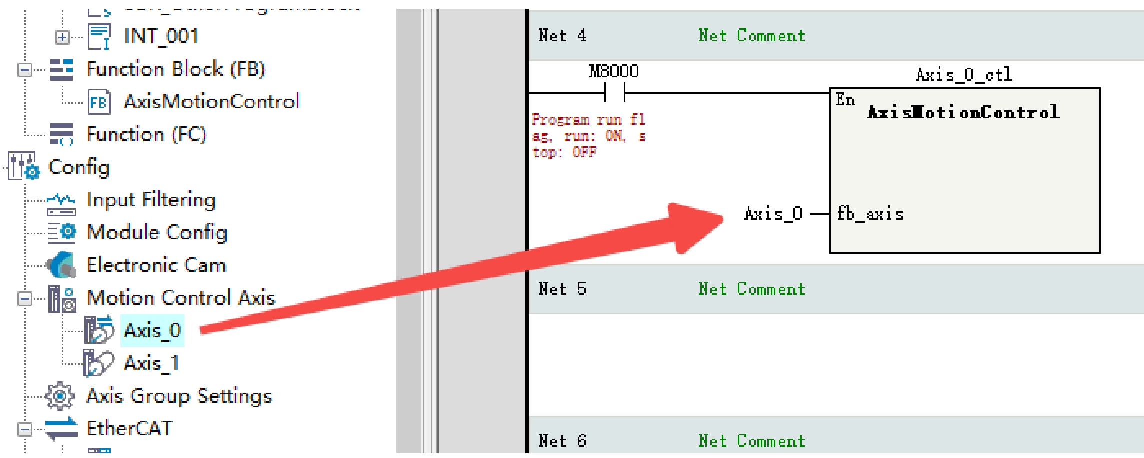
In the PLC program, a motion control axis can be accessed in two ways: motion control instructions and system variables.

- In AutoShop of version V4.0.0.0 or later versions in combination with PCB software of version V3.0.0.0 or later versions, axis instructions and system variables can be accessed by using axis names. Axis names can also be introduced into FB as parameters, for example:




Axes can also be introduced into FB as parameters.

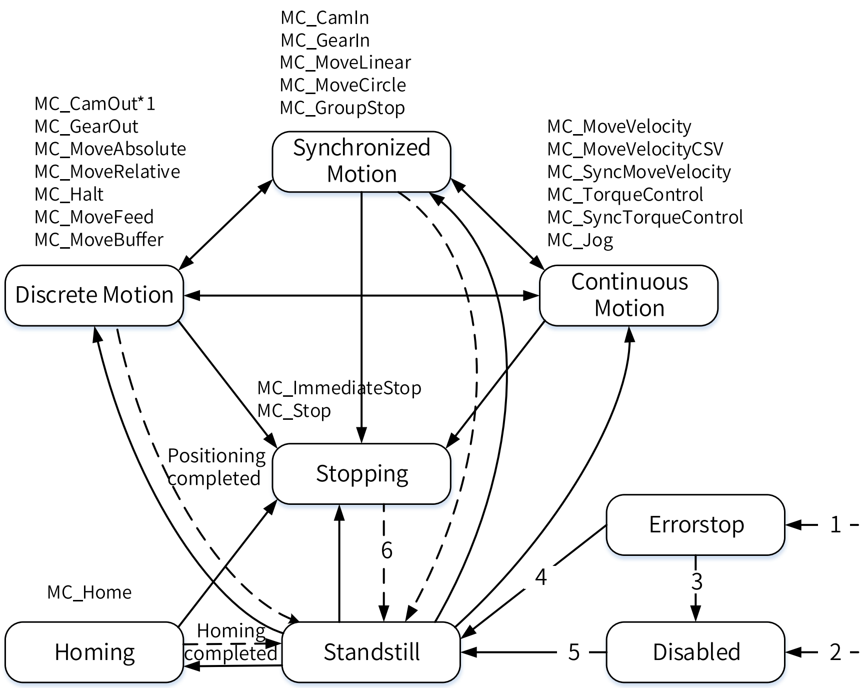



## 12.1.2 PLCOpen State Machine

The PLCOpen state machine allows you to manage axis status and motion and complete different functions in different states.

The status transition diagram is as follows.




The detailed description is as follows.

| Status Value | Status | Description |
|---|---|---|
| 0 | Disabled | Disabled |
| 1 | ErrorStop | Stopped due to a fault |
| 2 | Stopping | Stopping |
| 3 | Standstill | Enabled |
| 4 | Discrete Motion | Discrete motion |
| 5 | Continuous Motion | Continuous motion |
| 7 | Homing | Homing |
| 8 | Synchronized Motion | Synchronized motion |

The following table summarizes the status transition conditions.

| Transition | Transition Conditions |
|---|---|
| 1 | The fault detection logic of the axis detects a fault. In this case, the system immediately transits to this state. |
| 2 | The axis is free of faults and MC_Power.Enable=FALSE |
| 3 | MC_Reset is called to reset the axis fault and MC_Power.Status=FASLE. |
| 4 | MC_Reset is called to reset the axis fault and MC_Power.Status=TRUE. |
| 5 | MC_Power.Enable=TRUE and MC_Power.Status=TRUE. |
| 6 | MC_Stop(MC_ImmediateStop).Done=TRUE and MC_Stop(MC_ImmediateStop).Execute=FALSE. |

### 12.1.3 Axis Units

Two units are used in the axis structure: user unit and pulse unit.

#### User unit

It refers to the measurement units used in instructions, such as millimeters, centimeters, and angles, which are called user units and usually represented by Unit.

The user coordinate systems are divided into linear coordinate system and rotary coordinate system according to working conditions.

A linear coordinate system typically includes a zero point. An axis is in forward motion when the target position increases, or in reverse motion when the target position decreases. The linear coordinate system can set positive and negative software limits.

The rotary coordinate system includes a zero point and a rotation cycle in which CW motion occurs when the target position increases and CCW motion occurs when the target position decreases.

### Pulse unit

It refers to the units measured in pulses and used on the drive, which are usually represented by pulse.

The drive usually contains two parameters: the pulse zero point and the number of pulses of an encoder per revolution of the motor.

## 12.1.4 Axis Configuration Parameters

Attributes of motion control axes can be set as needed. The following table summarizes the axis configuration parameters.

| Category | Description | Bus Servo Axis | Local Pulse Axis |
|---|---|---|---|
| Basic settings | Axis number | √ | √ |
| | Axis type | √ | √ |
| | Input device | x | x |
| | Output device | √ | √ |
| | Automatic mapping | √ | x |
| | Virtual axis mode | √ | √ |
| | PDO | √ | x |
| Unit conversion settings | Reverse | √ | √ |
| | The number of instruction pulses per revolution of the motor/encoder | √ | √ |
| | The distance per revolution of the worktable in the background | √ | √ |
| | Gear ratio numerator | √ | √ |
| | Gear ratio denominator | √ | √ |
| Mode/parameter settings | Encoder mode | √ | x |
| | Linear/rotary mode settings | √ | √ |
| | Software limit | √ | √ |
| | Software error response | √ | √ |
| | Following error | √ | √ |
| | Axis velocity settings | √ | √ |
| | Torque limit | √ | x |
| | Probe settings | x | √ |
| | Output settings | x | √ |
| | Hardware limit logic | √ | x |
| | Not entering ErrorStop state upon a limit activation | √ | √ |

| Category | Description | Bus Servo Axis | Local Pulse Axis |
|---|---|---|---|
| Homing settings | Home signal | √ | √ |
| | Positive limit | √ | √ |
| | Negative limit | √ | √ |
| | Z signal | √ | x |
| | Homing direction | √ | √ |
| | Home input detection direction | √ | √ |
| | Homing list | √ | √ |
| | Homing velocity | √ | √ |
| | Homing closing velocity | √ | √ |
| | Homing acceleration | √ | √ |
| | Homing timeout time | √ [Note] | √ |
| | Negative limit terminal settings | x | √ |
| | Positive limit terminal settings | x | √ |
| | Home signal settings | x | √ |
| Online commissioning | Monitoring list | √ | √ |
| | Motion commissioning | √ | √ |

[Note]: This function is only available to Inovance servo drives.

### 12.1.5 Axis System Variables

In the program, you can monitor the current status of an axis through its system variables. The system variables of a bus servo axis/local pulse axis are shown in the following table.

| Variable | Data Type | Function |
|---|---|---|
| bPowerState | BOOL | Monitoring parameter, enabled or disabled status of the axis, read-only |
| bDebugState | BOOL | Monitoring parameter, commissioning status of the axis, read-only |
| fSetPosition | REAL | Monitoring parameter, position reference of the axis, user unit, read-only |
| fSetVelocity | REAL | Monitoring parameter, velocity reference of the axis (that is, the change rate of the position reference), user unit, read-only |
| fSet_Acc_Dec | REAL | Monitoring parameter, acceleration reference of the axis (that is, the change rate of the velocity reference), user unit, read-only |
| fSetTorque | REAL | Monitoring parameter, torque reference of the axis, user unit, read-only |
| fActPosition | REAL | Monitoring parameter, feedback position of the axis, user unit, read-only |
| fActVelocity | REAL | Monitoring parameter, the current velocity of the axis (that is, the change rate of the feedback position), user unit, read-only |
| fActAcc_Dec | REAL | Monitoring parameter, the current acceleration of the axis (that is, the change rate of the feedback velocity), user unit, read-only |
| fActTorque | REAL | Monitoring parameter, feedback torque of the axis, user unit, read-only |

| Variable | Data Type | Function |
|---|---|---|
| wPLCOpenState | INT | Monitoring parameter, PLCOpen state machine for the axis, read-only<br>0: PowerOff<br>1: ErrorStop<br>2: Stopping<br>3: StandStill<br>4: DiscreteMotion<br>5: ContinuousMotion<br>7: Homing<br>8: SynchronizedMotion |
| wConfigState | INT | Monitoring parameter, configuration status of the axis, read-only<br>0: Init (axis in the initialization state)<br>1: Configure finish (configuration reading completed)<br>2: Sync finish (synchronized with EtherCAT tasks)<br>3: Wait communication (communication with the servo drive established)<br>4: Slave ready (initialization completed for the servo drive controlled by axes)<br>5: Axis ready (communication established) |
| wAxisError | INT | Monitoring parameter, error code for the axis in the ErrorStop state, read-only |
| wServoError | INT | Monitoring parameter, error code for a drive or local axis, displaying 0x603f values, read-only |
| bEnterDebug | BOOL | Commissioning parameter, entering the commissioning mode when the variable is valid |
| bPowerOn | BOOL | Commissioning parameter, axis enable instruction |
| bStop | BOOL | Commissioning parameter, axis stop instruction |
| bReset | BOOL | Commissioning parameter, axis reset instruction |
| bJogP | BOOL | Commissioning parameter, forward jog instruction |
| bJogN | BOOL | Commissioning parameter, reverse jog instruction |
| bHome | BOOL | Commissioning parameter, homing instruction |
| bSetPos | BOOL | Commissioning parameter, current position setting instruction |
| bAbsPos | BOOL | Commissioning parameter, absolute positioning instruction |
| bRevPos | BOOL | Commissioning parameter, relative positioning instruction |
| bRelPos | BOOL | Commissioning parameter, reciprocating motion instruction |
| bVelocity | BOOL | Commissioning parameter, continuous motion instruction |
| bTorque | BOOL | Commissioning parameter, torque instruction |
| wDebugMotionType | INT | Commissioning parameter, commissioning mode<br>0: Idle<br>1: Relative positioning control<br>2: Absolute positioning control<br>3: Continuous motion control<br>5: Reciprocating motion control<br>6: Torque control |
| fJogVelocity | REAL | Commissioning parameter, jogging velocity |
| fPositionOffser | REAL | Commissioning parameter, homing offset |

| Variable | Data Type | Function |
|---|---|---|
| fPresetPosition | REAL | Commissioning parameter, preset positions |
| fTarPosition1 | REAL | Commissioning parameter, target position |
| fTarVelocity1 | REAL | Commissioning parameter, target velocity |
| fTarAcceleration1 | REAL | Commissioning parameter, target acceleration |
| fTarDeceleration1 | REAL | Commissioning parameter, target deceleration |
| wCurveType1 | REAL | Commissioning parameter, curve type |
| fTarPosition2 | REAL | Commissioning parameter, target position 2 |
| fTarVelocity2 | REAL | Commissioning parameter, target velocity 2 |
| fTarAcceleration2 | REAL | Commissioning parameter, target acceleration 2 |
| fTarDeceleration2 | REAL | Commissioning parameter, target deceleration 2 |
| wCurveType2 | INT | Commissioning parameter, curve type 2 |
| dUnused | | Commissioning parameter, reserved |
| fTarTorque | REAL | Commissioning parameter, target torque |
| fTarTorqueSlop | REAL | Commissioning parameter, torque slope |
| fLimitVelocity | REAL | Commissioning parameter, velocity limit in torque mode |
| wControlWord | INT | Loop variable, control word 0x6060, read-only |
| WStatusWord | INT | Loop variable, status word 0x6061, read-only |
| dSetPosition | DINT | Loop variable, target position 0x607a, read-only |
| dActPosition | DINT | Loop variable, feedback position 0x6064, read-only |
| dSetVelocity | DINT | Loop variable, velocity reference 0x60ff, read-only |
| dActVelocity | DINT | Loop variable, feedback velocity 0x606c, read-only |
| dSetTorque | DINT | Loop variable, torque reference 0x6071, read-only |
| dActTorque | DINT | Loop variable, feedback torque 0x6077, read-only |
| dDO | DINT | Loop variable, DO 0x60fe:1, read-only |
| dDI | DINT | Loop variable, DI 0x60fd, read-only |
| wModesOfOperation | INT | Loop variable, control mode 0x6060, read-only |
| wModesOfOperationDis-play | INT | Loop variable, current control mode 0x6061, read-only |
| wTouchFunction | INT | Loop variable, probe function settings 0x60b8, read-only |
| wTouchStatus | INT | Loop variable, probe status 0x60b9, read-only |
| dTouch1Ppos | DINT | Loop variable, probe 1 position on the rising edge 0x60ba, read-only |
| dTouch2Ppos | DINT | Loop variable, probe 2 position on the rising edge 0x60bb, read-only |
| dTouch1Npos | DINT | Loop variable, probe 1 position on the falling edge 0x60bc, read-only |
| dTouch2Npos | DINT | Loop variable, probe 2 position on the falling edge 0x60bd, read-only |
| dMaxVelocity | DINT | Loop variable, maximum velocity 0x607f, maximum velocity |
| wErrorCode | INT | Loop variable, drive error code 0x603f, read-only |
| wAxisRingPos | INT | Configuration parameter, axis configuration position, power-on initialization |
| WAxisID | INT | Configuration parameter, axis ID, power-on initialization |
| fUnits | REAL | Configuration parameter, axis gear ratio, power-on initialization |
| fFilter | REAL[3] | Setting the filter coefficient of the master axis, initialized to 1.0,.0.0,0.0 upon power-on, and modifiable |
| bMotionState | BOOL | Monitoring parameter, motion status, indicating whether the axis is in motion, read-only |
| bphlimit | BOOL | Monitoring parameter, hardware positive limit input status, read-only |
| bnhlimit | BOOL | Monitoring parameter, hardware negative limit input status, read-only |

| Variable | Data Type | Function |
|---|---|---|
| bhomestate | BOOL | Monitoring parameter, hardware home switch input status, read-only |
| bpslimit | BOOL | Monitoring parameter, indicating whether the software positive limit is reached, read-only |
| bnslimit | BOOL | Monitoring parameter, indicating whether the software negative limit is reached, read-only |
| dLocialAxisSetPos | DINT | Monitoring parameter, position reference of the local pulse axis, read-only |
| fFollowPos | REAL | Following error, read-only |

### 12.1.6 List of Axis Control Instructions

The following table lists single-axis control instructions. For details about how to use these instructions, see the *H5U and Easy Series Programmable Logic Controllers Instructions Guide*.

| Instruction | Name |
|---|---|
| MC_Power | Enable control |
| MC_Reset | Fault reset |
| MC_ReadStatus | Axis status reading |
| MC_ReadAxisError | Axis error reading |
| MC_ReadDigitalInput | Digital input reading |
| MC_ReadActualPosition | Actual position reading |
| MC_ReadActualVelocity | Actual velocity reading |
| MC_ReadActualTorque | Actual torque reading |
| MC_SetPosition | Position setting |
| MC_TouchProbe | Probe |
| MC_MoveRelative | Relative positioning |
| MC_MoveAbsolute | Absolute positioning |
| MC_MoveVelocity | Velocity |
| MC_Jog | Jogging |
| MC_TorqueControl | Torque control |
| MC_Home | Homing |
| MC_Stop | Stop |
| MC_Halt | Pause |
| MC_ImmediateStop | Emergency stop |
| MC_MoveFeed | Interrupt positioning |
| MC_MoveBuffer | Multi-position positioning |
| MC_MoveSuperImposed | Motion superimposition |
| MC_MoveVelocityCSV | CSV-based velocity control with adjustable pulse width |
| MC_SyncMoveVelocity | CSV-based synchronous velocity control with adjustable pulse width |
| MC_SyncTorqueControl | Synchronous torque control |

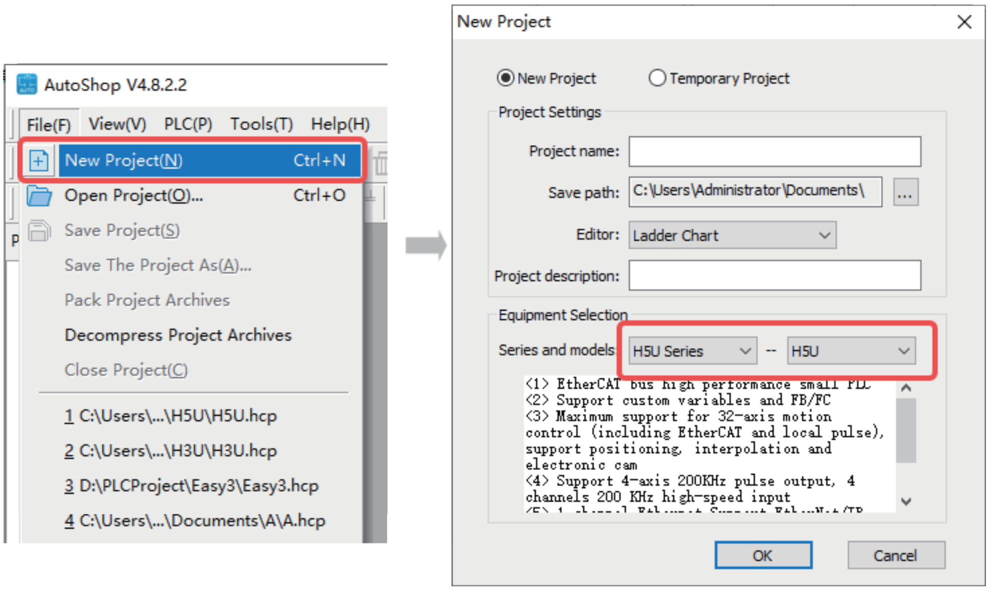
# 12.2 Setting Motion Control Axes

## 12.2.1 Creating a Project

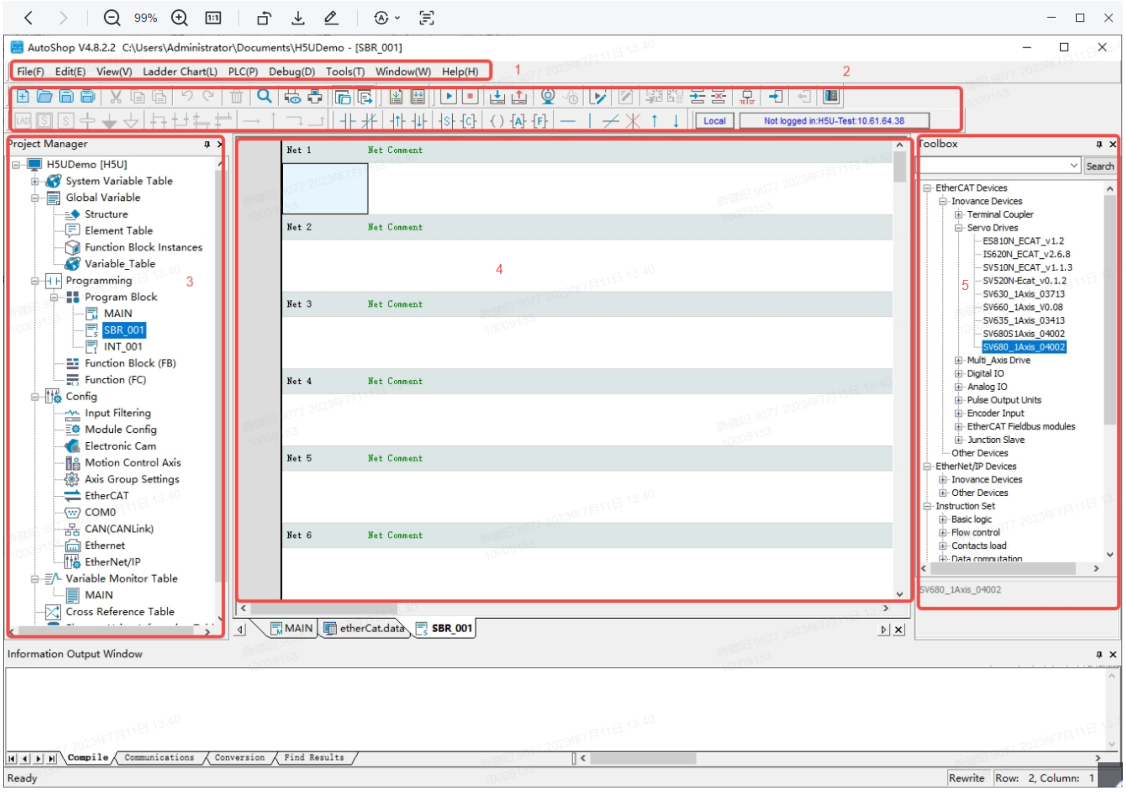
Follow these steps to accurately control an axis: First, create a configuration based on the needs of your project. Then, set relevant parameters based on the working conditions, download the project, and carry out simple operations through online commissioning to determine whether the parameter settings are reasonable and whether the hardware connection is reliable. Lastly, write a PLC program to complete the overall control logic. Here is an example.

This routine creates a new bus servo axis and a local pulse axis, and implements simple motion through two ways: online commissioning interface and instructions.

1. Open AutoShop, click "New Project", and set the PLC type to H5U.




2. After the project is successfully created, enter the main interface.




Zone 1: Menu bar

Zone 2: Toolbar

Zone 3: Project management area

Zone 4: Program editing section

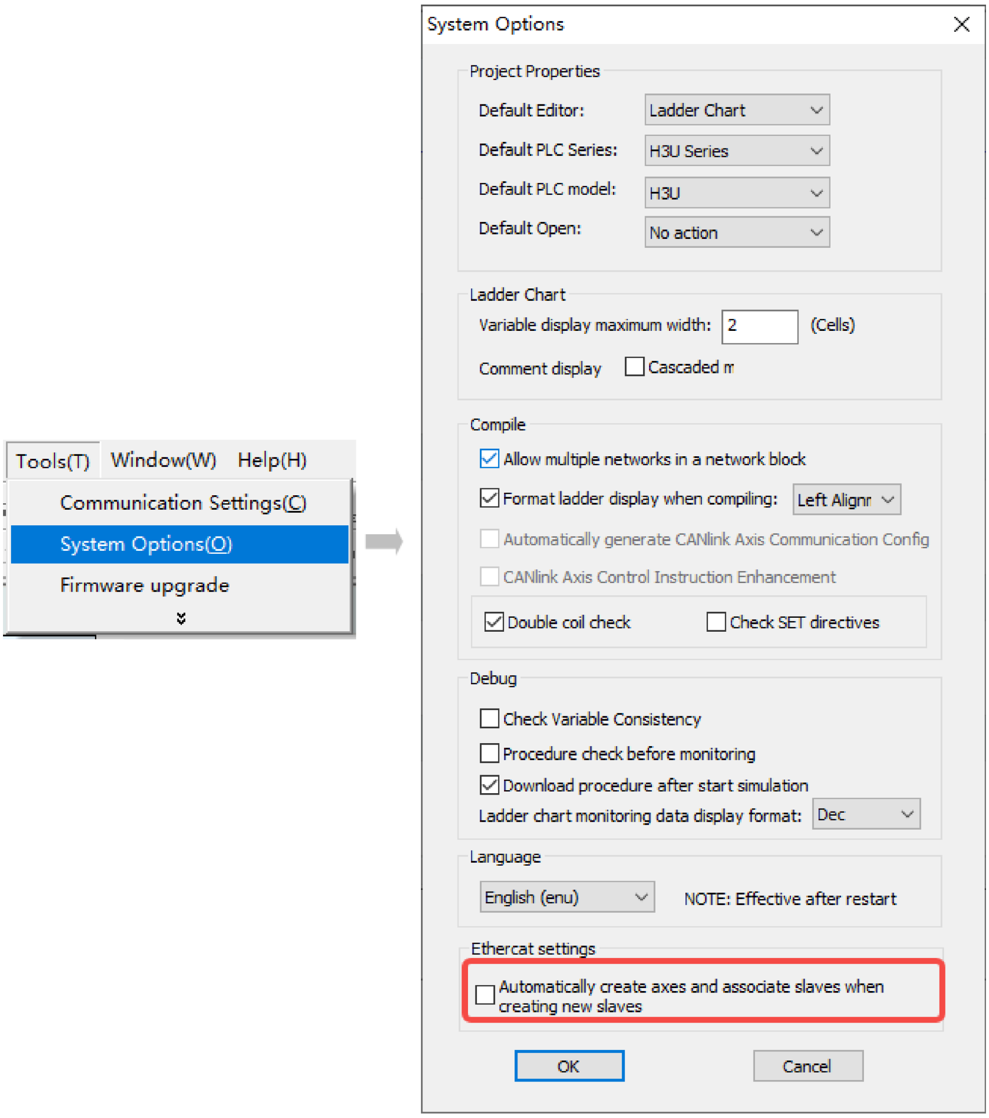
Zone 5: Toolbox

## 12.2.2 Creating Project Configuration

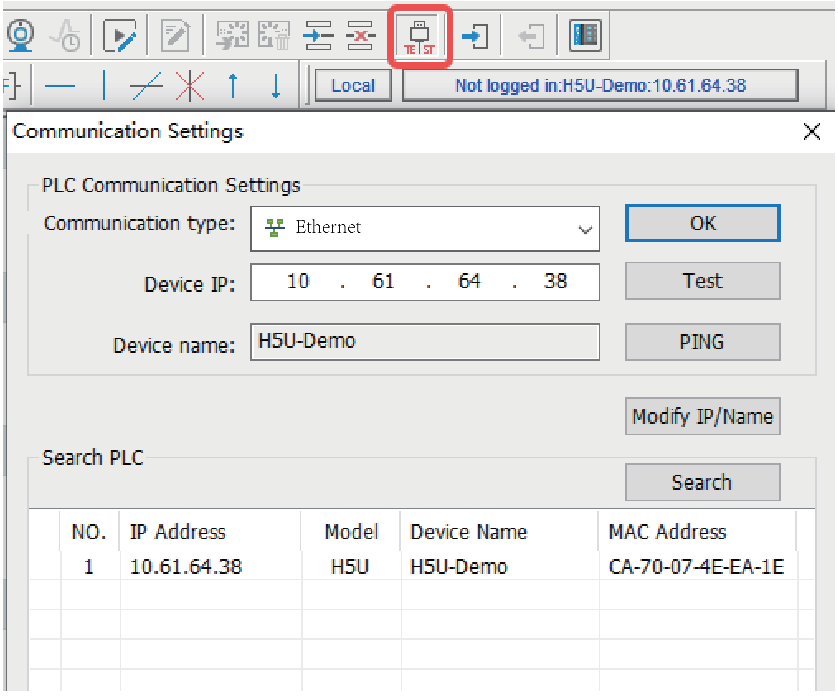
To control the IS620N motion, you can configure a servo drive and a bus servo axis and link them together in two modes: automatic scan and manual adding.
In the automatic scan mode, bus servo axes are automatically added, while local pulse axes need to be added manually. The operations of the two modes are explained below.

### Automatic scan

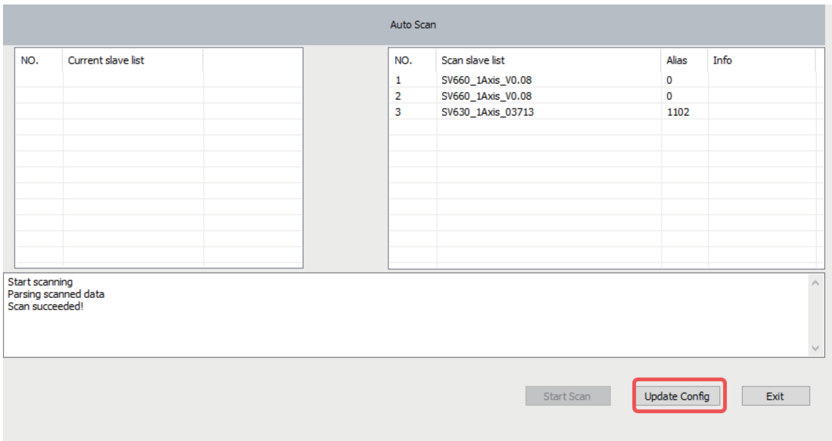
1. In "System Options", check whether the option "Automatically create axes and associate slaves when creating new slaves" is ticked. If not, tick it.



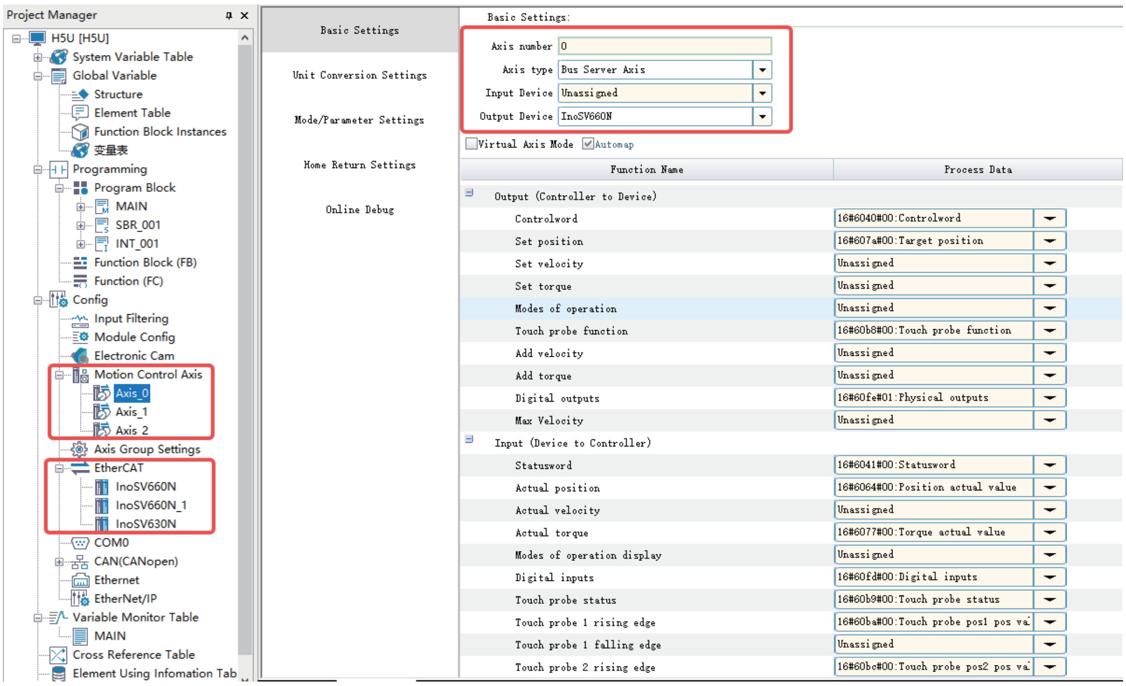

2. Check whether the computer host is normally connected to a PLC and whether the EtherCAT network port of the PLC is normally connected to a servo drive.
   The way to test the connection of PLC to the computer host is as follows.




3. In the toolbox, check whether the EtherCAT device list includes the IS620N. If not, add the corresponding XML file.
4. Select the master station, right-click, select "Auto Scan", and the "Auto Scan" dialog box will pop up.
5. Click "Start Scan". After the scan is completed, click "Update Config" to complete the creation of a bus servo axis.

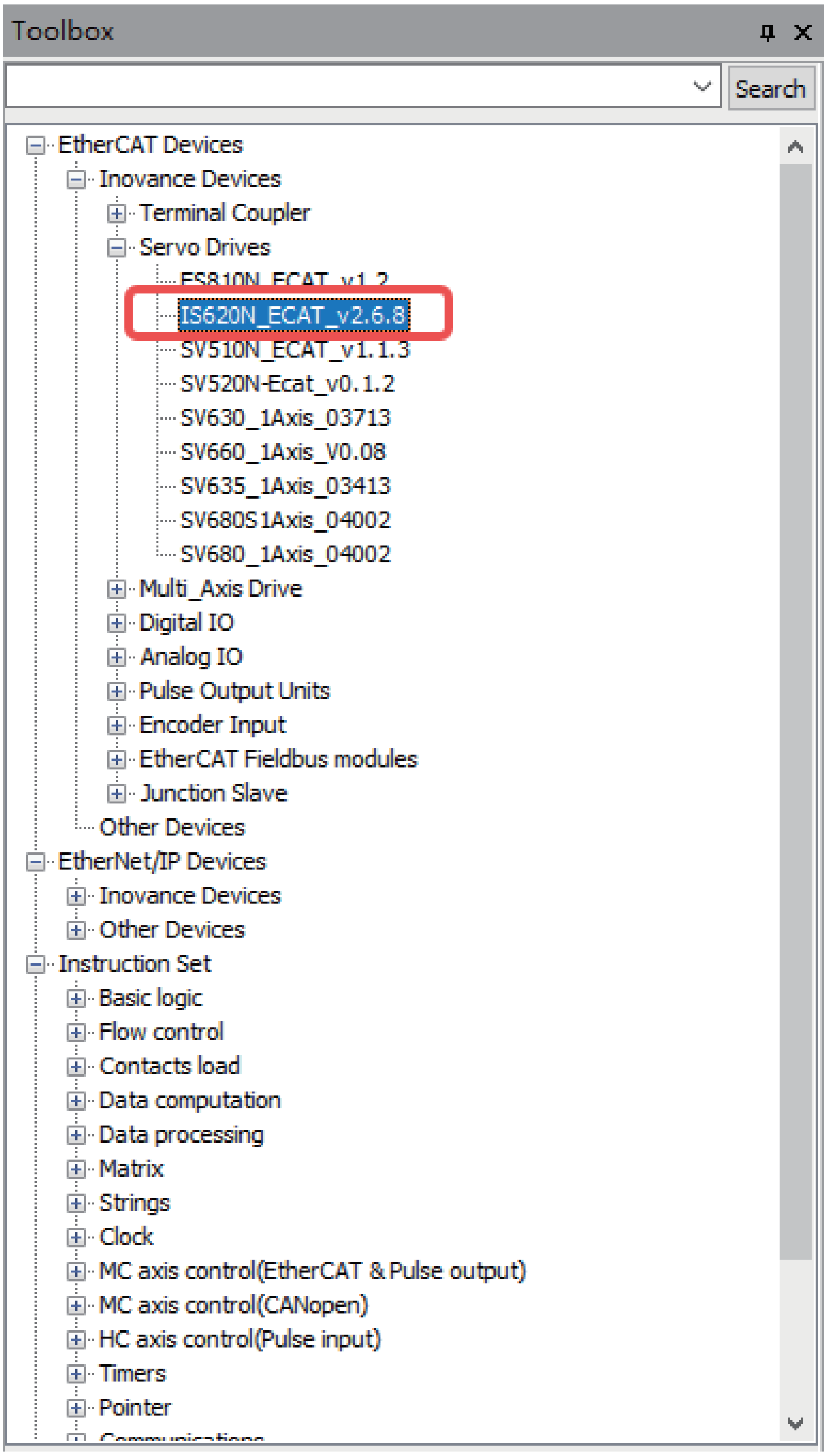



6. After the scan is completed, you can see the servo drive and bus servo axis in the device tree.

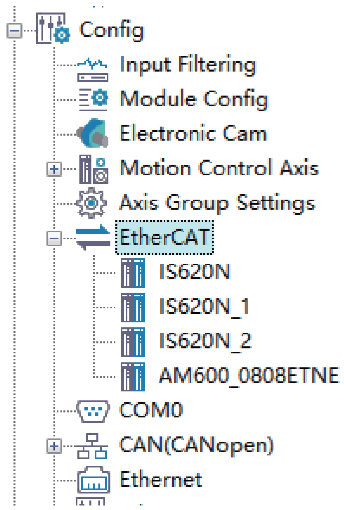


## Manual adding

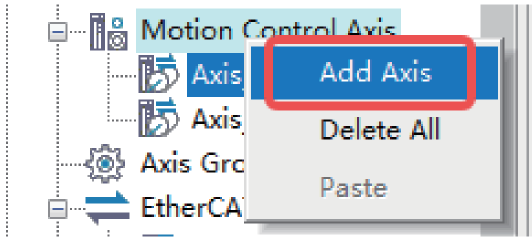
1. Open the toolbox and locate the IS620N. If it is unavailable, you can add the device profile ESI for IS620N to the toolbox by importing the file.



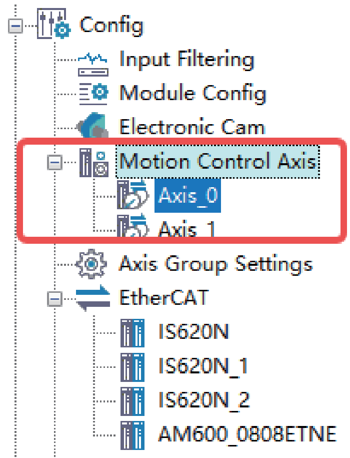

2. Double-click the IS620N in the toolbox to add an IS620N to the device tree EtherCAT configuration. If you have ticked "Automatically create axes and associate slaves when creating new slaves" in the "System Options", a bus servo axis will be added when you add the IS620N. Otherwise, the bus servo axis will not be added automatically. The assumption in this routine is that "Automatically create axes and associate slaves when creating new slaves" is not ticked.




3. You can add a motion control axis by choosing "Motion Control Axis" in the device tree, and right-clicking the "Add Axis". You can establish two axes by repeating this operation twice.




Configuration after adding two axes:




4. Set the first axis as the bus servo axis and associate it with IS620N. Set the second axis to be the local pulse axis and associate it with the Y0/Y1 channel.

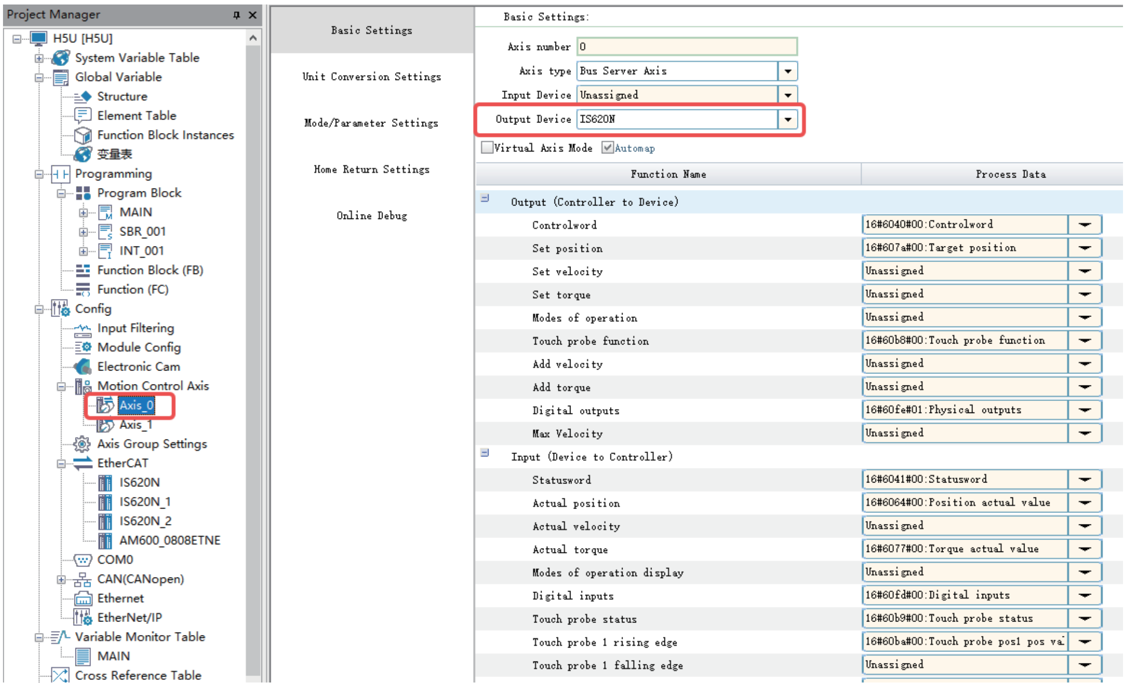


Figure 12-2 Adding the bus servo drive

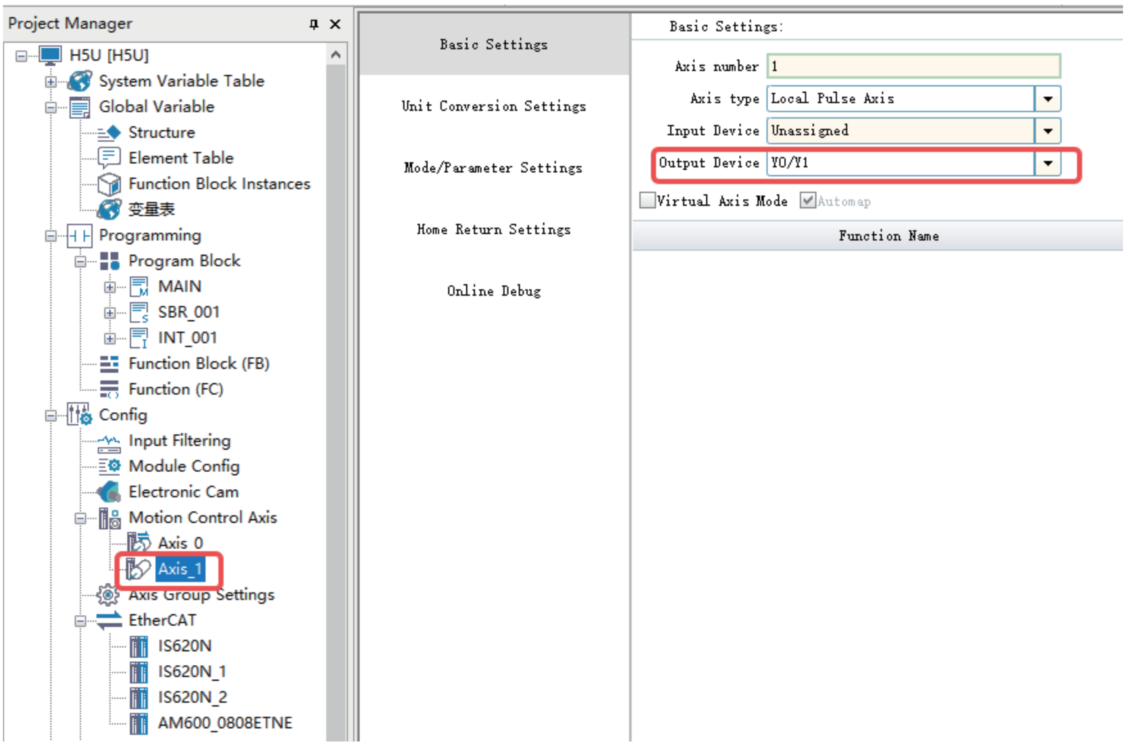


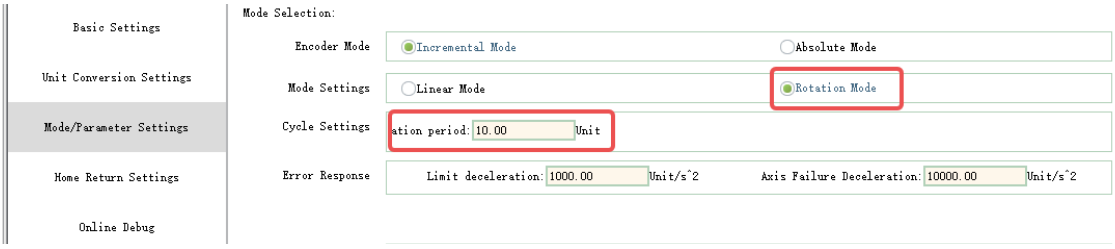
Figure 12-3 Local output axis

## 12.2.3 Setting Axis Parameters

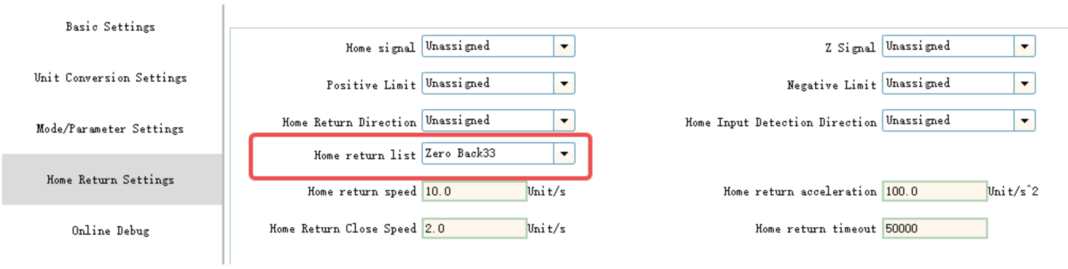
### 12.2.3.1 Bus Servo Axis

You can set the relevant parameters of an axis based on actual working conditions and requirements. The settings in this routine are as follows.

1. Set the mode to rotary and the rotation cycle to 10.



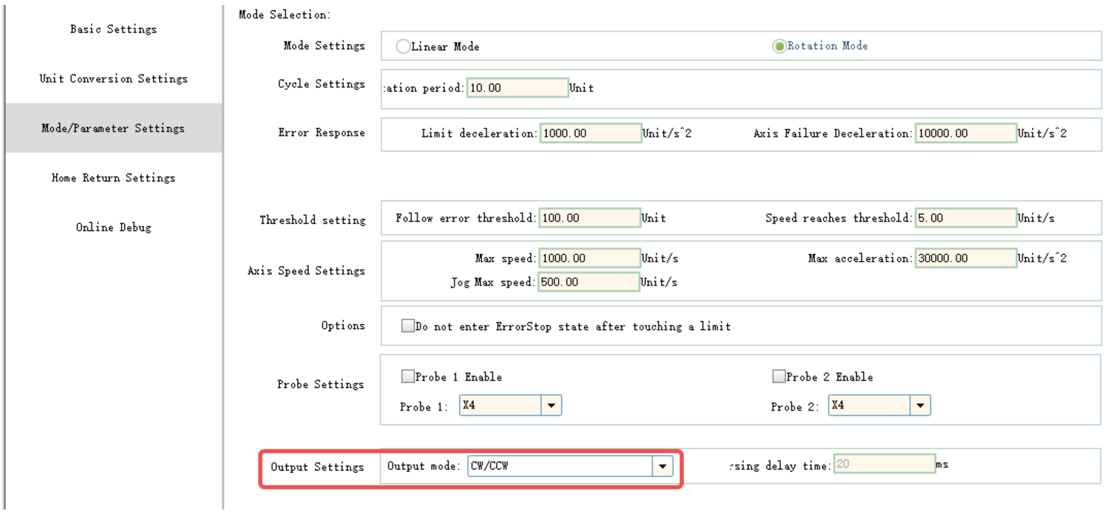

2. Set the homing mode to 33.



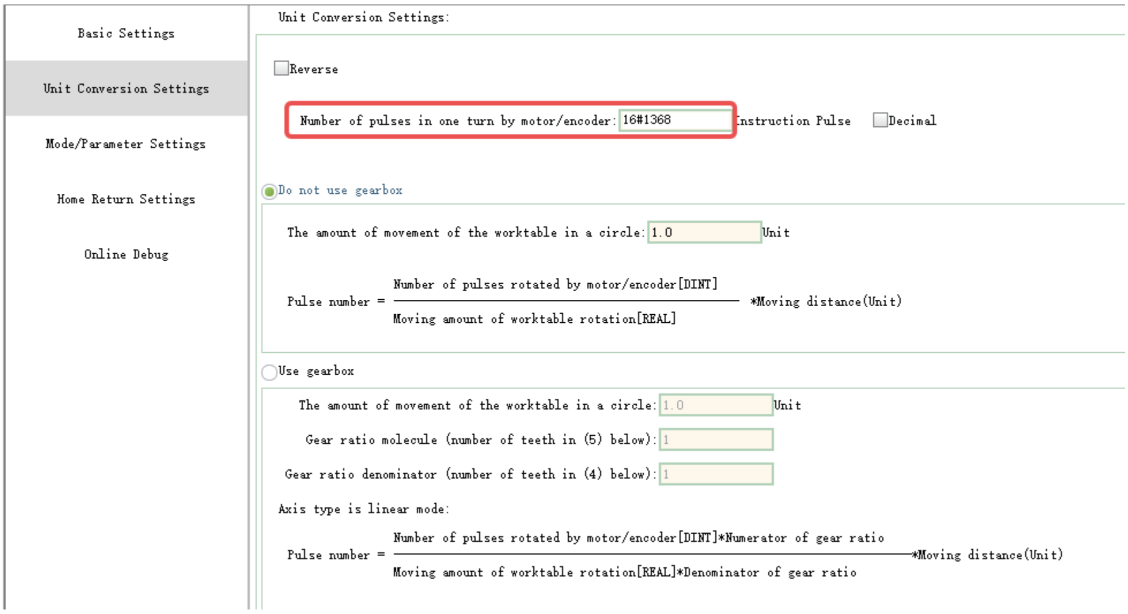

## 12.2.3.2 Local Pulse Axis

You can set the relevant parameters of an axis based on actual working conditions and requirements. The settings in this routine are as follows.

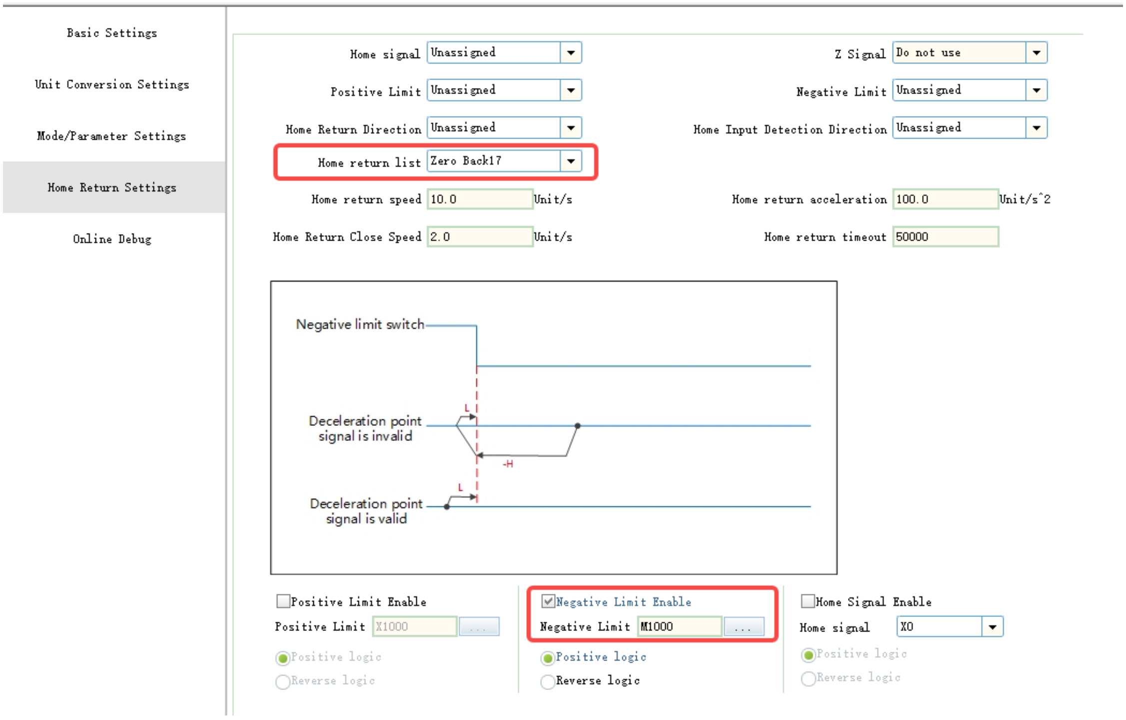
1. Set the pulse output mode to CW/CCW.




2. Set the "Pulses per motor/encoder revolution" to 5000 (16#1388).

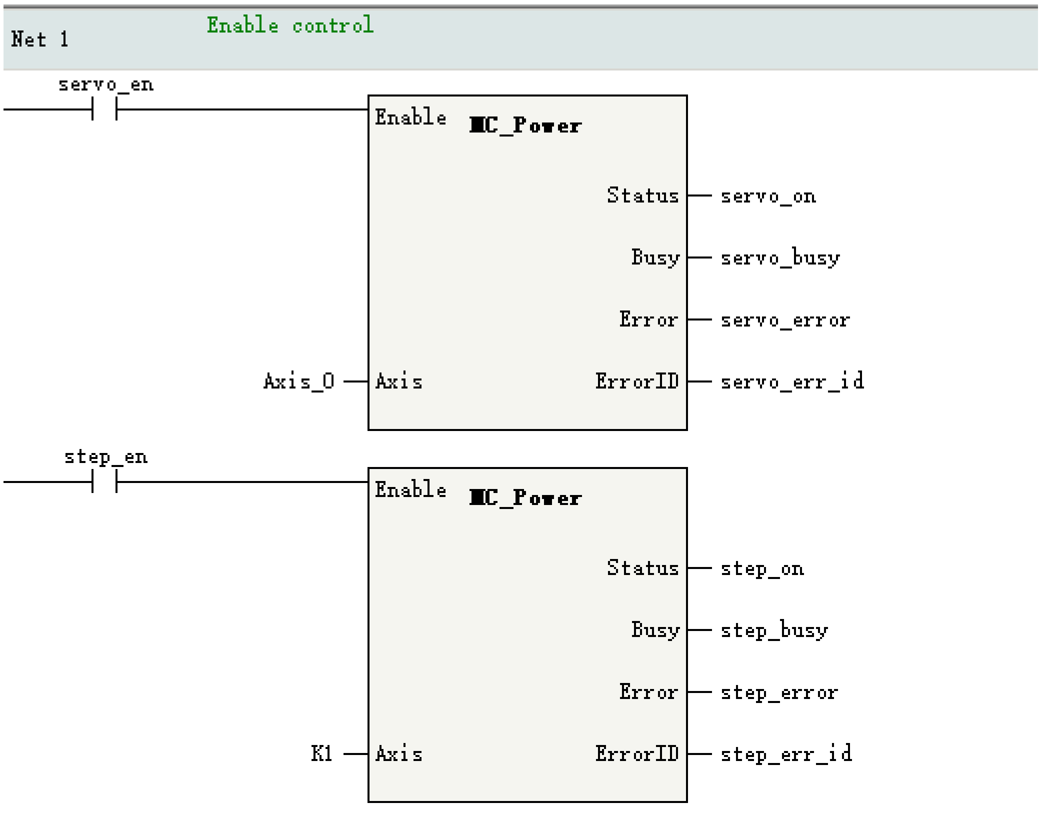



3. Set the homing mode to 17 and the negative limit to M1000.

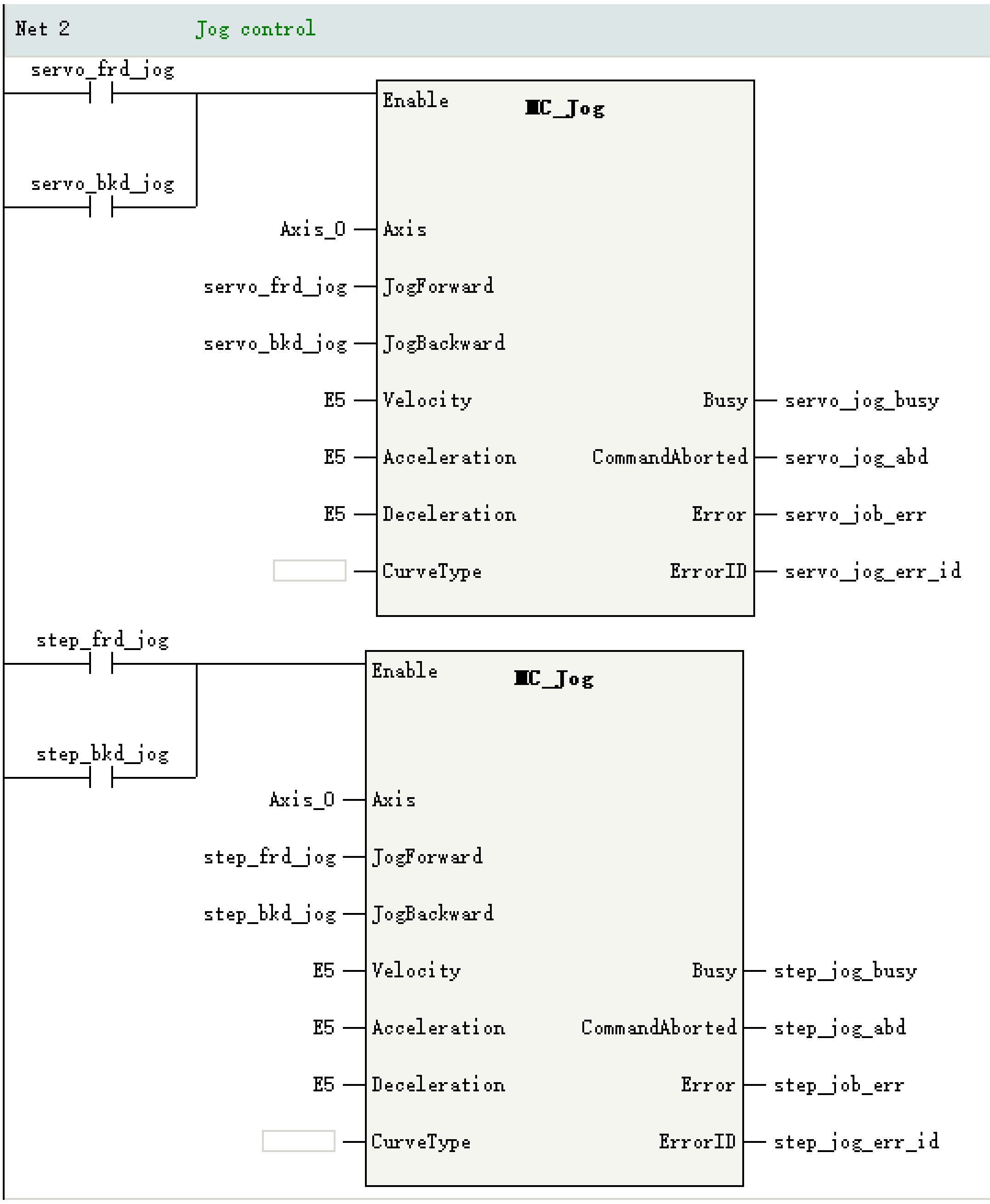



## 12.2.4 Writing a Program

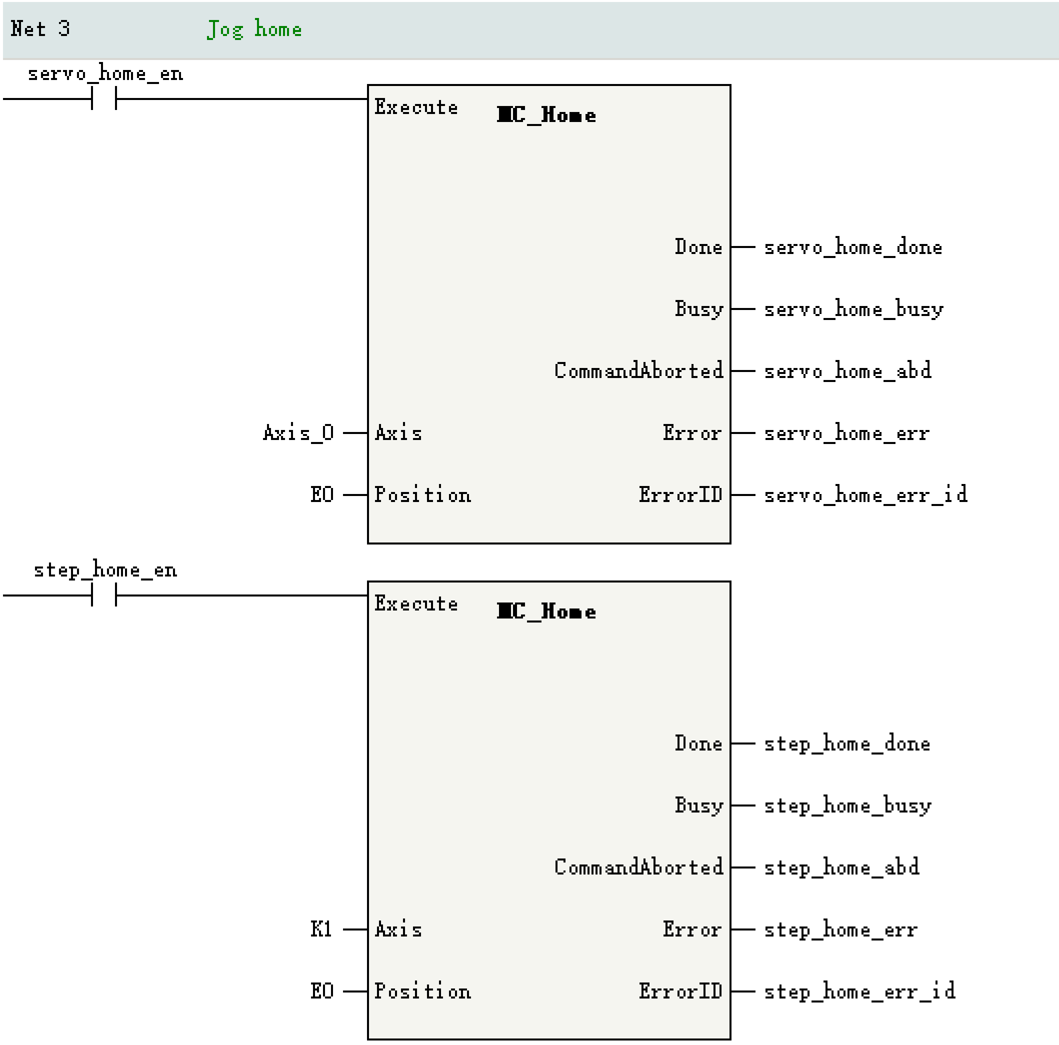
1. The function block MC_Power is used to control the enabling of an axis. MC_Power is an instruction and therefore does not need to be instantiated. This also applies to the following instructions.



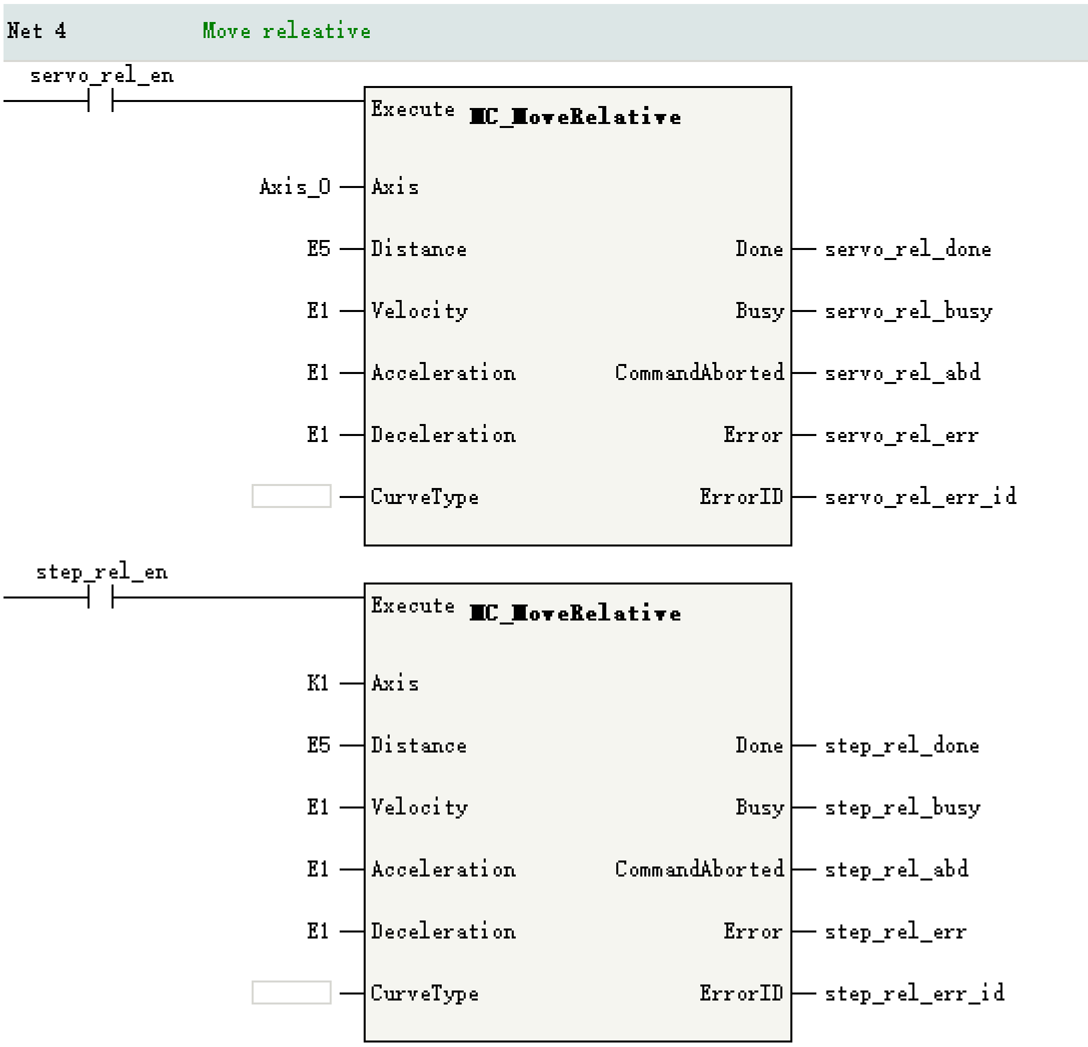

2. Call instruction MC_Jog for a test.




3. Call instruction MC_Home for a test.

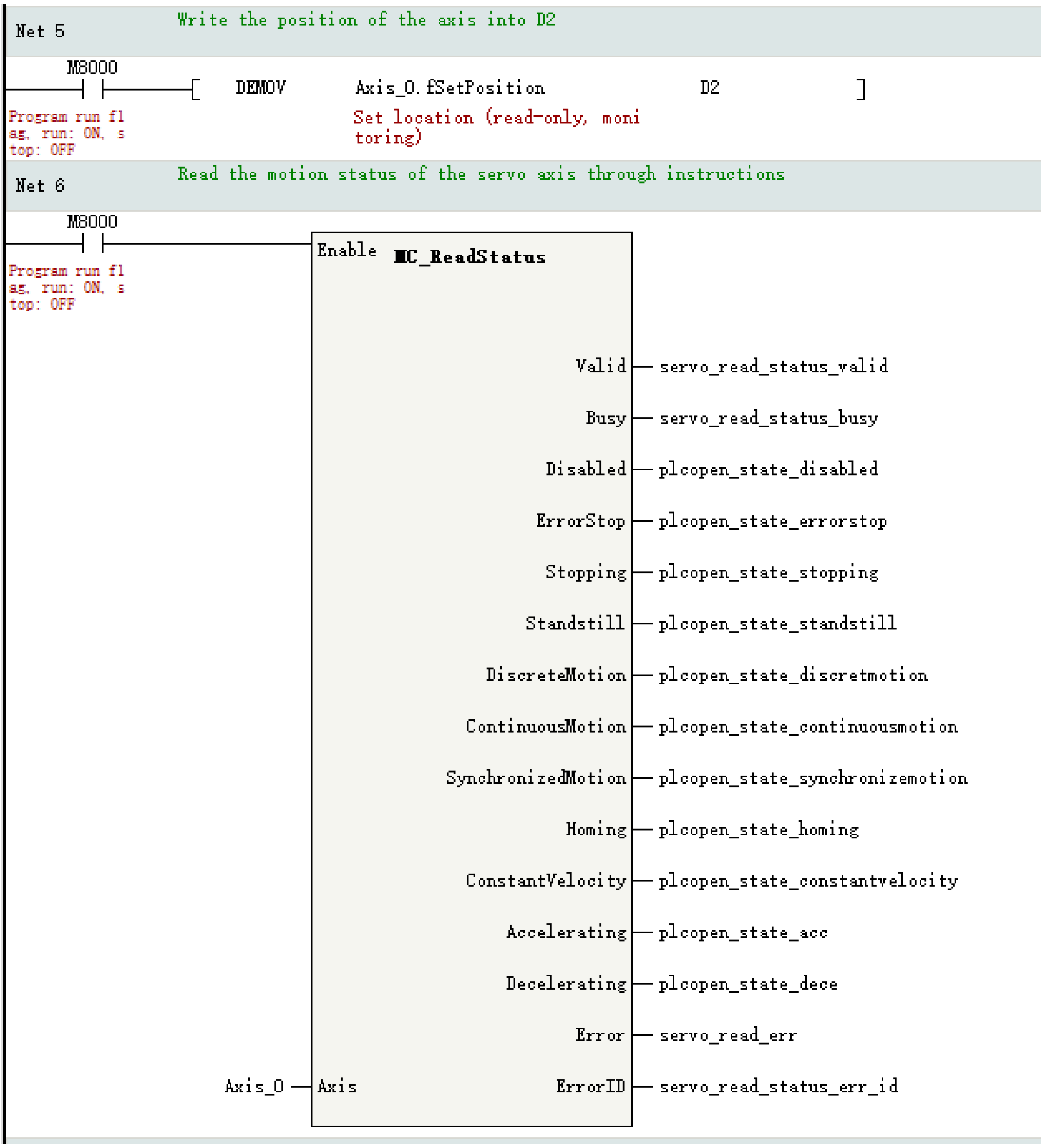



4. Call instruction MC_MoveRelative to test discrete motion.




5. Monitoring axis status

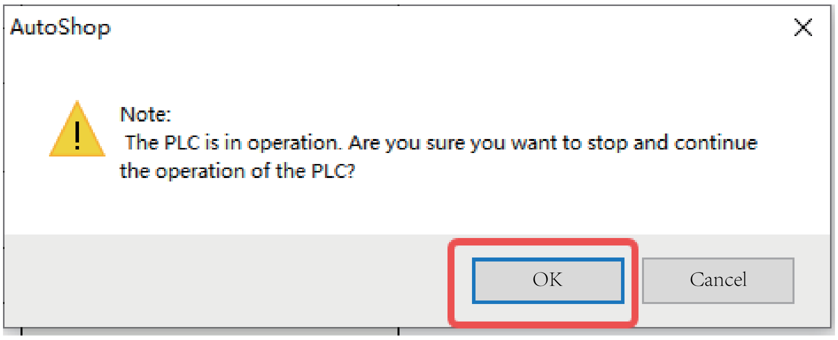
   In the PLC program, the status of the axes can be monitored through function blocks or axis system variables.



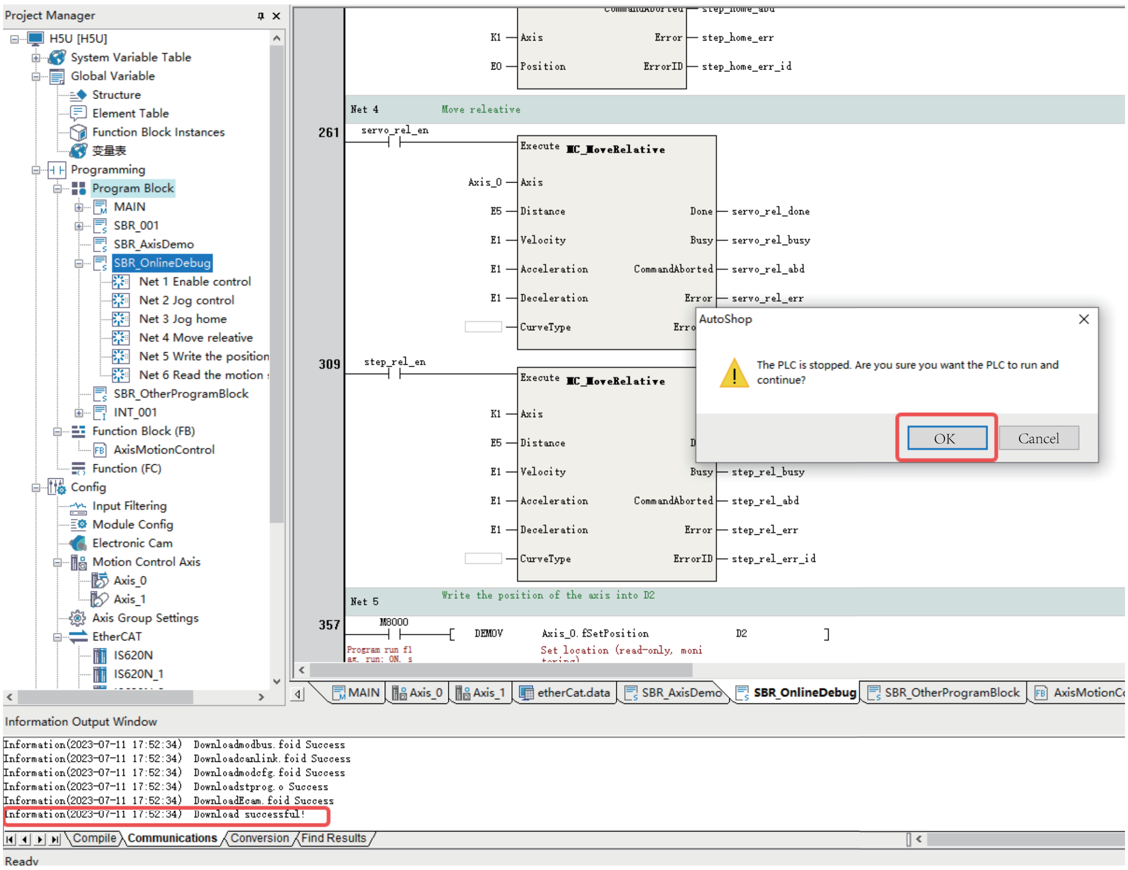

## 12.2.5 Downloading a Project

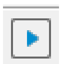
After completing the programming and project setup, perform the download operation as follows.

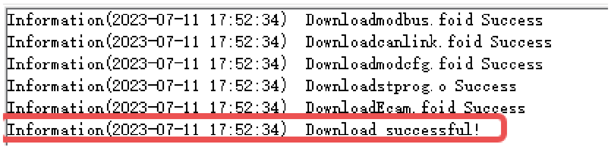
1. Click the download button , in which case the compilation operation is performed first.
2. After the compilation is completed, if the PLC is in the running state, the following dialog box will pop up. Select "OK" to go to step 3. If the PLC is in the stopped state, download the project directly and go to step 4.




3. If the PLC is in the running state before you download the program, you can see the download completion prompt after the download is completed. In the dialog box that pops up, select "OK" to switch the PLC to the running state.




4. If the PLC is in a stopped state before you download the program, the information output window will pop up the download completion prompt after the download is completed. Manually click the start button  to switch the PLC to the running state.

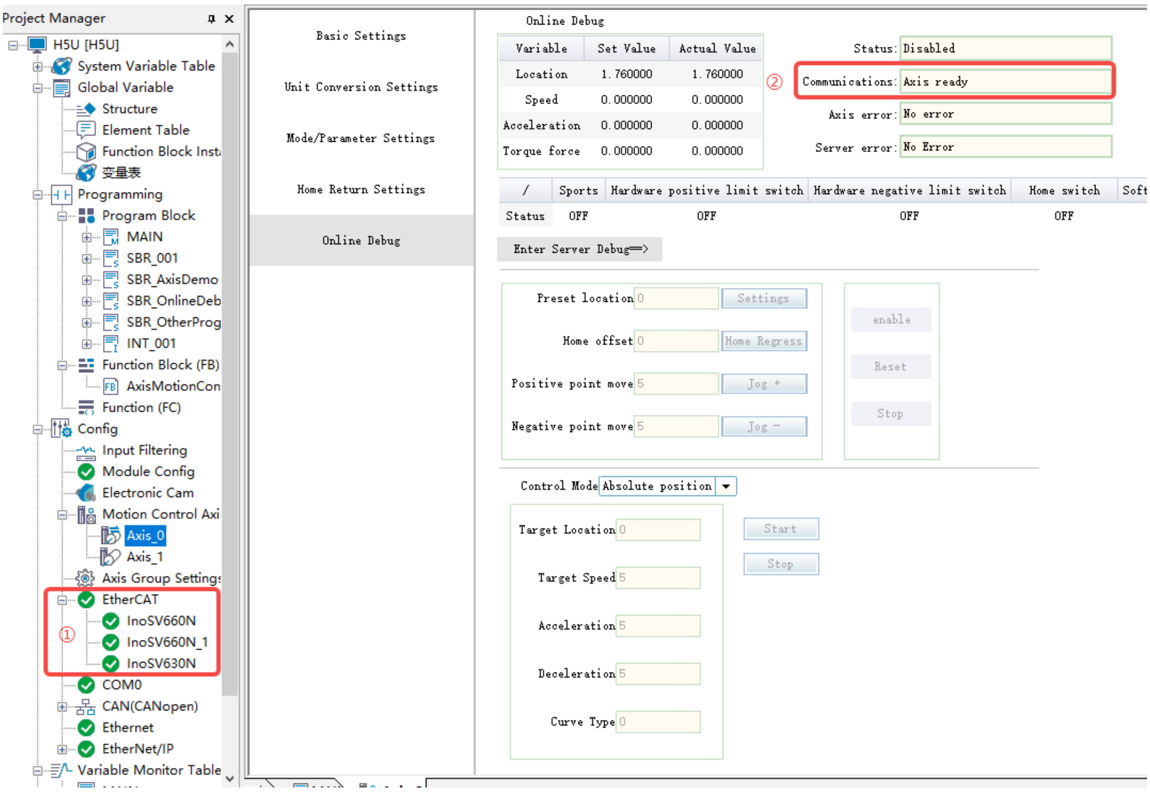


## 12.2.6 Basic Motions

### 12.2.6.1 Pre-conditions

To complete the basic action in this routine, it is recommended to first enter the monitoring mode, and click the monitoring button  to enter the monitoring mode.

After entering the monitoring mode, you can see that the EtherCAT bus startup is completed and the servo axis initialization is completed.



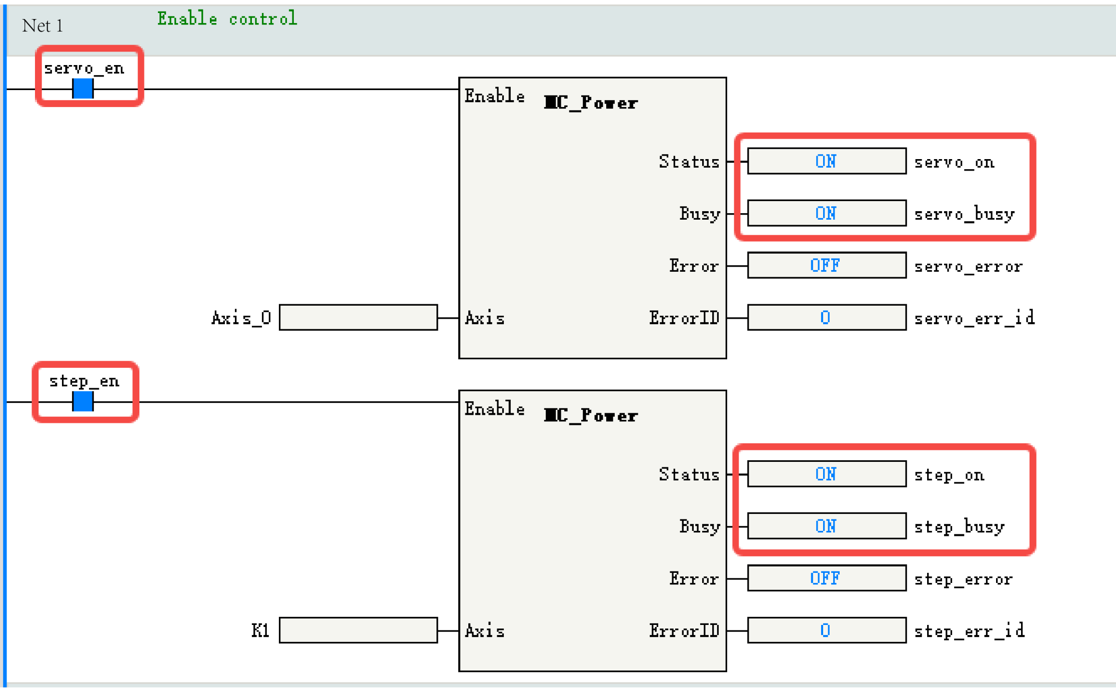

① EtherCAT initialization completed

② Axis initialization completed

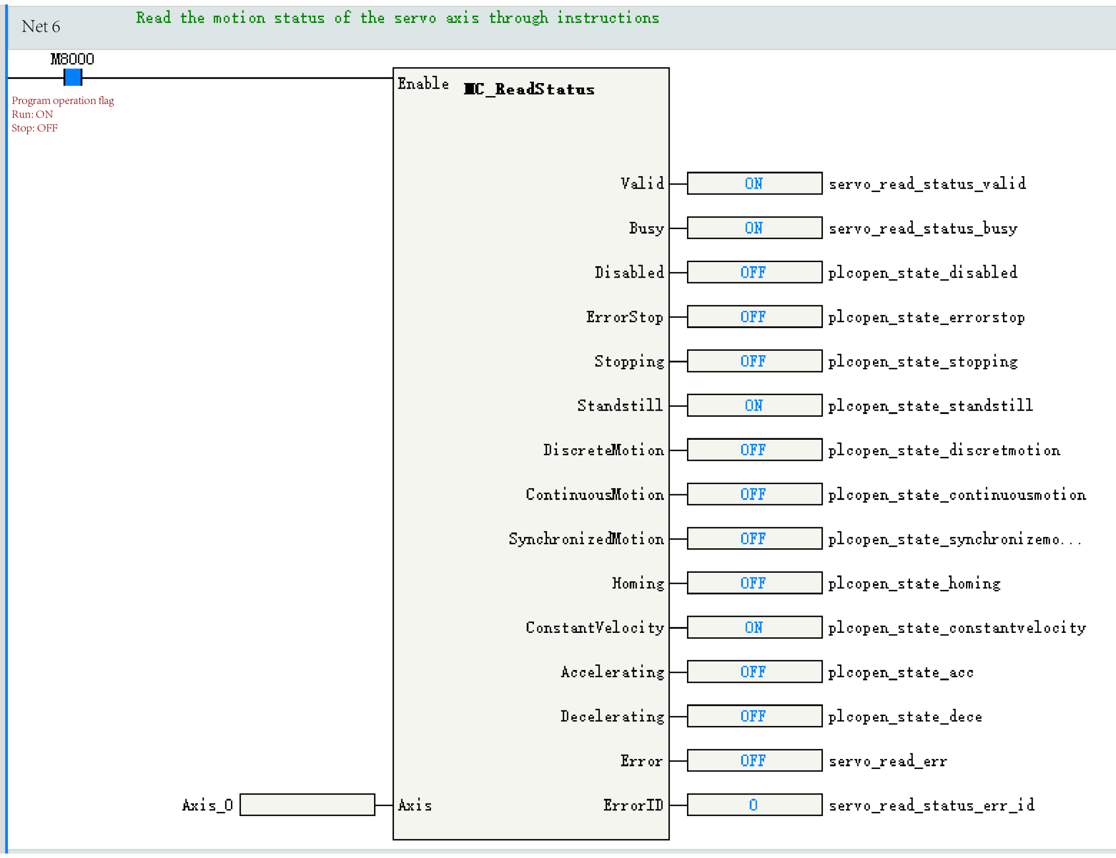
The following describes the ways to control the servo axis motion through PLC program and online commissioning.

### 12.2.6.2 PLC Program Control

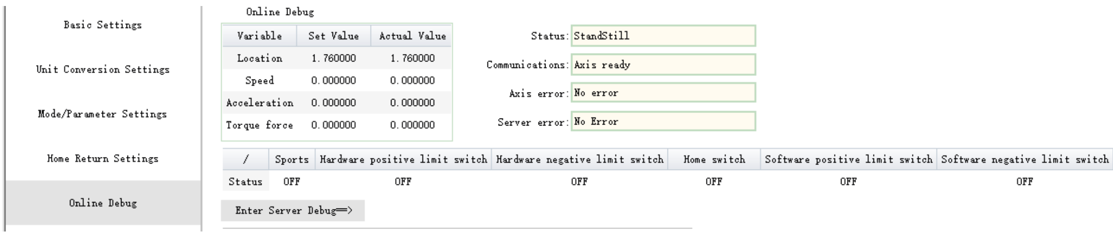
1. Enable control: Set the two BOOL variables of servo_en and step_en to TRUE, and the output of servo_on and step_on will be valid after the bus servo axis and local pulse axis are enabled.




Call the MC_ReadStatus instruction to view the status of the bus servo axis.

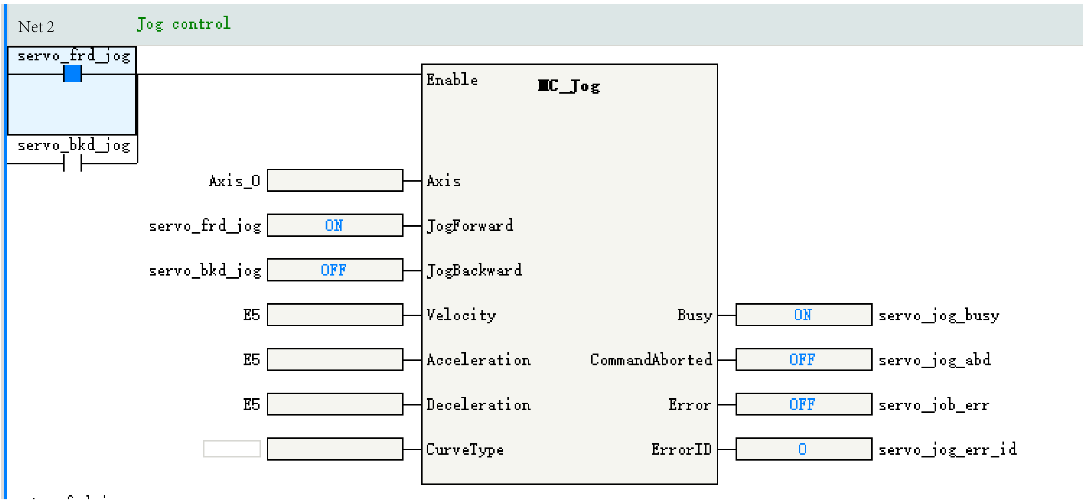


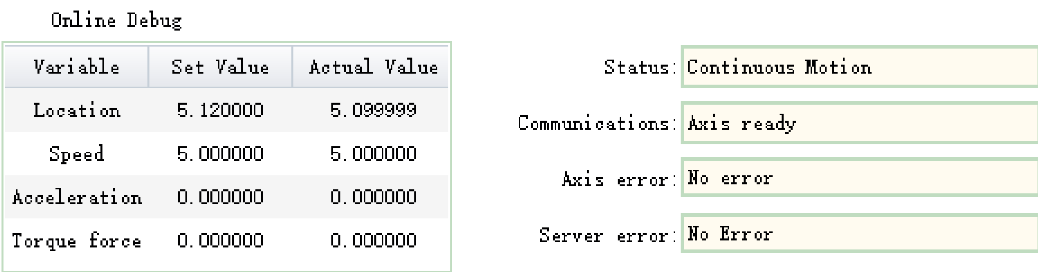

Alternatively, enter the online commissioning interface to view the axis status, which is standstill in this example.



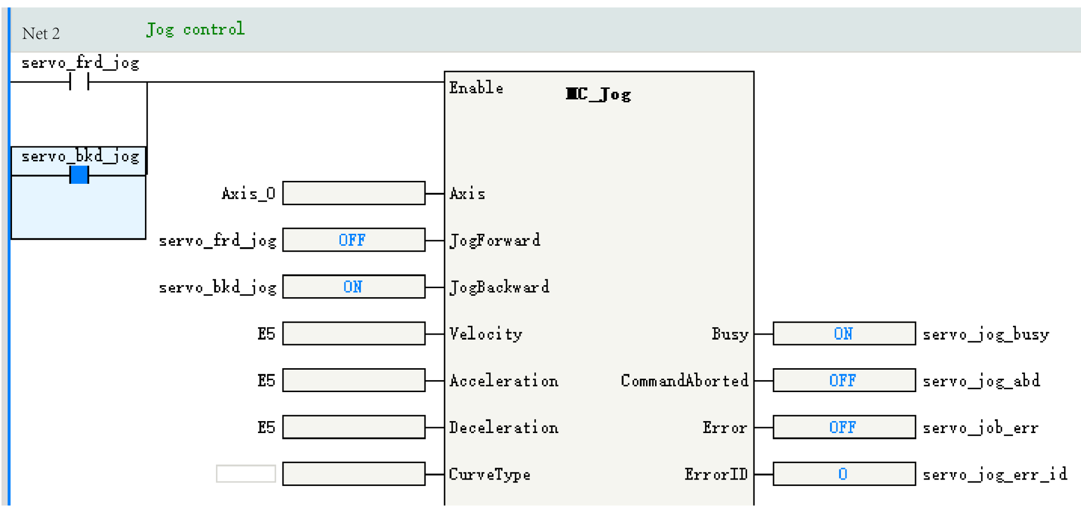

2. Jogging operation of the bus servo axis

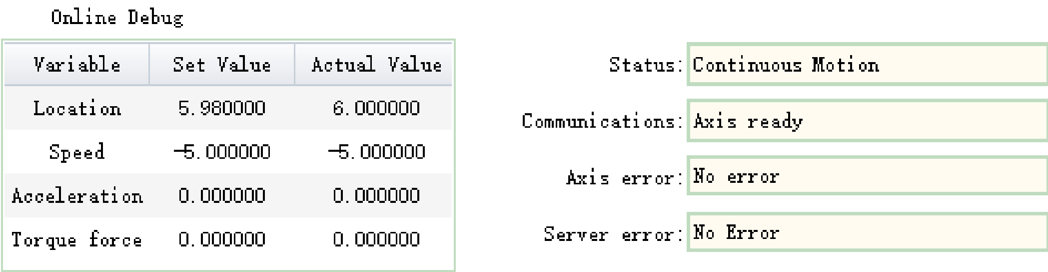
- When the variable servo_frd_jog is set to TRUE, the bus servo axis starts to run forward at the velocity reference, and the actual axis driven by the servo drive runs forward at 5 rpm/s.



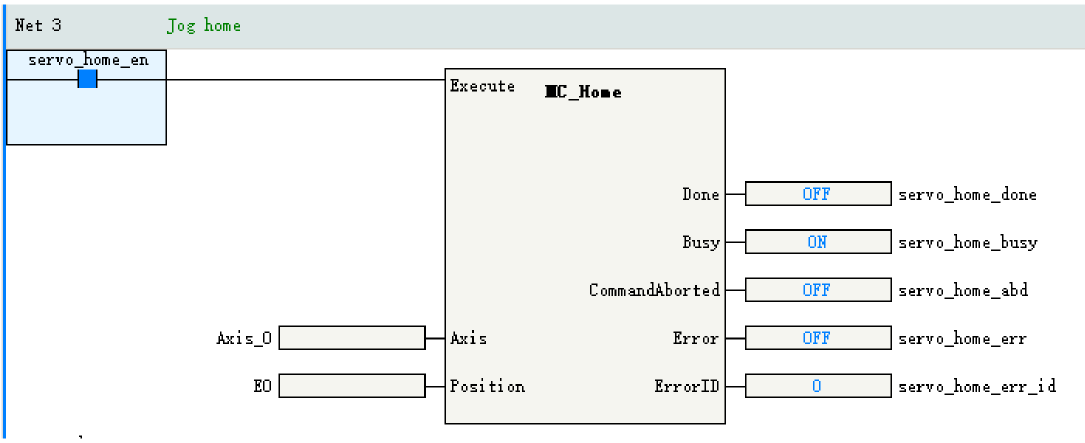

- When the variable servo_bkd_jog is set to TRUE, the bus servo axis starts to run in reverse at the velocity reference, and the actual axis driven by the servo drive runs in reverse at 5 rpm/s.



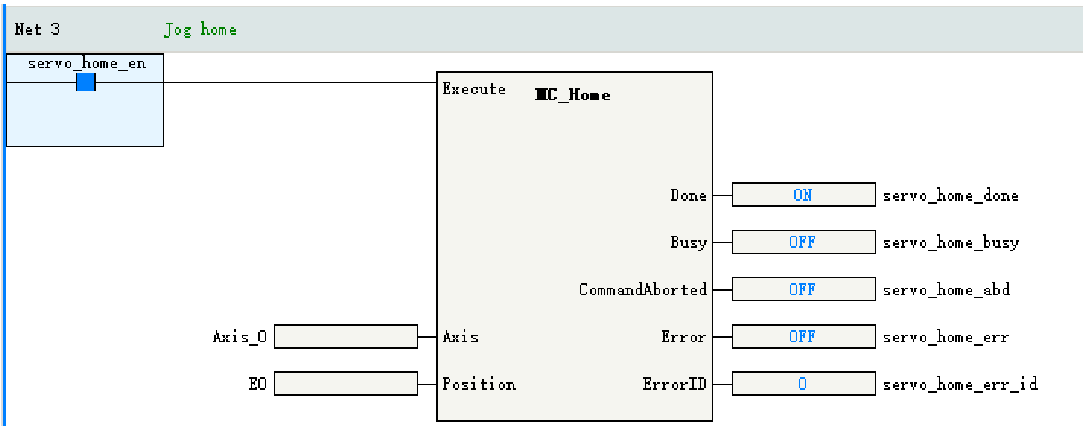



3. Homing test of the bus servo axis

- When the servo_home_en is set to ON, the servo_home_busy will automatically set to ON.

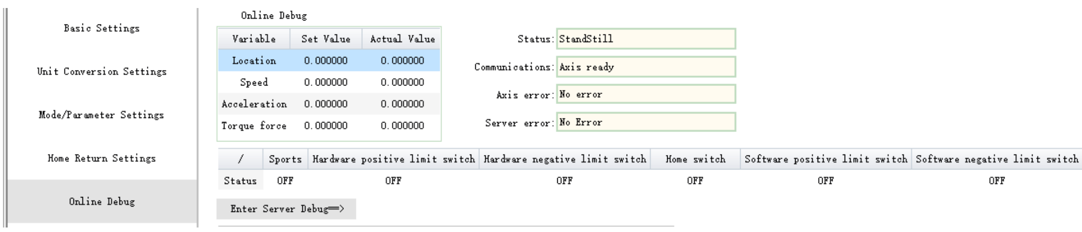



- When the servo motor encounters the Z signal, the homing is automatically completed, in which case the servo_home_done is set to ON, and the servo_home_busy is automatically set to OFF.

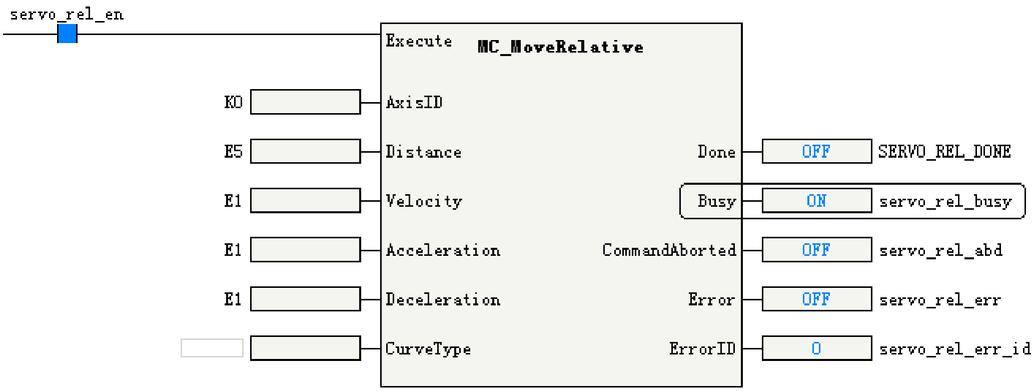



4. Relative positioning test of the bus servo axis

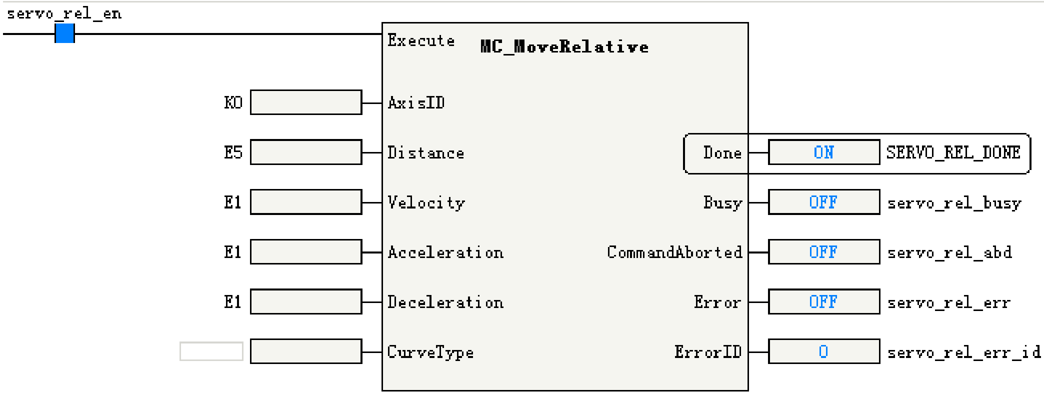
- The current position of the bus servo axis is as follows:



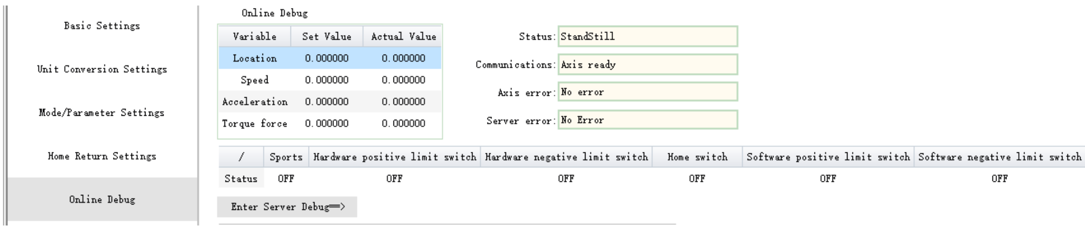

- When the variable servo_rel_en is set to TRUE, the output of variable servo_rel_busy by the function block is TRUE, in which case the bus servo axis starts to run.




- After the positioning is completed, the output of variable servo_rel_done is TRUE.




- Through the online commissioning interface, you can see that the set position of the servo at this time has increased by 5 user units compared with the original.

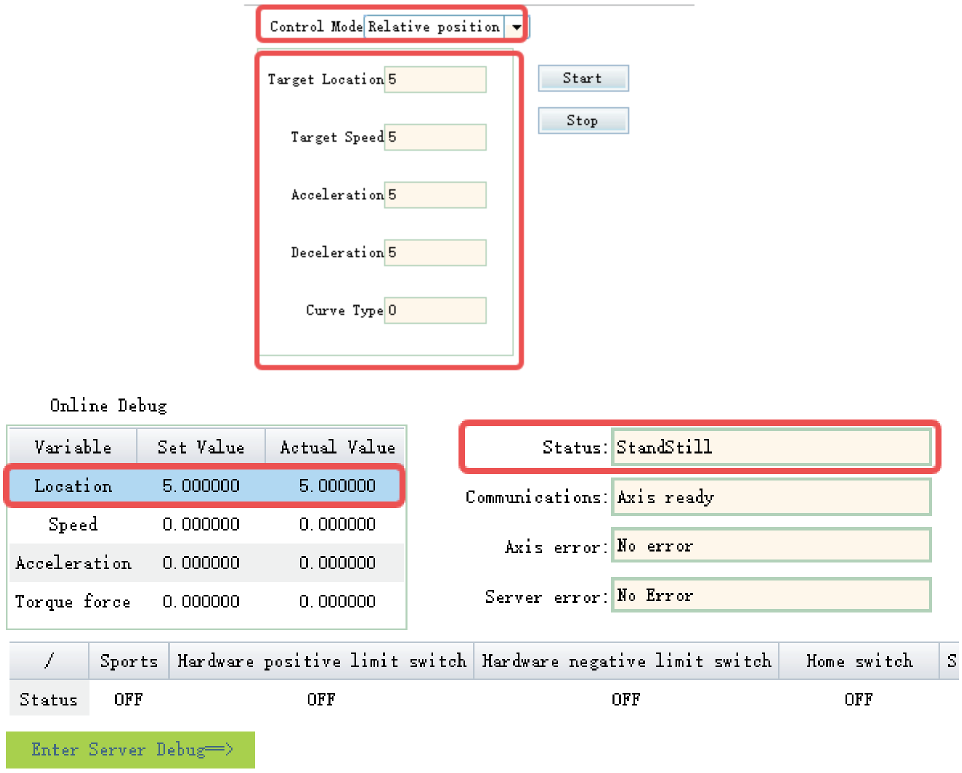



### 12.2.6.3 Online Commissioning

1. Open the online commissioning interface of the local pulse axis. Click "Enter servo debug" to enter the commissioning mode.
2. Click "Enable" to enable the servo drive.
3. Click "Homing" to start homing. Correctly operate the negative limit variable M1000 to complete the homing action.

   - When M1000 is set to FALSE, homing begins and the axis returns to home through reverse motion.
   - When M1000 is set to TRUE, the axis decelerates to stop after triggering the negative limit, and then moves forward at a low speed.
   - Set M1000 to FALSE and complete homing.

4. Choose "Relative locate mode", set the parameters as follows, and click "Start" to complete the relative positioning test.




# 12.3 Configuring Motion Control Axes

## 12.3.1 Bus Servo Axis versus Local Pulse Axis

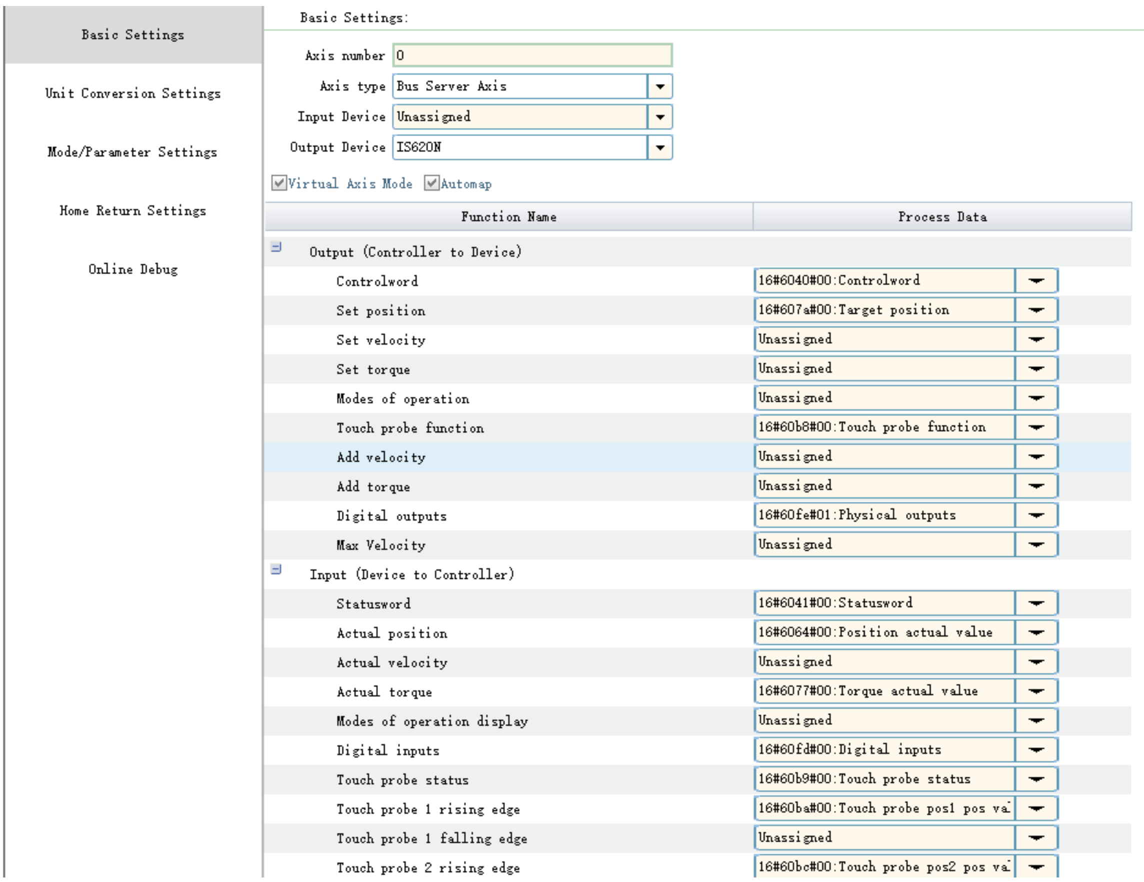
The local pulse output and the EtherCAT drive are controlled with the same set of instructions, and share the same axis structure in design. The main differences between them are listed below.

| Item | Local Pulse Output | EtherCAT Bus Drive |
|---|---|---|
| Different axis types | A local pulse axis needs to be selected. | A bus servo axis needs to be selected. |
| Different output devices | Local IO terminals need to be set up, with every two of them forming a group, that is, Y0/Y1, Y2/Y3, Y4/Y5, and Y6/Y7 groups. | The PDO needs to be configured and mapped into the loop variable of the axis. |
| Pulse output forms | The two supported pulse forms are pulse+direction and CW/CCW, which can be selected in the "Mode/Parameter setting" -> "Output setting". | No setup is required. |

| Item | Local Pulse Output | EtherCAT Bus Drive |
|---|---|---|
| Probe function | Two probes are supported, and each probe terminal can be selected from X0 to X7. This function needs to be selected in the "Mode/Parameter setting" -> "Probe setting". | The probe terminals need to be configured according to the application guide for the EtherCAT drive. |
| Homing settings | The supported homing modes (except for the Z signal) are specified in the CiA 402 protocol. The limit signal and home signal of the local pulse output axis can be selected through the interface "Set the homing". | The homing modes No 1 to No 35 specified in the CiA 402 protocol are supported in setting, while the limits and home signals need to be set on the drive side. |

## 12.3.2 Basic Settings

The basic settings interface of an axis is used to set the type of the axis, and select a physical drive. The basic settings interface is shown in the following figure.




- **Axis No**: Each axis is assigned a separate number in the range of 0 to 36, which cannot be modified manually. An axis number can be used as a unique input parameter of the MC instruction to access the axis.
- **Axis type**: Optional axis types are bus servo axis, local pulse axis, bus encoder axis (not supported before version 4.2.0.0), and local encoder axis.
- **Input device**: It is used only for bus encoder axes and local encoder axes.

- **Output device**: It is active only in bus servo axis and local pulse axis modes. In case of a bus servo axis, it is used to select EtherCAT servo drives; in case of a local pulse axis, it is used to select the local high-speed output terminals. Four groups of high-speed output terminals including Y0/Y1, Y2/Y3, Y4/Y5, and Y6/Y7 are available for selection.
- **Virtual axis mode**: It is active only in bus servo axis and local pulse axis mode. When the virtual axis mode is ticked, the axis will no longer control the drive selected by the output device (high-speed output terminal), but will execute motion control instructions internally on a virtual servo axis.
- **Loop variables**: It is active only in bus encoder axis and bus servo axis modes. The EtherCAT slave communicates periodically based on the PDO and an axis is connected to the object dictionary of the EtherCAT slave through a loop variable. When automatic mapping is selected, the mapping process is assigned automatically and cannot be configured manually.

## Loop variables of the bus servo axis

The list of variables is as follows. For the detailed meaning of the object dictionary, see the standard CiA 402 protocol.

Table 12–1 List of Variables

| Loop Variable | Object Dictionary | Function |
|---|---|---|
| Controlword | 0x6040 | Control word |
| Set position | 0x607a | Corresponding to the target position in servo drive CSP mode |
| Set velocity | 0x60ff | Reserved |
| Set torque | 0x6071 | Corresponding to the target torque in CST mode of the servo drive. |
| Modes of operation | 0x6060 | Control mode, with a range of setting as follows.<br>6: Homing mode<br>8: Cyclic synchronous position (CSP) mode<br>9: Cyclic synchronous velocity (CSV) mode<br>10: Cyclic synchronous torque (CST) mode |
| Touch probe function | 0x60b8 | Probe control word |
| Add velocity | Reserved | Reserved |
| Add torque | Reserved | Reserved |
| Digital outputs | 0x60fe:1 | Digital output (DO) |
| Max Velocity | 0x60FF | Maximum velocity |
| Statusword | 0x6041 | Status word |
| Actual position | 0x6064 | Feedback position |
| Actual velocity | 0x606c | Feedback velocity |
| Actual torque | 0x6077 | Feedback torque |
| Modes of operation display | 0x6061 | Current control mode |
| Digital inputs | 0x60fd | DI terminal status, with functions as follows:<br>Bit2: Home switch<br>Bit1: Positive limit switch<br>Bit0: Negative limit switch |
| Touch probe status | 0x60b9 | Touch probe status |
| Touch probe 1 rising edge | 0x60ba | Probe 1 position on the rising edge |
| Touch probe 1 falling edge | 0x60bb | Probe 1 position on the falling edge |

| Loop Variable | Object Dictionary | Function |
|---|---|---|
| Touch probe 2 rising edge | 0x60bc | Touch probe 2 positive edge |
| Touch probe 2 negative edge | 0x60bd | Probe 2 position on the falling edge |
| Errorcode | 0x603f | Drive error code |

## Parameters that need to be set for unit conversion

Table 12–2 Related Parameters

| Parameter | Function |
|---|---|
| The number of pulses per revolution of the motor/encoder | Set the number of pulses required for the motor to rotate one turn according to the encoder resolution. |
| Gear change mechanisms in use or not | Specify whether gear change mechanisms are in use or not. |
| Distance per revolution of the motor/ encoder | The workpiece-moving distance per revolution of the motor when no gear change mechanism is in use |
| Distance per revolution of the worktable | The distance per revolution on the workpiece side when gear change mechanisms are in use |
| Gear ratio on the workpiece side | Set a gear ratio on the workpiece side. |
| Gear ratio on the motor side | Set a gear ratio on the motor side. |

The bus drives (local pulse axes) use pulse units when controlling a motor, and use common measurement units for motion control instructions, such as millimeters, degrees, and inches, which are called user units (Unit). According to the configuration parameters, the two units are converted to each other within an axis. The conversion between the two units is divided into the following modes.

- With gear change mechanisms
  When the gear change mechanisms are not in use, the conversion equation from user unit to pulse unit is as follows.

$$\text{Number of pulses (unit: pulse)} = \frac{\text{Number of pulses per revolution of the motor/encoder [DINT]}}{\text{Number of pulses per revolution of the motor/encoder [REAL]}} \times \text{Distance (unit: Unit)}$$

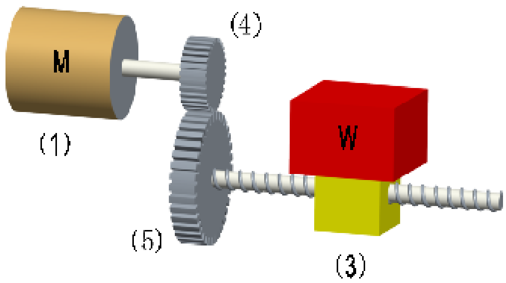
  Take the Inovance 20-bit encoder as an example. The set parameters are as follows.

  Number of pulses per revolution of the motor/encoder = 1048576

  Distance per revolution of the motor/encoder = 1

  Then, when the target displacement given by the relative positioning instruction is 10, the actual number of pulses sent by the motion control axis is 10485760, and the motor rotates by 10 revolutions.

- With gear change mechanisms
  Typical working condition in linear mode is shown in the following figure.

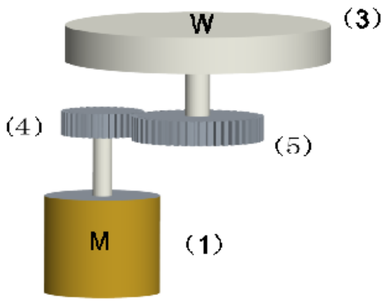



In the figure, (1) is the servo motor, (3) is the workpiece, (4) is the gear ratio denominator, and (5) is the gear ratio numerator.

The calculation equation from user unit to pulse unit is as follows.

$$\text{Number of pulses (unit: pulse)} = \frac{\text{Number of pulses per revolution of the motor/encoder [DINT] x Gear ratio numerator [DINT]}}{\text{Distance per revolution of the workbench [REAL] x Gear ratio denominator [DINT]}} \times \text{Distance (unit: Unit)}$$

Typical working condition in ring mode is shown in the following figure.




In the figure, (1) is the servo motor, (3) is the workpiece, (4) is the gear ratio numerator, and (5) is the gear ratio denominator.

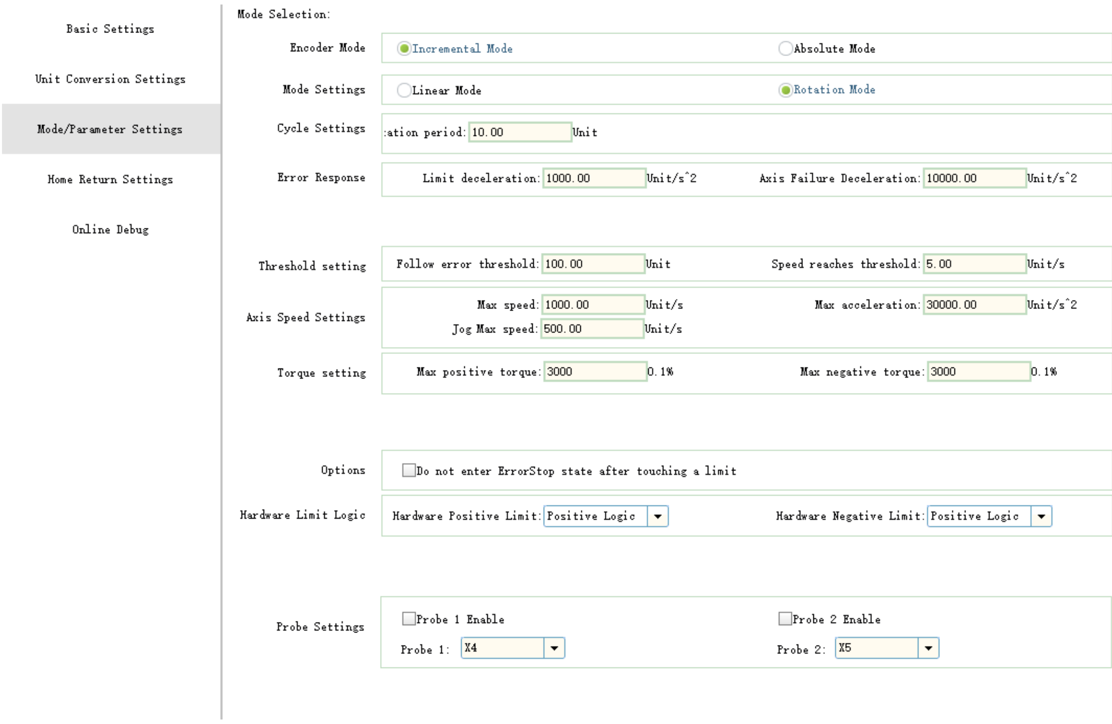
The calculation equation from user unit to pulse unit is as follows.

$$\text{Number of pulses (unit: pulse)} = \frac{\text{Number of pulses per revolution of the motor/encoder [DINT] x Gear ratio numerator [DINT]}}{\text{Distance per revolution of the workbench [REAL] x Gear ratio denominator [DINT]}} \times \text{Distance (unit: Unit)}$$

## 12.3.3 Mode/Parameter Settings

### 12.3.3.1 Configuration Interface

The following figure shows the "Basic setting" page. The parameter list varies with the selected axis type.




### 12.3.3.2 Encoder Mode

The encoder mode is only valid in the bus servo axis mode and is used with incremental encoder servo drives and absolute encoder servos. Choose the mode according to the type of servo drive actually used. The processing on the PLC side is as follows.

#### Incremental mode

The increase in the number of revolutions caused by the overflow of the 32-bit counter of servo drive encoder is not taken into account on the PLC side. The PLC does not save the current position of the encoder when the power is turned off and on again. After the second power-on, the current position of the axis is calculated only according to the position of a single revolution given by the servo drive.

#### Absolute mode

The increase in the number of revolutions caused by the overflow of the 32-bit counter of servo drive encoder is taken into account on the PLC side. The PLC saves the current position given the encoder when the power is turned off and on again. After the second power-on, the encoder position of the axis saved inside the PLC and the position given the servo drive are read during the initialization to calculate the current absolute position of the axis.

***Note***

If an Inovance servo is used and process parameters 200B.3Bh (low-order 32 bits of mechanical absolute position) and 200B.3Dh (high-order 32 bits of mechanical absolute position) are configured, the axis calculates its current absolute position during initialization. The calculation is based on the 64-bit mechanical absolute position feedback from the servo drive and the position offset saved in the PLC. This can effectively prevent data overflow in the 32-bit counter.

### 12.3.3.3 Mode Setting

Set the motion control axis to linear mode or ring mode based on actual working conditions.

## Linear mode

Linear mode is usually used for devices that move within the range of mechanical actions in the X-Y linear coordinate system.

Linear mode typically involves a zero point.

An increase in the feedback position during motion indicates a forward motion, while a decrease indicates a reverse motion.

Forward and reverse software limits can be set. After the software limit is enabled, an axis can only move within the limit range.

Absolute positioning mode: When the target position is greater than the start position, the axis moves forward over a distance equal to the result of the target position minus the start position. When the target position is less than the start position, the axis moves reversely over a distance equal to the result of the start position minus the target position.

Relative positioning mode: When the target displacement is greater than 0, the axis moves forward over a distance equal to the target displacement. When the target displacement is less than 0, the axis moves reversely over a distance equal to the target displacement.

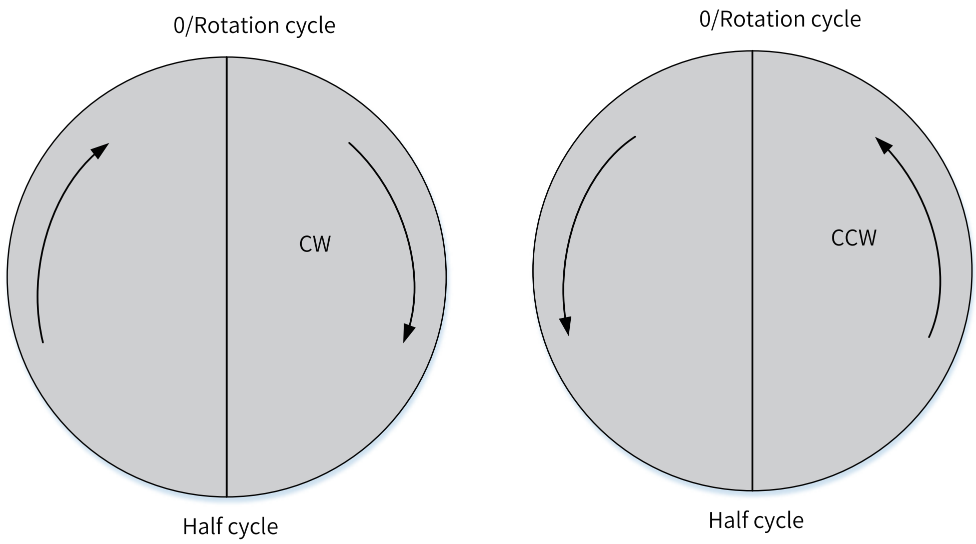
Processing mode of velocity instructions in linear mode: If the target velocity is greater than 0, a forward motion is performed. If the target velocity is less than 0, a reverse motion is performed.

## Ring mode

The ring mode is a mode in the form of a ring counter that is capable of infinitely repeated counting within a set range. It is usually used in revolving stages or rolls.

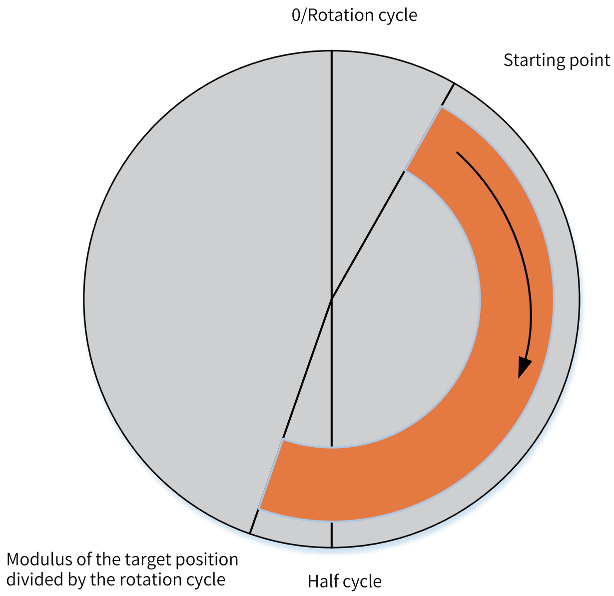
The ring mode usually involves a zero point and a rotation cycle. The feedback position of a ring counter is greater than or equal to 0 and less than one rotation cycle.

In ring mode, an increase in feedback position indicates a CW motion, and a decrease in feedback position indicates a CCW motion.

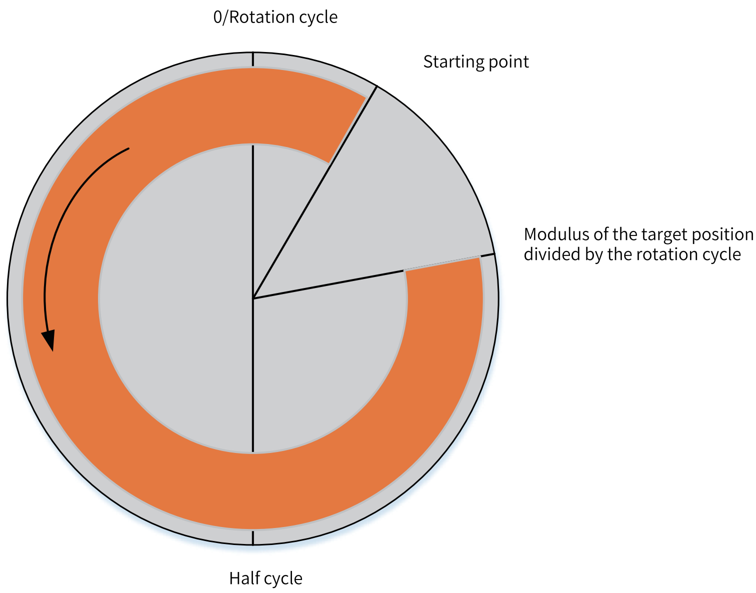


Software limits are not applicable in ring mode.

- Processing mode of relative positioning: When the target displacement is greater than 0, the axis moves clockwise over a distance equal to the target displacement. When the target displacement is less than 0, the axis moves counter-clockwise over a distance equal to the target displacement.
- Processing mode of absolute positioning:
  Forward: First, take the modulus of the target position divided by the rotation cycle. Then, move the axis in a CW manner from the start position to the target position.




Reverse: First, take the modulus of the target position divided by the rotation cycle. Then, move the axis from the start position to the target position in a CCW manner.




The shortest distance: First, take the modulus of the target position divided by the rotation cycle to obtain the target position. Then, calculate the displacement from the start point in a CW manner to the target position. If the displacement is less than or equal to half cycle, a CW motion is performed; otherwise, a CCW motion is performed to the target position.

Current direction: A motion is performed to the target position in the latest axis motion direction, or a forward motion is performed to the target position in case of initial power-on.

Processing mode of velocity instructions in ring mode: If the target velocity is greater than 0, a CW motion is performed; if the target velocity is less than 0, a CCW motion is performed.

#### 12.3.3.4 Software Limits

Software limits can be set in linear mode.
When software limits are valid, the system constantly detects the absolute position of an axis that decelerates from the current velocity to 0 at the set limit deceleration rate according to T-type deceleration mode. If the absolute position of the axis is beyond the limit range, the axis will execute the software limit deceleration algorithm and the positioning or velocity instruction being executed will be aborted.

Software limits are invalid in homing or torque mode.

#### 12.3.3.5 Deceleration upon Axis Fault

During the operation of an axis, if the axis must switch to the ErrorStop state due to a logic failure of the motion instruction itself, the axis will do T-type deceleration according to the setting of deceleration upon axis fault. The axis will not enter the ErrorStop state until it decelerates to 0.

#### 12.3.3.6 Following Error

During the execution of positioning and velocity instructions, the servo drive actually works in cyclic synchronous position (CSP) mode, and the planning of the position curve is done on the PLC. The PLC sends the target position to the servo drive through 0x607A, the servo drive drives the servo motor to move, and the position of the motor encoder is sent back to the PLC through 0x6064. Due to the inherent features of the servo drive and the motor, a difference between 0x607A and 0x6064 is generated. This difference is called the following error when converted to user units. You can set a following error limit. If the absolute value of the following error of an axis exceeds the limit, the axis reports an excessive following error and enters the ErrorStop state.

#### 12.3.3.7 Axis Speed Setting

You can set three parameters: maximum velocity, maximum acceleration, and maximum jogging velocity. When a parameter, such as the target velocity, acceleration, and deceleration, in the positioning instruction or velocity instruction exceeds the velocity limit, the relevant instruction reports an error and the axis enters the ErrorStop state.

For the bus servo axis, the maximum velocity is converted into pulse units and written into the object dictionary 0x607f of the servo drive in the form of startup parameters.

#### 12.3.3.8 Torque Setting

The torque setting is only applicable to the bus servo axis.

If the target torque exceeds the maximum torque in the torque instruction, the instruction reports an error and the axis enters the ErrorStop state.

The forward torque limit will be written into the object dictionary 0x60e0 of the servo drive in the form of startup parameters, and the reverse torque limit will be written into the object dictionary 0x60e1 of the servo drive in the form of startup parameters.

### 12.3.3.9 Probe Setting

Probe terminals can be enabled for local pulse axes through probe setting.

Each local pulse axis can be configured with up to two probe terminals. The probe terminals can be selected from X0 to X7.

When a probe terminal is enabled, the local pulse axis can use probe instructions and interrupt positioning instructions.


### 12.3.3.10 Output Setting

You can select Y0/Y1, Y2/Y3, Y4/Y5, and Y6/Y7 as four local pulse axes.

The output of local pulse axes can be set as pulses in the format of pulse+direction or CW/CCW.

For channels that are set as pulse axes, when pulse+direction is selected, Y0, Y2, Y4, and Y6 are the pulse terminals, and Y1, Y3, Y5, and Y7 are the direction terminals. When CW/CCW is selected, Y0, Y2, Y4, and Y6 are CW pulse terminals, and Y1, Y3, Y5, and Y7 are CCW terminals.

### 12.3.3.11 Not Entering ErrorStop State upon a Limit Activation

This function is only available for AutoShop 4.0.0.0 matching PCB software of version 3.0.0.0 or later.

- When this option is selected, the motion mode is synchronized, and only the axis control instruction reports an error when the motion control axis reaches the limit, but the motion control axis does not enter the ErrorStop state.
- When this option is not selected, if the motion control axis reaches the limit after a motion control instruction other than MC_Jog is called, the motion control axis enters the ErrorStop state, and the instruction reports an error.

### 12.3.3.12 Hardware Limit Logic

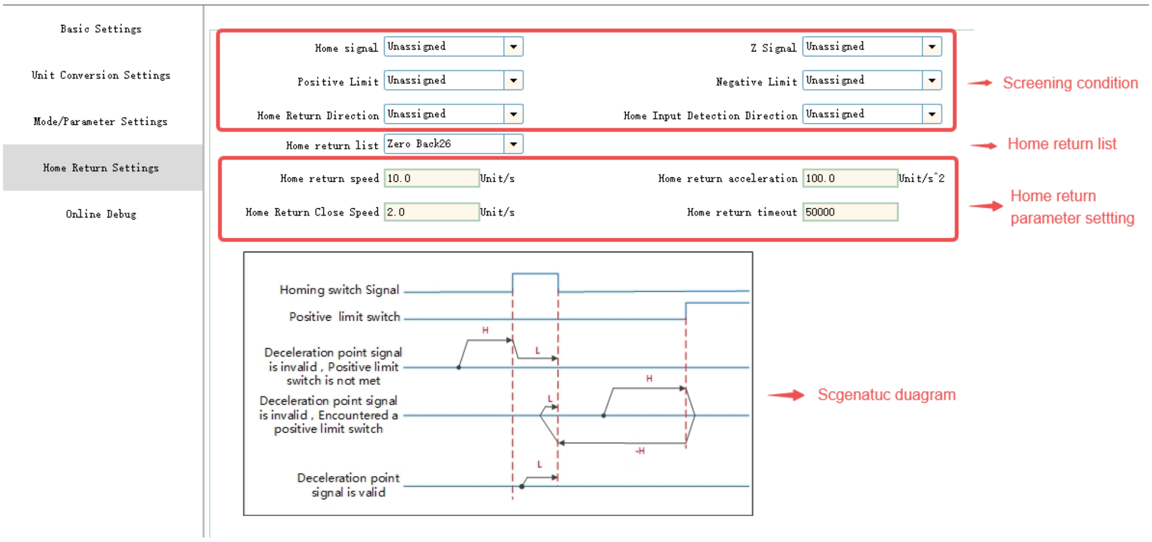
This function is only available for AutoShop 4.0.0.0 matching PCB software of version 3.0.0.0 or later.

Among axis system variables, bphlimit and bnhlimit indicate the hardware positive limit and hardware negative limit, respectively. When the hardware limit logic is positive, they correspond to the values of bit1 and bit0 in the object dictionary 0x60fd, respectively. When the hardware limit logic is negative, they are inverted values of bit1 and bit0 in the object dictionary 0x60fd, respectively.

The hardware limit logic setting is only reflected in the above variables and has no impact on the limit stop processing when the servo reaches the limit.

## 12.3.4 Homing

The homing modes No. 1 to No. 35 specified in the CiA 402 protocol are supported.
The homing settings interface is as follows.




The parameters in the configuration interface are as follows.

| Parameter | Description |
|---|---|
| Home signal | It is used to choose whether to use a home signal.<br>When "Unassigned" is selected, it is not used as a mandatory filter.<br>When "Do not use" is selected, the homing modes that must use a home signal are removed.<br>When "Use" is selected, the homing modes that do not support a home signal are removed. |
| Negative limit | It is used to select whether to use a hardware left limit signal.<br>When "Unassigned" is selected, it is not used as a mandatory filter.<br>When "Do not use" is selected, the homing modes that must use a negative limit signal are removed.<br>When "Use" is selected, the homing modes that do not support a negative limit signal are removed. |
| Positive limit | It is used to choose whether to use a hardware right limit signal.<br>When "Unassigned" is selected, it is not used as a mandatory filter.<br>When "Do not use" is selected, the homing modes that must use a positive limit signal are removed.<br>When "Use" is selected, the homing modes that do not support a negative limit signal are removed. |
| Z signal | It is used to choose whether to use a motor Z signal.<br>When "Unassigned" is selected, it is not used as a mandatory filter.<br>When "Do not use" is selected, the homing modes that must use a z signal are removed.<br>When "Use" is selected, the homing modes that do not support a Z signal are removed. |

| Parameter | Description |
|---|---|
| Homing direction | It is used to set the direction of motion at the beginning of homing.<br>Forward: The direction of motion is forward when the limit (home) signal input is inactive, otherwise it is the opposite.<br>Reverse: The direction of motion is reverse when the limit (home) signal input is inactive, otherwise it is the opposite. |
| Homing detection direction | The direction of motion when the home signal is reached<br>Forward: stopping at the edge of the home signal during forward motion.<br>Reverse: stopping at the edge of the home signal during the reverse motion. |
| Homing list | The homing modes, with a setting range of 1 to 35, are written into the object dictionary 0x6098 in the form of startup parameters. |
| Homing mode | It is used to set the relative mode or absolute mode in homing mode No. 35, which are written into the object dictionary 0x60e6 in the form of startup parameters. |
| Homing velocity | The homing velocity is written into the sub-index No. 1 of the object dictionary 0x6099 in the form of startup parameters after the user units are converted into pulse units. |
| Homing closing velocity | The homing closing velocity is written into the sub-index No. 2 of the object dictionary 0x6099 in the form of startup parameters after the user units are converted into pulse units. |
| Homing acceleration | The homing acceleration is written into the object dictionary 0x609A in the form of startup parameters after the user units are converted into pulse units. |
| Homing timeout time | This parameter is exclusive to Inovance drives. |

In actual use, the homing mode is defined by several parameters, such as home signal, positive limit, negative limit, Z signal, homing direction, and homing detection direction, and then selected from the options of the homing list as needed.

It is worth noting that multiple homing modes are still left after the conditions for homing are filtered, in which case you can choose an appropriate homing mode from the homing list. For example, if the parameters are set as in the following table, you can filter out two homing modes.

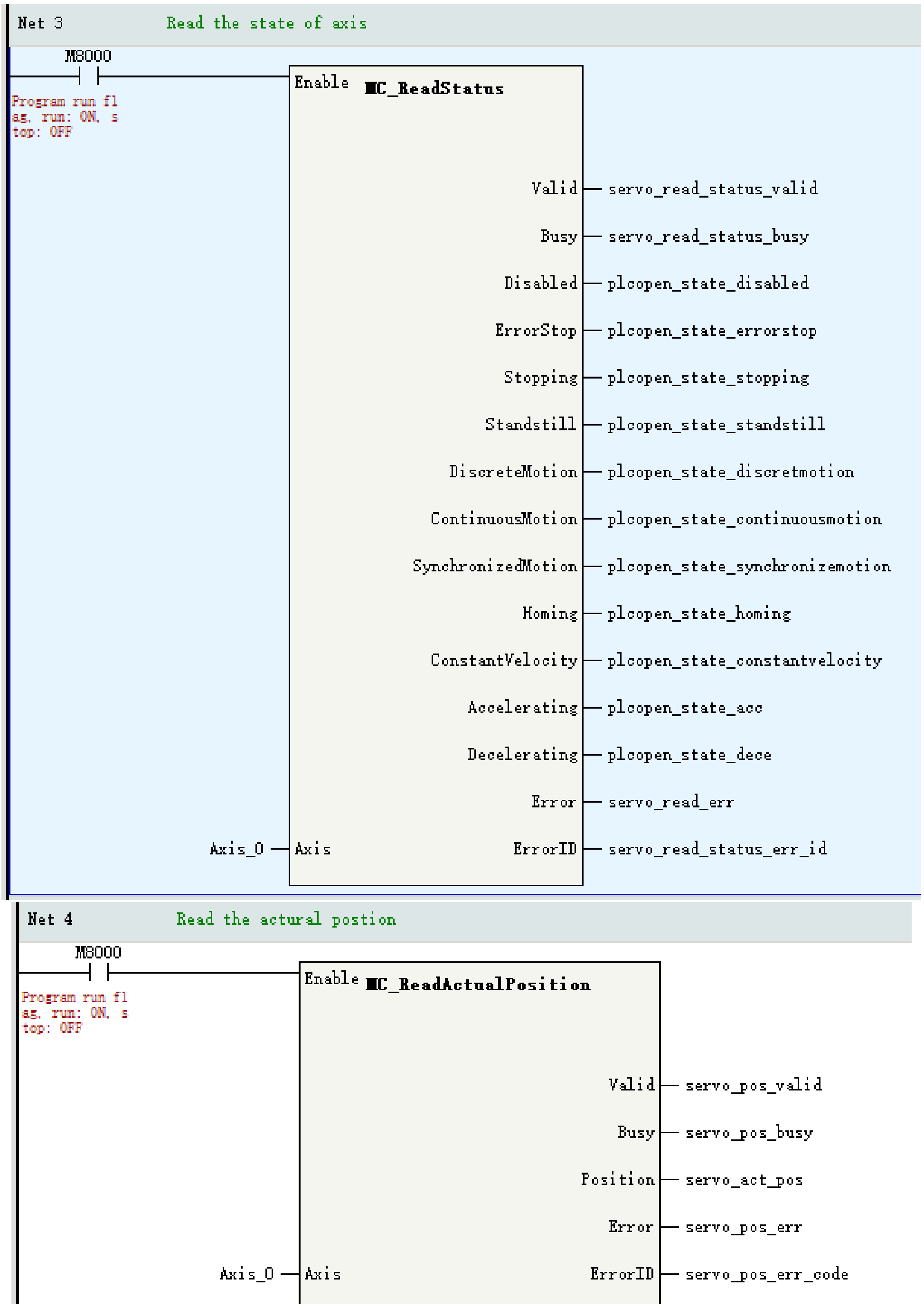
| Signal | Value |
|---|---|
| Home signal | "Use" |
| Negative limit | "Do not use" |
| Positive limit | "Use" |
| Z signal | "Use" |
| Homing direction | "Forward" |
| Homing detection direction | "Forward" |

According to the above settings, the two homing modes No. 8 and No. 10 can be filtered out, and the difference between the two is whether the home input signal is active when the homing is completed.

## 12.4 Online Monitoring

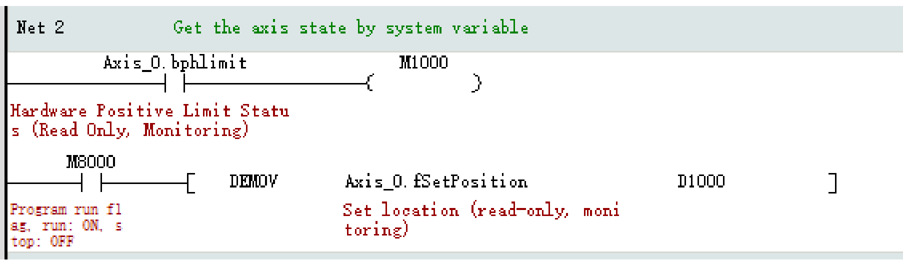
You can obtain the status of an axis through PLC instructions, system variables of the axis, and the online commissioning interface in the background.

1. Obtaining the axis status through instructions
   You can obtain the status of an axis through status instructions such as MC_ReadStatus and MC_ReadPosition.



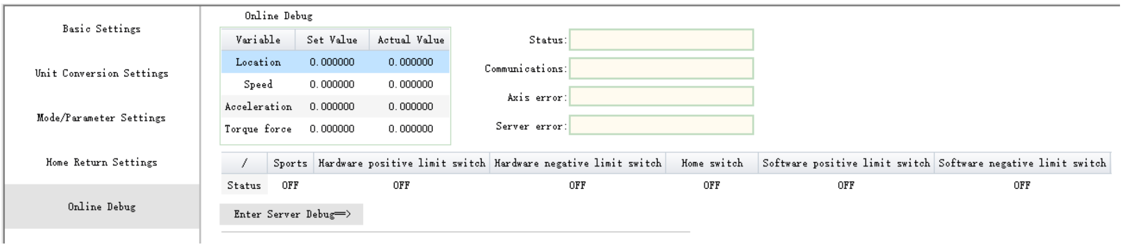

2. Obtaining the status of an axis through system variables

With system variables, you can view the motion status of each axis in real time.




3. Obtaining the axis status through the online commissioning interface

Through the online commissioning interface, you can view the motion status of each axis in real time. The online monitoring interface of an axis is shown in the following figure.




The following table shows the data that can be monitored.

| Object | System Variable | Function |
|---|---|---|
| Position reference | fSetPosition | Target position (user unit) when PLC performs path planning |
| Velocity reference | fSetVelocity | Target velocity (user unit) when PLC performs path planning |
| Acceleration reference | fSet_Acc_Dec | Target acceleration (user unit) when PLC performs path planning |
| Torque reference | fSetTorque | Target torque when PLC performs torque planning (%) |
| Actual position | fActPosition | Current position of drive feedback (user unit) |
| Actual velocity | fActVelocity | Velocity calculated from actual position (user unit) |
| Actual acceleration | fAct_Acc_Dec | Acceleration calculated from actual velocity (user unit) |
| Actual torque | fActTorque | Actual torque of drive feedback (%) |
| Status | wPLCOpenState | The status of the PLCOpen state machine:<br>0: PowerOff<br>1: ErrorStop<br>2: Stopping<br>3: StandStill<br>4: DiscreteMotion<br>5: ContinuousMotion<br>7: Homing<br>8: SynchronizedMotion |
| Communication | wConfigState | The status of data communication between the motion control axis and the drive<br>0: Init (axis in the initialization state)<br>1: Configure finish (configuration reading completed)<br>2: Sync finish (synchronized with EtherCAT tasks)<br>3: Wait communication (communication with the servo drive established)<br>4: Slave ready (initialization completed for the servo drive controlled by axes)<br>5: Axis ready (communication established) |
| Axis error | wAxisError | The internal error of a motion control axis |
| Servo error | wServoError | For a local pulse axis, it is the error code of the axis; for a bus servo axis, it is the corresponding 0x603F value. See the guide for the drive used. |
| Motion | bMotionState | Indicates whether a motion control axis is currently in motion. |

| Object | System Variable | Function |
|---|---|---|
| Hardware positive limit | bphlimit | Indicates whether the hardware positive limit input for a motion control axis is valid. |
| Hardware negative limit | bnhlimit | Indicates whether the hardware negative limit input for a motion control axis is valid. |
| Home switch | bhomestate | Indicates whether the home switch input of a motion control axis is valid. |
| Software positive limit | bpslimit | Indicates whether a motion control axis has reached the software positive limit. |
| Software negative limit | bnslimit | Indicates whether a motion control axis has reached the software negative limit. |

## 12.5 Axis Control Functions

### 12.5.1 Overview

Basic servo control can be realized through the online commissioning function, such as enable, stop, jogging, and point-to-point control. After the basic actions are confirmed to be normal, complex logic control can be realized through motion control instructions. Online commissioning and PLC instruction control cannot be used at the same time. The restrictions are as follows:

- When the MC_Stop instruction is called to make an axis enter the Stopping state, the axis cannot enter the online commissioning mode through the background.
- The MC_Power instruction and the enable function in online commissioning are in a OR relationship, that is, when either of them is valid, the axis can be enabled.
- Motion instructions, such as MC_MoveAbsolute, that have a lower priority than the online commissioning are invalid when an axis is in the online commissioning mode. In this case, the instructions will report an error if called, but the axis will not enter the fault state.

### 12.5.2 Online Commissioning

The functions that can be achieved by online commissioning are as follows:

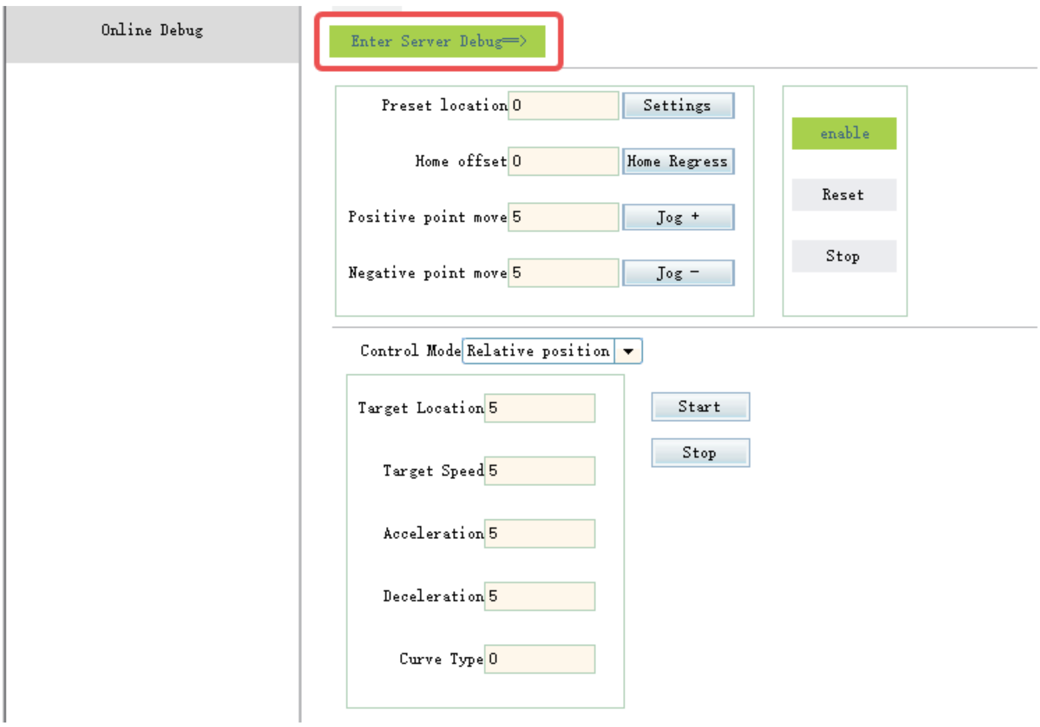
| Function | System Variable | Description |
|---|---|---|
| Entering the online commissioning mode | bEnterDebug | Makes an axis enter the online commissioning mode, after which the PLC will not continue to execute motion control instructions. |
| Enable | bPowerOn | Similar to the way to call the MC_Power instruction to put an axis in an enabled or disabled state. |
| Reset | bReset | Resets a fault that occurs on an axis. This instruction is equivalent to the MC_Reset instruction. |
| Stop | bStop | Stops the motion of an axis. This instruction is equivalent to the MC_Stop instruction. |
| Homing | bHome | Performs a homing action. This instruction is equivalent to the MC_Home instruction. |
| Setting the current position | bSetPos | Sets the current position of an axis. This instruction is equivalent to the MC_SetPosition instruction. |
| Jog | bJogP/bJogN | Implements the jog function. This instruction is equivalent to the MC_Jog instruction. |

| Function | System Variable | Description |
|---|---|---|
| Motion Type | bDebugMotionType | Selects a motion mode from the following options:<br>1: Absolute positioning<br>2: Relative positioning<br>3: Continuous motion<br>5: Reciprocating motion<br>6: Torque mode |
| Relative positioning | bAbsPos | Implements the relative positioning. This instruction is equivalent to the MC_MoveRelative instruction. |
| Absolute positioning | bRelPos | Implements the absolute positioning. This instruction is equivalent to the MC_MoveAbsolute instruction. |
| Continuous motion | bVelocity | Implements continuous motion at a certain velocity. This instruction is equivalent to the MC_MoveVelocity instruction. |
| Reciprocating motion | bRevPos | Implements the reciprocating motion between two absolute positions. This instruction is equivalent to two MC_MoveAbsolute instructions in a loop. |
| Torque control | bTorque | Implements the torque control. This instruction is equivalent to the MC_ MoveTorque instruction. |

## Operation steps for online commissioning

1. Entering the online commissioning mode

   As shown in the following figure, click "Enter online debug" to put an axis in the online commissioning mode.



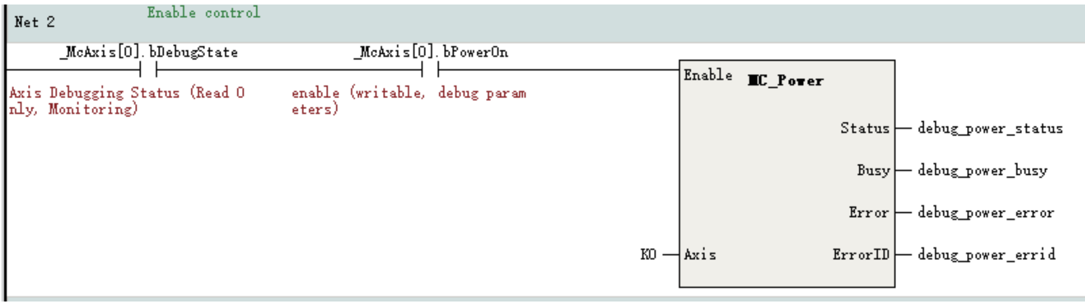

After receiving the instruction to enter the online commissioning mode, the background will do the following checks:

- If the current axis is in the Stopping state, the axis cannot enter online commissioning mode.

- If the current axis is already in motion, the user will be asked whether to enter the online commissioning mode. If the axis is forced to enter the online commissioning mode, the original motion state will be interrupted and the axis motion will stop.
- If the axis is already enabled when entering the online commissioning mode, the axis remains enabled after entering the mode.

2. Basic operations

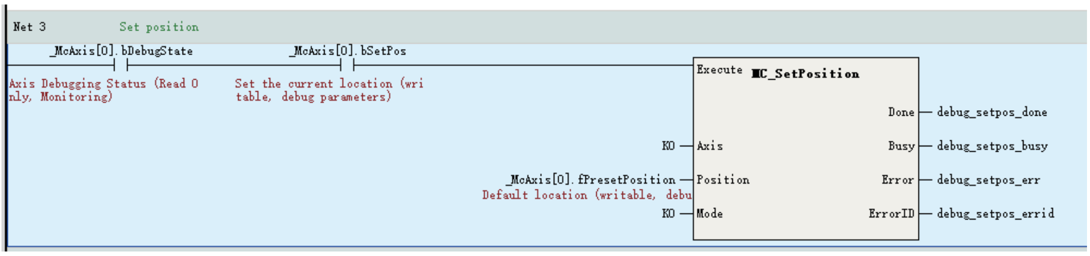
- Enable: After an axis enters the online commissioning mode, click "Enable" to make the axis enter the enabled state, and the execution effect is equivalent to the following instructions.



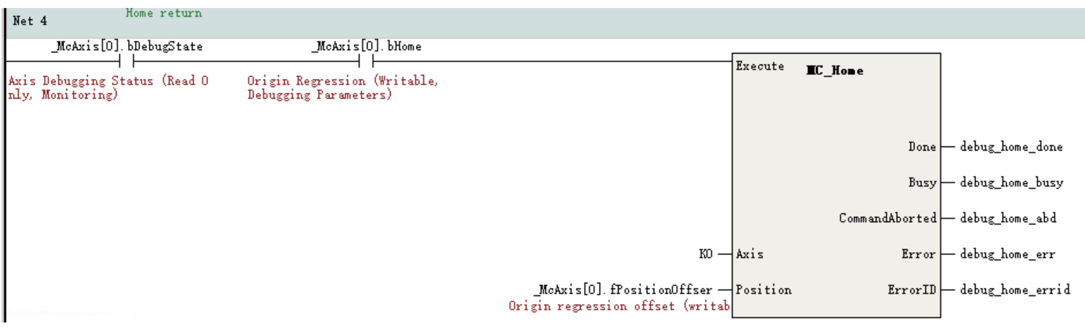

## *Note*

The enable-control in online commissioning and the MC_Power instruction called in the PLC program jointly control the enable-state of the axis. When either of the inputs is active, the axis is enabled.

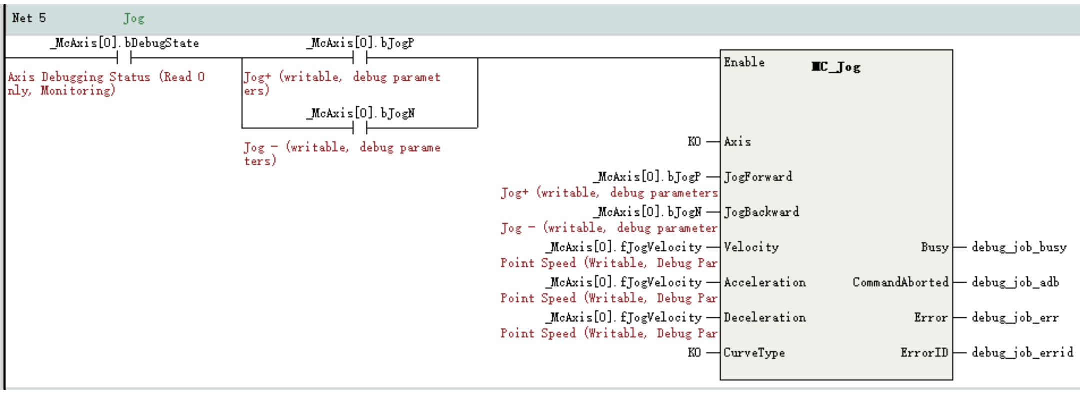
- Preset position: When an axis is in non-motion mode, click "Settings" to write the value in the preset position field to the axis. The execution logic is as follows:



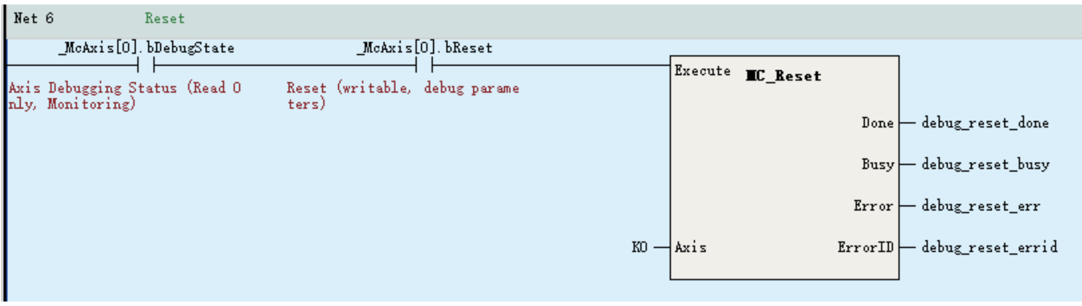

- Homing control: When an axis is in the Standstill state, click "Homing", the axis will control the servo drive to perform the homing operation. When the homing is completed, the value set in the "Home offset" field will be written into the servo drive. The execution logic is as follows:



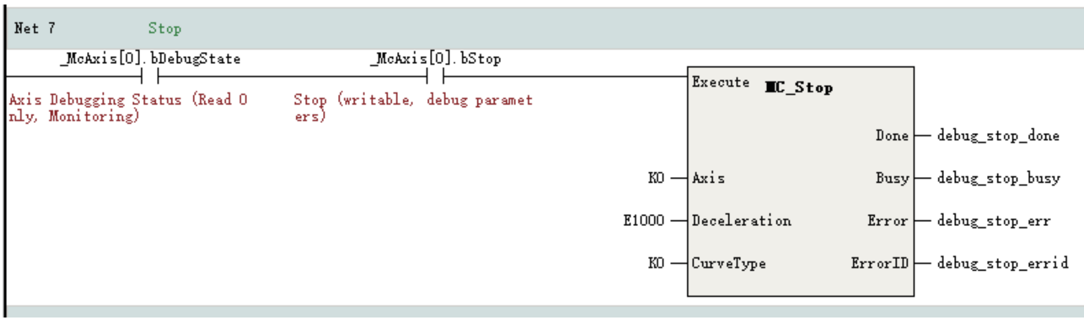

- Jog: When an axis is in the Standstill state, click "Jog+" to move the axis in the forward direction according to the target velocity set in the "Forward jog" field. Click "Jog–" to move the axis in the opposite direction according to the target velocity set in the "Reverse jog" field. The execution logic is as follows:




- Reset: When an axis is in the ErrorStop state, click "Reset" in attempt to reset the axis faults. If the servo drive fault cannot be reset, the reset may fail. The execution logic is as follows:




- Stop: There are two stop buttons in the interface, both with the same function, and both for stopping the motion of an axis. The deceleration used is the limit deceleration in the mode/ parameter settings of an axis. The execution logic is as follows:

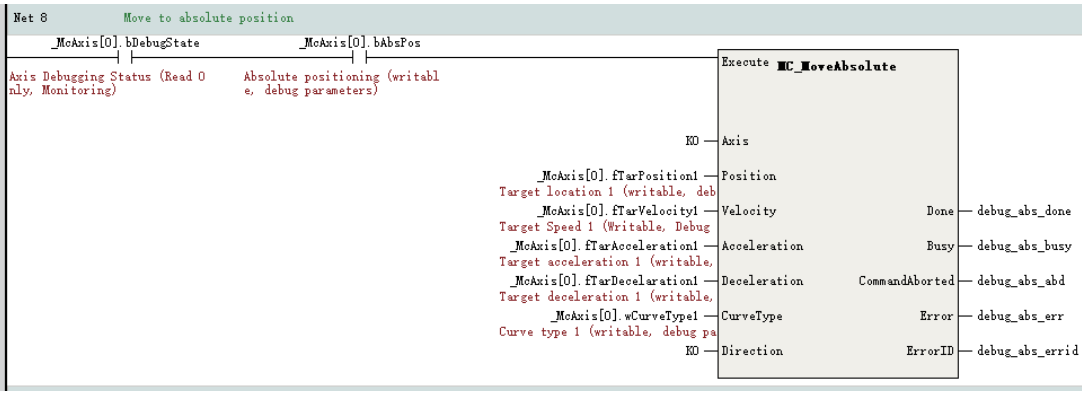



3. Motion modes

A motion mode can only be set when an axis is enabled.

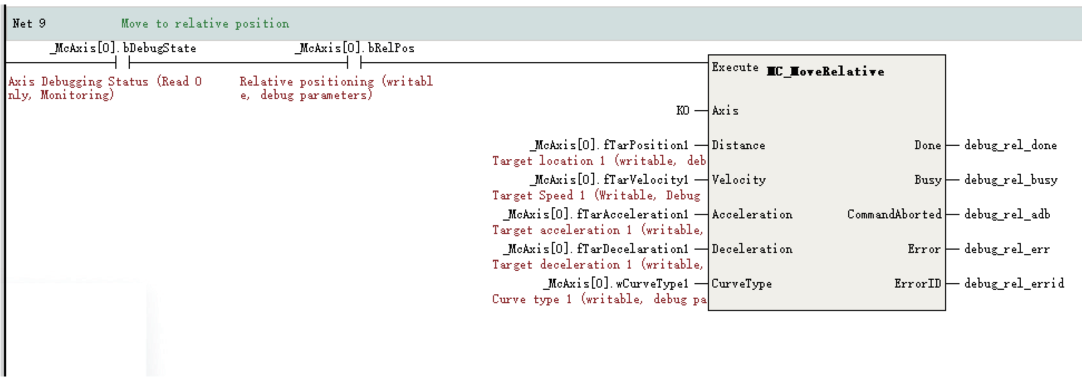
- Absolute positioning

  After the control mode is set to absolute positioning, you can set five parameters: target position, target velocity, acceleration, deceleration, and curve type. Click the start button to start absolute positioning according to the above parameters. The execution logic is as follows:



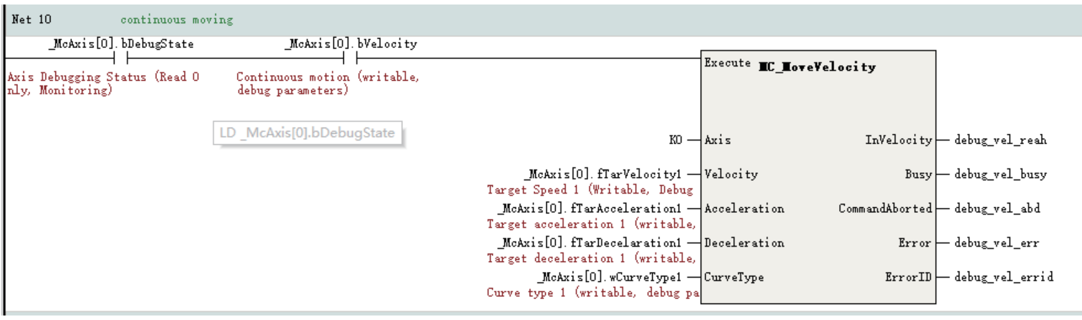

- Relative positioning

  After the control mode is set to relative positioning, you can set five parameters: target position, target velocity, acceleration, deceleration, and curve type. Click the start button to start relative positioning according to the above parameters. The execution logic is as follows:



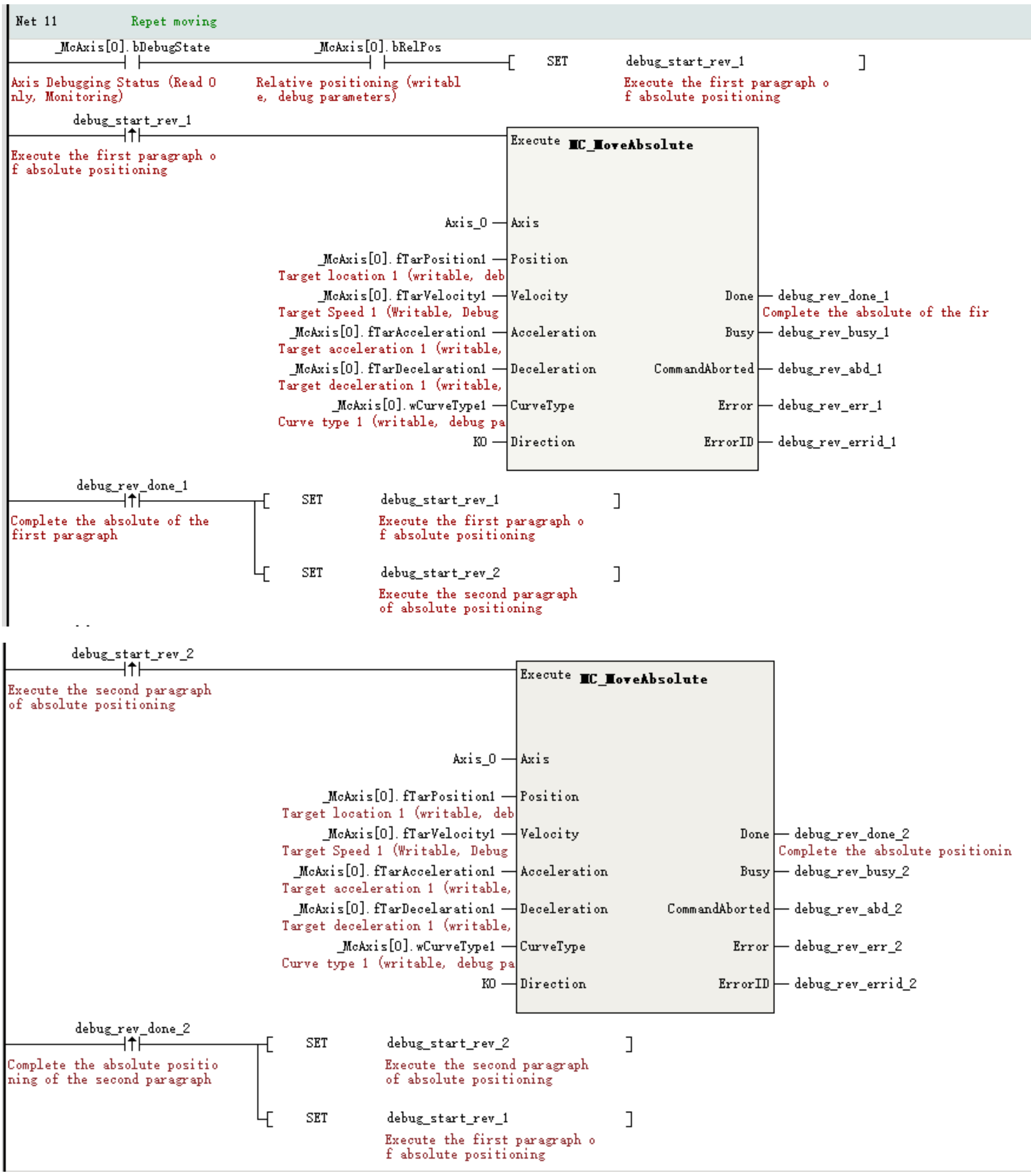

- Continuous motion

  After the control mode is set to continuous motion, you can set four parameters: target velocity, acceleration, deceleration, and curve type. Click the start button to start absolute positioning according to the above parameters. The execution logic is as follows:



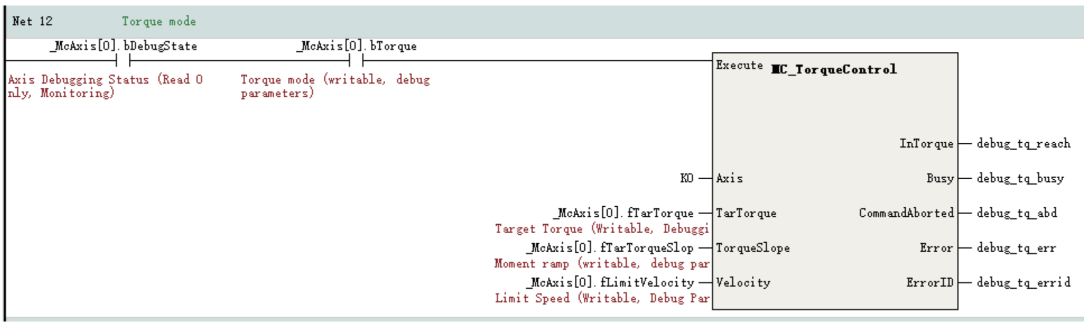

- Reciprocating motion

  After the control mode is set to the reciprocating motion, you can set two sets of target positions, target velocities, acceleration rates, deceleration rates, and curve types. Click the start button, and the axis will first locate the target position 1 according to the set parameters, and then locate the target position 2, followed by reciprocating. The execution logic is as follows:




- Torque mode

  After the control mode is set to the torque mode, you can set three parameters: target torque, torque slope, and limit velocity. Click the start button to start absolute positioning according to the above parameters. The execution logic is as follows:



## 12.5.3 Instruction Control Rules

Motion of axes can be controlled in the PLC through instructions. The rules for calling instructions are as follows.

- Instructions do not need to be instantiated.
- The axis number in the instruction is the unique identifier to access the axis.
- The priority of motion instructions is generally lower than the priority of online commissioning mode.
- Floating-point parameters in the instructions must meet the precision range of floating-point numbers, which generally contain 7 valid digits and can be set to 9999999 at the maximum.

## 12.5.4 Limit Handling

Two limit detection methods are supported: software limit detection and hardware limit detection.

- To ensure correct processing of hardware limit signals, 0x60Fd must be configured in the process data.
- Software limit processing is only valid for calling position and velocity instructions in linear mode. It is invalid for calling homing and torque instructions.
- If the absolute target position of the called position instruction is within the software limit, the instruction can be executed. If the absolute target position exceeds the software limit, the execution of the positioning instruction is interrupted and the axis stops at the software limit.
- When a velocity instruction is called, if the current velocity of the axis exceeds the software limit, the execution of the velocity instruction is interrupted and the axis stops at the software limit.
- If the axis position has exceeded the positive (negative) limit, the axis can only run in the negative (positive) direction.

The following table lists system variables of limits.

| Variable | Function |
|---|---|
| bphlimit | Positive limit input status of hardware |
| bnhlimit | Negative limit input status of hardware |
| bpslimit | Software positive limit status |
| bnslimit | Software negative limit status |

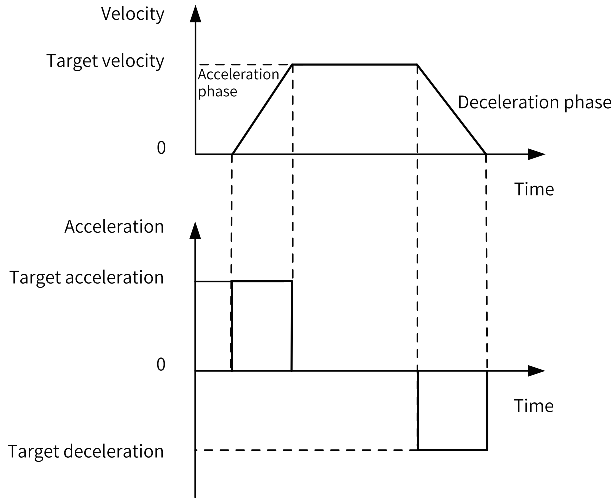
## 12.5.5 Positioning Curve

Two types of velocity curves are supported: T-shape acceleration/deceleration curve, and 5-segment S-shape acceleration/deceleration curve. The curve type is determined by the CuriveType parameter in the instructions.

When the axis reaches the limit or enters the ErrorStop state and decelerates to stop upon a fault, the axis decelerates to stop according to the T-shape curve.

### T-shape velocity curve

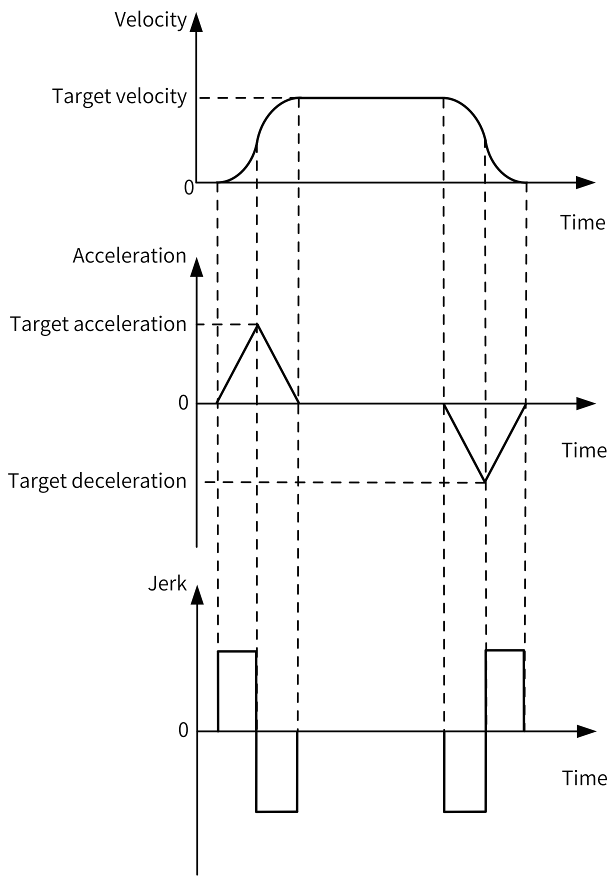
When CuriveType in the instruction is 0, the axis accelerates or decelerates according to the T-shape curve. In the T-shape velocity curve, the axis plans the curve according to the target position, target velocity, target acceleration rate, and target deceleration rate. The actual acceleration/deceleration rate is fixed during acceleration/deceleration. The following figure shows a positioning curve.




- Target position: Indicates the final position of the axis in the absolute positioning instruction, in the unit of Unit (user unit)
- Target velocity: Indicates the maximum velocity of the axis, in the unit of Unit/s (user unit/second).
- Target acceleration rate: Indicates the amount of change in velocity per second when the axis accelerates, in the unit of Unit/$t^2$.
- Target deceleration rate: Indicates the amount of change in velocity per second when the axis decelerates, in the unit of Unit/$t^2$.
- Assume that the axis initial velocity is Vs, target velocity is Vt, and target acceleration rate is Acc, then the acceleration time is:
  Tacc = (Vt – Vs)/Acc
- Assume that the axis initial velocity is Vs, target velocity is Ve, and target deceleration rate is Dec, then the deceleration time is:
  Tdec = (Vs – Ve)/Dec

## S-shape velocity curve

When CuriveType in the instruction is 1, the axis accelerates or decelerates according to the S-shape curve. In the 5-segment S-shape curve, the axis plans the curve according to the target position, target velocity, target acceleration rate, and target deceleration rate, of which the target acceleration rate and target deceleration rate refer to the maximum accelerate rate and deceleration rate the axis can reach. The following figure shows a positioning curve.




The 5-segment S-shape velocity curve is divided into 5 stages based on the acceleration rate state: increasing acceleration, decreasing acceleration, constant speed, increasing deceleration, and decreasing deceleration. The constant acceleration and constant deceleration stages do not exist. During variable acceleration stages such as increasing acceleration or increasing deceleration, the actual Jerk is calculated by the PLC and cannot be set by users.

- Target position: Indicates the final position of the axis in the absolute positioning instruction, in the unit of Unit (user unit)
- Target velocity: Indicates the maximum velocity of the axis, in the unit of Unit/s (user unit/second).
- Target acceleration rate: Indicates the amount of change in velocity per second when the axis accelerates at variable velocities, in the unit of Unit/$t^2$. In the velocity curve, the acceleration rate at the moment (t2) when the stage changes from increasing acceleration to decreasing acceleration is certainly the target acceleration rate.
- Target deceleration rate: Indicates the amount of change in velocity per second when the axis decelerates at variable velocities, in the unit of Unit/$t^2$. In the velocity curve, the deceleration rate at the moment (t5) when the stage changes from decreasing acceleration to decreasing deceleration is certainly the target deceleration rate.
- Assume that the axis initial velocity is Vs, target velocity is Vt, and target acceleration rate is Acc, then the acceleration time is:
  Tacc = 2 x (Vt – Vs)/Acc
-

  Assume that the axis initial velocity is Vs, target velocity is Ve, and target deceleration rate is Dec, then the deceleration time is:

  Tdec = 2 x (Vs – Ve)/Dec

## 12.6 Dragging Motion Control Axes

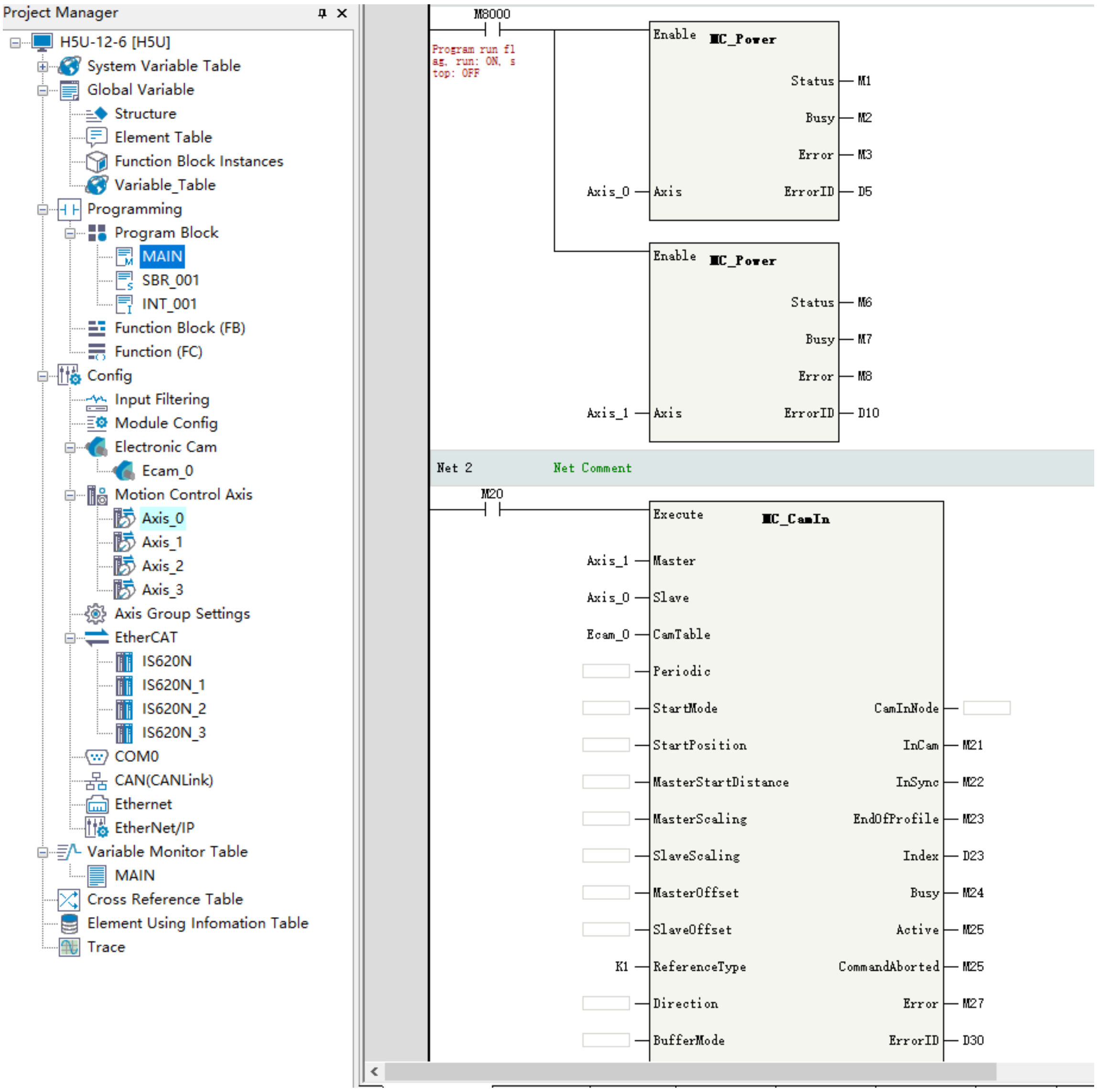
You can directly drag motion control axes to adjust their configuration sequences.

### *Note*

This function is available in AutoShop V4.4.0.0 and PCB software V5.0.0.0 or later versions.

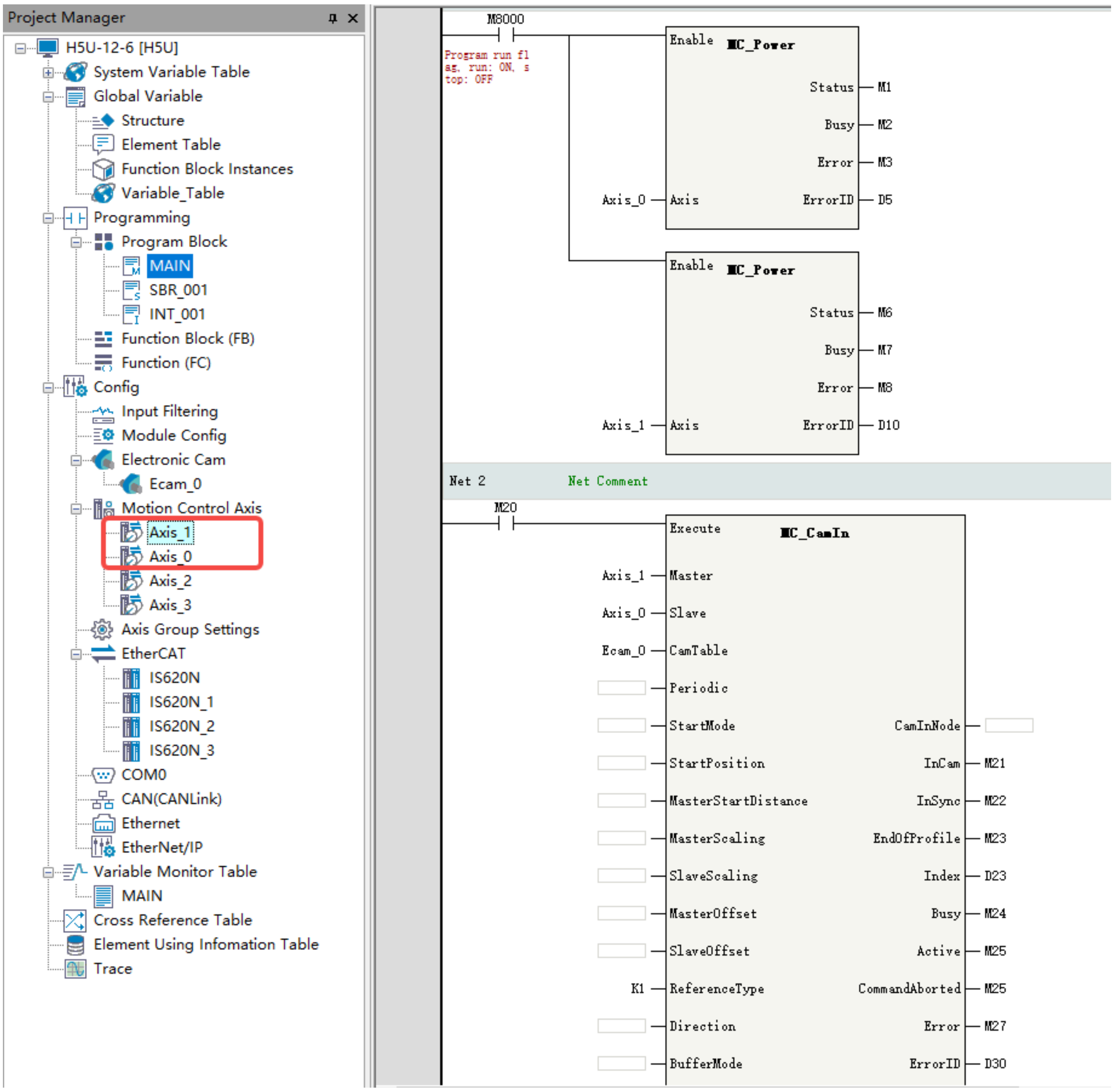
### Example

Create a project containing four bus servo axes with Axis_1 as the cam master axis and Axis_0 as the cam slave axis. When the cam position type is 1 (Position set in the current period), an error is reported after the MC_CamIn instruction is called. The fault code is 9251, indicating that the configured master axis address is equal to or greater than the slave axis address. In this case, you can drag motion control axes to adjust their sequences to eliminate the error as follows.




Hover the pointer over Axis_0, hold down the left mouse button, drag Axis_0 to cover Axis_1, and then release the mouse. The configuration positions of Axis_0 and Axis_1 are changed. The servos bound with Axis_0 and Axis_1 remain unchanged.

Download the adjusted configuration to the PLC and call the MC_CamIn instruction again. Then, no error will be reported.




## 12.7 Modifying Axis Configuration Parameters Using Instructions

You can modify configuration parameters of an axis in the PLC program to meet different application requirements, such as software limit and rotation cycle in ring mode.

### Function

- To modify configuration parameters of an axis in the PLC program, you need to use the system structure variable _sCfgAxis of the axis configuration to set parameters. The setting of this structure is not retentive upon power failure.
- After the PLC is powered on, this structure variable is initialized based on the axis configuration in the software background.
- After modifying the value of the initialized variable based on application requirements, call the MC_SetAxisConfigPara instruction. Then, the setting takes effect.

***Note***

The axis configuration parameters are variables that are not retentive at power failure. After the PLC is restarted, the previously set values are lost. Therefore, set the values every time the PLC is started.

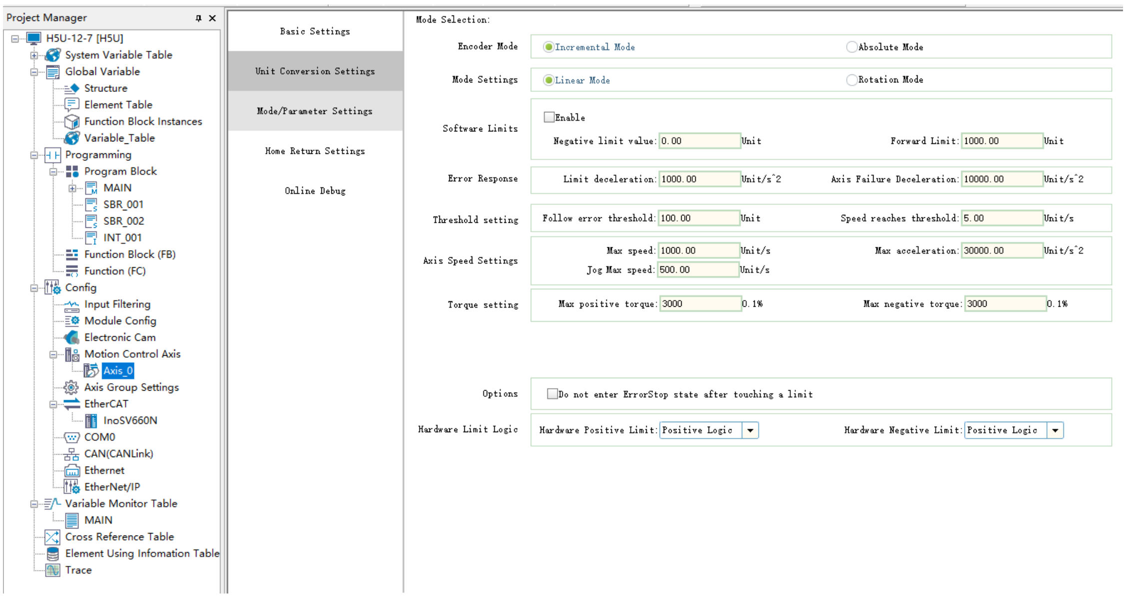
Table 12–3 Definitions of _sCfgAxis structure variables

| Variable | Data Type | Description |
|---|---|---|
| dPlusePreCycle | DINT | Number of pulses per revolution of the motor/encoder |
| fDistancePreCycle | REAL | Distance per revolution of the worktable |
| dNumerator | DINT | Gear ratio numerator |
| dDenominator | DINT | Gear ratio denominator |
| bDirection | BOOL | Direction<br>OFF: Forward<br>ON: Reverse |
| bVirtualMode | BOOL | Virtual axis mode<br>OFF: Invalid<br>ON: Valid |
| bSoftLimitEnable | BOOL | Software limit enable control<br>OFF: Disabled<br>ON: Enabled |
| bEnterErrorStop | BOOL | Not entering ErrorStop state upon an axis fault<br>OFF: Disabled<br>ON: Enabled |
| bPLimitTerminalPolarity | BOOL | Forward limit polarity selection<br>OFF: Positive logic<br>ON: Negative logic |
| bNLimitTerminalPolarity | BOOL | Negative limit polarity selection<br>OFF: Positive logic<br>ON: Negative logic |
| bHomeTerminaPolarity | BOOL | Home signal polarity selection<br>OFF: Positive logic<br>ON: Negative logic |
| iEncoderMode | INT | Encoder mode (valid for bus servo axis)<br>0: Absolute<br>1: Incremental |
| iLineRotateMode | INT | Selection of linear or rotary mode<br>0: Linear<br>1: Rotary |
| fPLimit | REAL | Positive limit in linear mode |
| fNLimit | REAL | Negative limit in linear mode |
| fRotation | REAL | Rotation period in rotary mode |
| fLimitDeceleraion | REAL | Limit deceleration rate |
| fErrorStopDeceleration | REAL | Deceleration rate at axis fault |
| fFollowErrorWindow | REAL | Following error threshold |
| fInVelocityWindow | REAL | Velocity reach threshold |

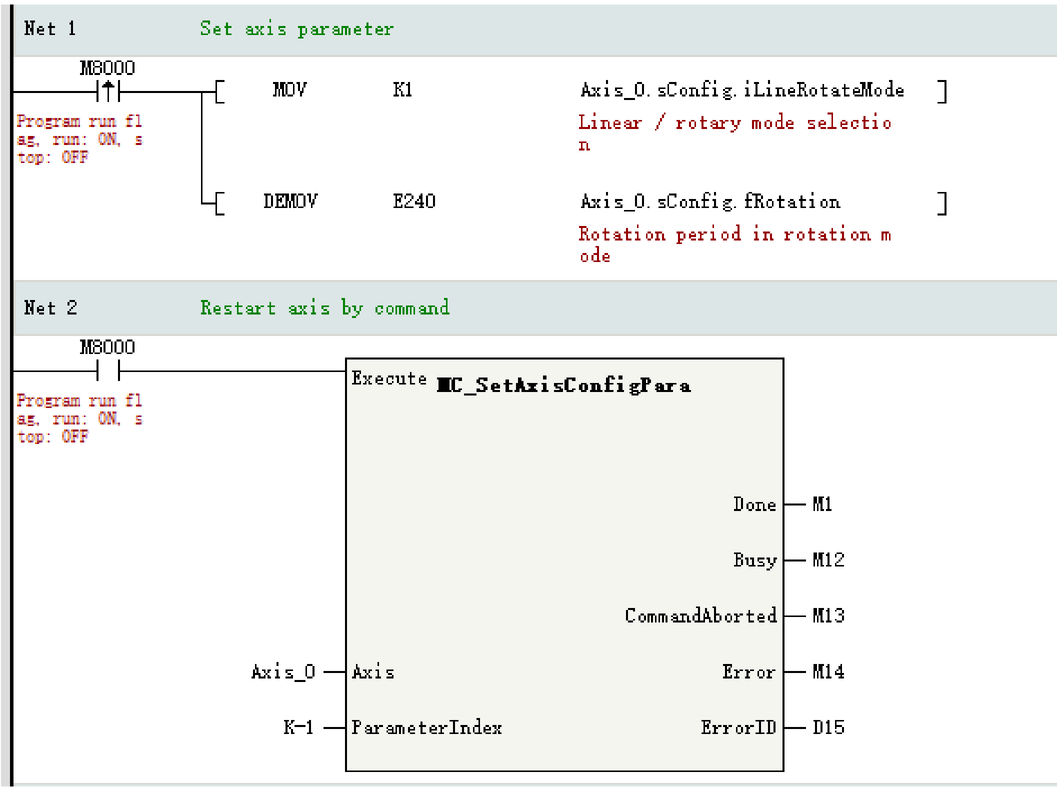
| Variable | Data Type | Description |
|---|---|---|
| fMaxVelocity | REAL | Max. velocity |
| fMaxJogVelocity | REAL | Max. jog velocity |
| fMaxAcc | REAL | Max. acceleration rate |
| fMaxPTorque | REAL | Max. positive torque (bus servo axis)<br>Only used for instruction parameter inspection, not delivered to servo |
| fMaxNTorque | REAL | Max. negative torque (bus servo axis)<br>Only used for instruction parameter inspection, not delivered to servo |
| iHomeMethod | INT | Homing mode, local pulse axis<br>Options are 17 to 30 and 35. |
| fHomeVelocity | REAL | Homing velocity, valid for local pulse axis |
| fHomeApproachVelocity | REAL | Homing approaching velocity, valid for local pulse axis |
| fHomeAcceleration | REAL | Homing acceleration rate, valid for local pulse axis |
| dHomeTimeOut | DINT | Homing timeout time, valid for local pulse axis |
| iHomePositionMode | INT | Homing position mode selection, local pulse axis<br>0: Absolute homing<br>1: Relative homing |
| dTouchProbeID1 | DINT | ID of the probe terminal 1 (Modbus address)<br>–2: Disabled<br>–1: Reserved |
| dTouchProbeID2 | DINT | ID of the probe terminal 2 (Modbus address)<br>–2: Disabled<br>–1: Reserved |
| iPluseMethod | INT | Pulse output mode (valid for local pulse axis)<br>3: Phase A/B<br>4: Pulse + direction<br>5: CW/CCW |
| dPLimitTerminalID | DINT | ID of positive limit signal (Modbus address)<br>–2: Disabled<br>–1: Reserved |
| dNLimitTerminalID | DINT | ID of negative limit signal (Modbus address)<br>–2: Disabled<br>–1: Reserved |
| dHomeTerminalID | DINT | ID of home signal (Modbus address)<br>Only X0 to X7 are supported.<br>–2: Disabled<br>–1: Reserved |

## Example

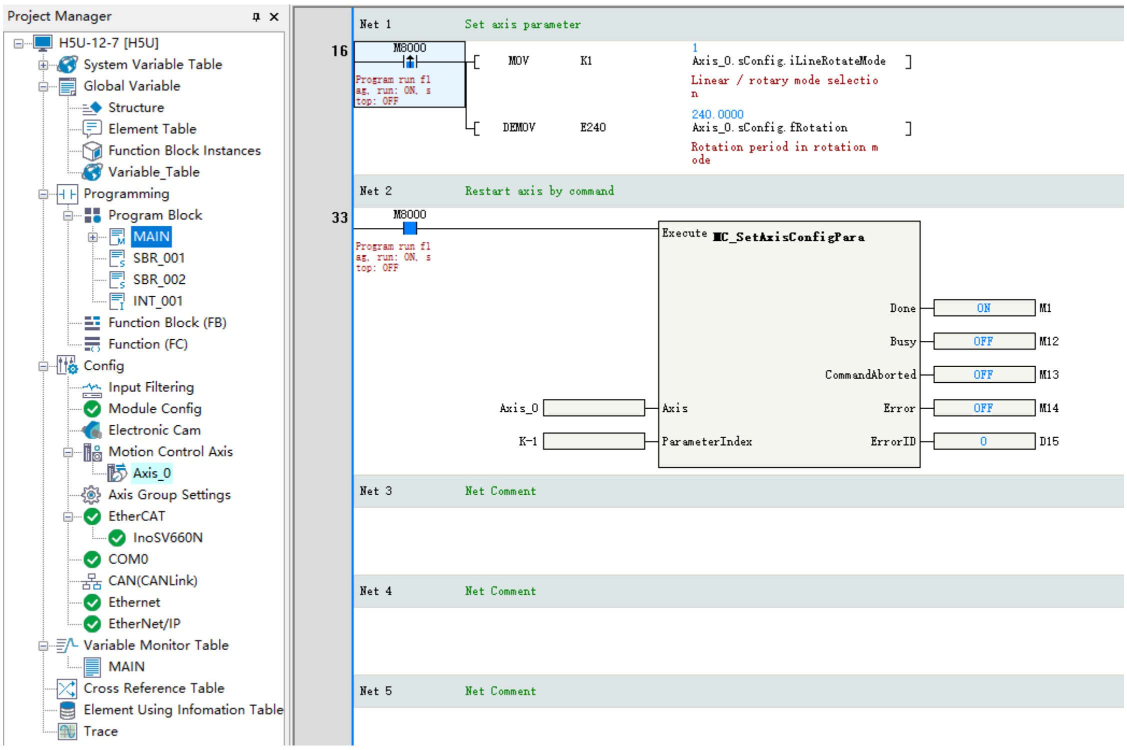
1. Create a network consisting of H5Us and IS620Ns, enable EtherCAT communication, and add a motion control axis Axis_0 with default parameters.



2. Compile the PLC program, modify the mode of Axis_0 to rotary, set the rotation period to 240, and then call the MC_SetAxisConfigPara instruction to make the settings take effect.




3. Connect one IS620N to the EtherCAT network port of the controller, and compile and download the program. The following figure shows the running effect.



## 12.8 Fault Categories

Axis faults are divided into instruction faults, axis faults, and drive faults.

- Instruction faults are faults of MC axis control instructions due to reasons such as inappropriate instruction parameter settings or change to the PLCOpen state machine during axis running. You can obtain the fault codes based on ErrorID in the failed instructions.
- Axis faults are faults of axes, such as excessive following error. You can view axis fault codes in four ways. Method 1: On the "Online debug" page of the background, view the fault codes in the "Axis fault" column. Method 2: Obtain fault codes based on AxisErrorID in the MC_ReadAxisError instruction. Method 3: Obtain fault codes based on wAxisError in the axis system variables. Method 4: View fault codes on the "Fault Diagnosis" page.
- Drive faults are faults of the EtherCAT bus drive or local pulse output axis. To view the fault codes of the EtherCAT bus drive, you must configure 0x603F in the PDO mapping and associate it with the axis. You can view drive faults in three ways. Method 1: On the "Online debug" page of the background, view the fault codes in the "Servo error" column. Method 2: Obtain fault codes based on ServoErrorID in the MC_ReadAxisError instruction. Method 3: Obtain fault codes based on wServoError in the axis system variables.

# 13 High-speed Counter

## 13.1 Introduction to High-speed Counter Axes

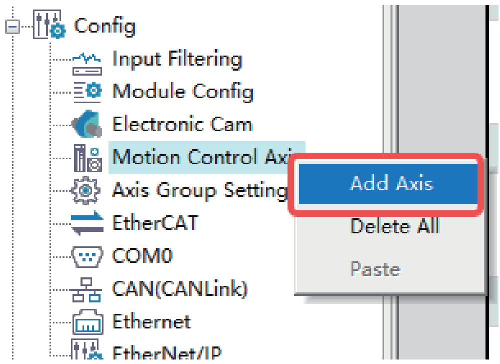
In AutoShop software and engineering applications, a counter is used as an encoder axis to enable management, and the counter associated with an axis is known as a counter axis.

AutoShop supports 4-axis 32-bit high-speed counters, which can realize phase AB frequency multiplication by 1/2/4, CW/CCW, pulse+direction, and single-phase counting. Counting signal sources are external pulse input or internal 1 ms/1 μs clock counting, which can be used to preset and latch the counter in combination with other input signals.

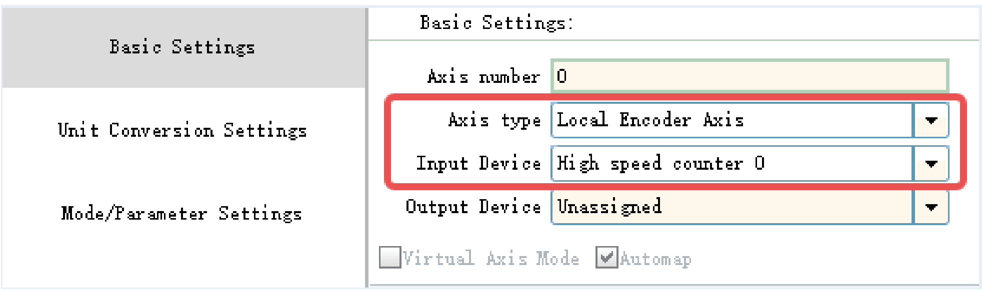
## 13.2 Creating Counter Axes

Before using a counter in AutoShop, you must associate the counter with an axis.

1. In the column "Project Manager", right-click a motion control axis under "Config" and choose "Add Axis" to create a motion control axis.

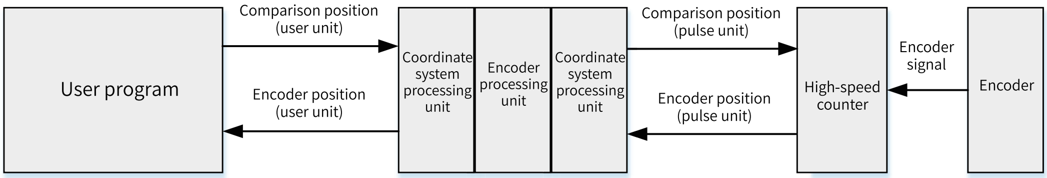



2. Double-click the added axis (Axis_0 is selected in the following figure). On the "Basic setting" interface displayed, select "Local encoder axis" as the axis type, and select "High Speed Counter" as the input device to associate the axis and counter. The axis number is used in the program as an axis identifier to control the corresponding counter axis.




## 13.3 Counter Axis User Unit and Conversion

High-speed counters use pulse units when decoding encoder signals, and use common measurement units for counter instructions such as millimeters, degrees, and inches, which are called user units (Unit). Through unit conversion, the number of pulses can be converted into user units (Unit), which can be defined as equipment-related units (such as millimeters and revolutions) according to actual applications.



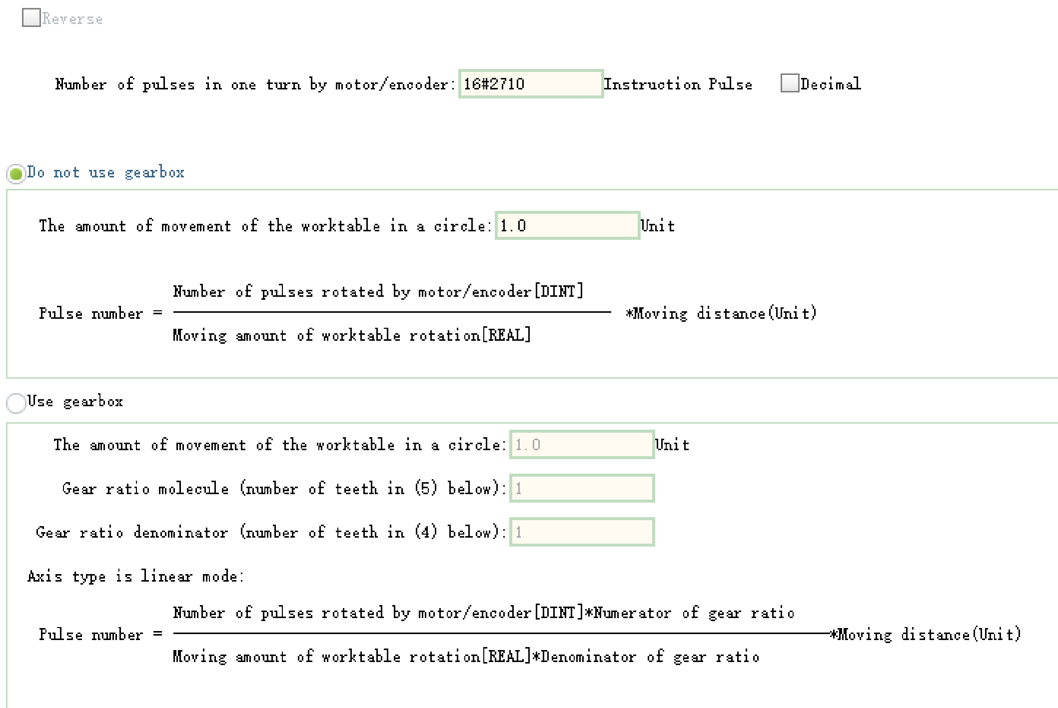

The following table lists parameters that need to be set for unit conversion.

| Parameter | Function |
|---|---|
| Number of pulses in one turn by motor/encoder | Set the number of pulses required for the motor to rotate one turn according to the encoder resolution. |
| Gear change mechanisms in use or not | Specify whether gear change mechanisms are in use or not. |
| Amount of movement in one turn by motor/encoder | The workpiece movement amount per turn of the motor when no gear change mechanism is in use |
| Amount of movement of the worktable in a circle | The workpiece movement amount per turn of the worktable when gear change mechanisms are in use |
| Gear ratio numerator | Set a gear ratio on the workpiece side. |
| Gear ratio denominator | Set a gear ratio on the motor side. |

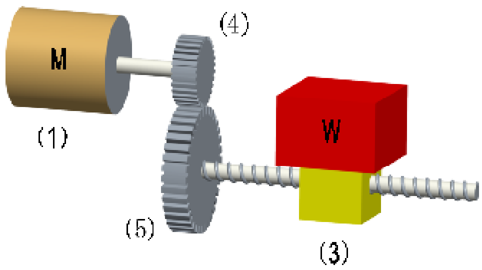
When a servo motor is connected to a screw rod through a reducer to drive the worktable and gives feedback about the worktable position to an encoder counter through the PLC, if the counter counts the encoder in pulses, the number of pulses shall be the unit, and if the counter axis is used to represent the worktable position, then millimeter shall be the unit.

Therefore, in the program, the Unit is used uniformly as the user unit of the counter axis.

The conversion rule between the user unit (Unit) and the pulse is as follows:



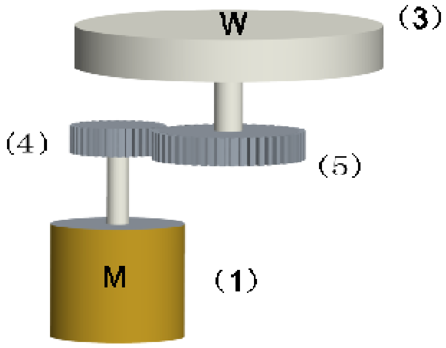
M: Motor/Encoder, W: Workbench




Axis type is rotation mode:

$$\text{Pulse number} = \frac{\text{Number of pulses rotated by motor/encoder[DINT]*Numerator of gear ratio}}{\text{Moving amount of worktable rotation[REAL]*Denominator of gear ratio}} \text{*Moving distance(Unit)}$$

M: Motor/Encoder, W: Workbench




In the unit conversion setting, set the relevant parameters according to the actual device.

1. Number of pulses in one turn by motor/encoder: "16#" in the input box indicates that hexadecimal numbers are used.
   If the number of pulses in one turn by the encoder is 10000, whose hexadecimal equivalent is 2710, input 16#2710.

   Number of pulses in one turn by motor/encoder: 16#2710 Instruction Pulse ☐Decimal

2. Working stroke setting: The working stroke can be set with or without gear change mechanisms.

   - Without gear change mechanisms
     When gear change mechanisms are not in use, the conversion equation from user unit to pulse unit is as follows.

$$\text{Pulse number} = \frac{\text{Number of pulses rotated by motor/encoder[DINT]*Numerator of gear ratio}}{\text{Moving amount of worktable rotation[REAL]*Denominator of gear ratio}} \text{*Moving distance(Unit)}$$

If one revolution of the encoder corresponds to one revolution of the working axis and the user unit (Unit) is revolution, then the working stroke of the motor/encoder per revolution shall be set to 1.

The amount of movement of the worktable in a circle: 1.0 Unit

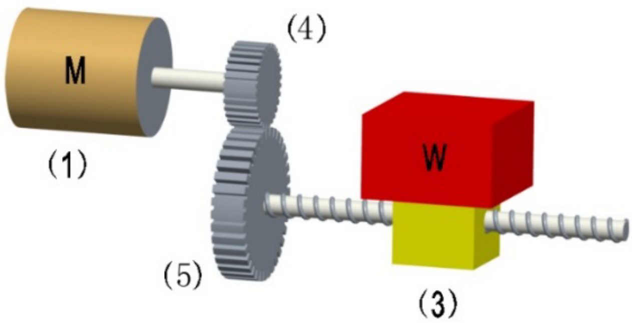
Take the Inovance 20-bit encoder as an example. The set parameters are as follows.

Number of pulses in one turn by motor/encoder = 1048576

Amount of movement in one turn by motor/encoder = 1

Then, when the target displacement given by the relative positioning instruction is 10, the actual number of pulses sent by the motion control axis is 10485760, then the motor rotates by 10 revolutions.

- With gear change mechanisms
  Typical working condition in linear mode is shown in the following figure.




Where, (1) is the servo motor, (3) is the workpiece, (4) is the gear ratio numerator, and (5) is the gear ratio denominator.

The calculation equation from user unit to pulse unit is as follows.

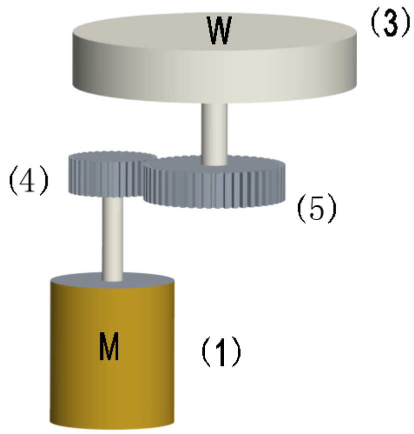
$$\text{Pulse number} = \frac{\text{Number of pulses rotated by motor/encoder[DINT]*Numerator of gear ratio}}{\text{Moving amount of worktable rotation[REAL]*Denominator of gear ratio}} * \text{Moving distance(Unit)}$$

If a servo motor is connected to a screw rod through a reducer to drive the worktable, the working stroke per revolution of the screw rod is 5 mm, and the reduction ratio is 20:10. The setting is as follows.

The amount of movement of the worktable in a circle: 5.0 Unit

Gear ratio molecule (number of teeth in (5) below): 20

Typical working condition in ring mode is shown in the following figure.




Where, (1) is the servo motor, (3) is the workpiece, (4) is the gear ratio numerator, and (5) is the gear ratio denominator.

The calculation equation from user unit to pulse unit is as follows.

$$\text{Number of pulses (unit: pulse)} = \frac{\text{Number of pulses per revolution of the motor/encoder [DINT]} \times \text{Gear ratio numerator [DINT]}}{\text{Distance per revolution of the workbench [REAL]} \times \text{Gear ratio denominator [DINT]}} \times \text{Distance (unit: Unit)}$$

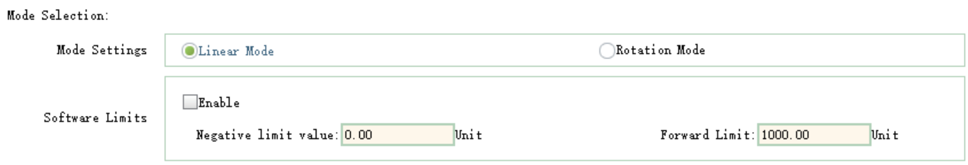
## 13.4 Setting Working Modes

### 13.4.1 Linear Mode

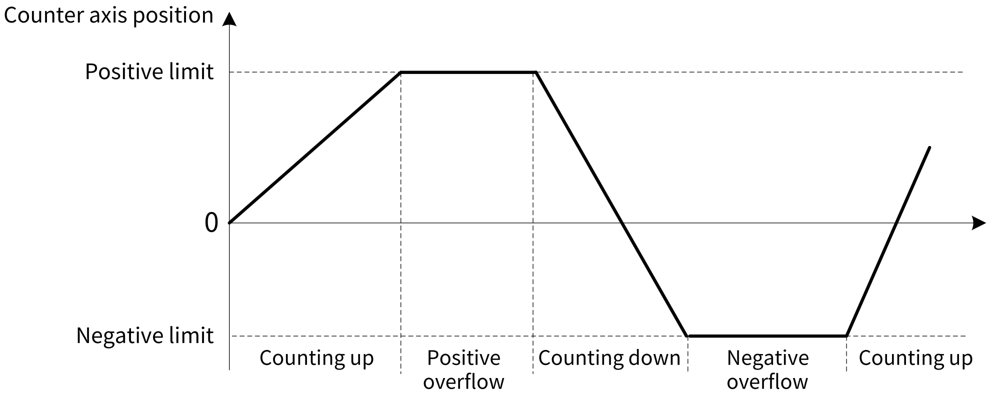
The counter axis moves between the negative and positive limits. After the counter axis reaches the limits, pulses in the same direction are still input; the counter axis reports an overflow while the counter axis position remains unchanged. After the counter axis reports an overflow, input the reverse pulses. The counter axis counts in reverse, and the overflow error is removed.

In linear mode, you can set the negative and positive position limits of the counter axis in the interface, with user unit (Unit) as the position unit. The negative limit must be less than or equal to 0, and the positive limit must be greater than or equal to 0.

Since the high-speed counter is a 32-bit counter, the negative and positive limits must be within the 32-bit integer range [–2147483648, +2147483647] after being converted to pulse units.



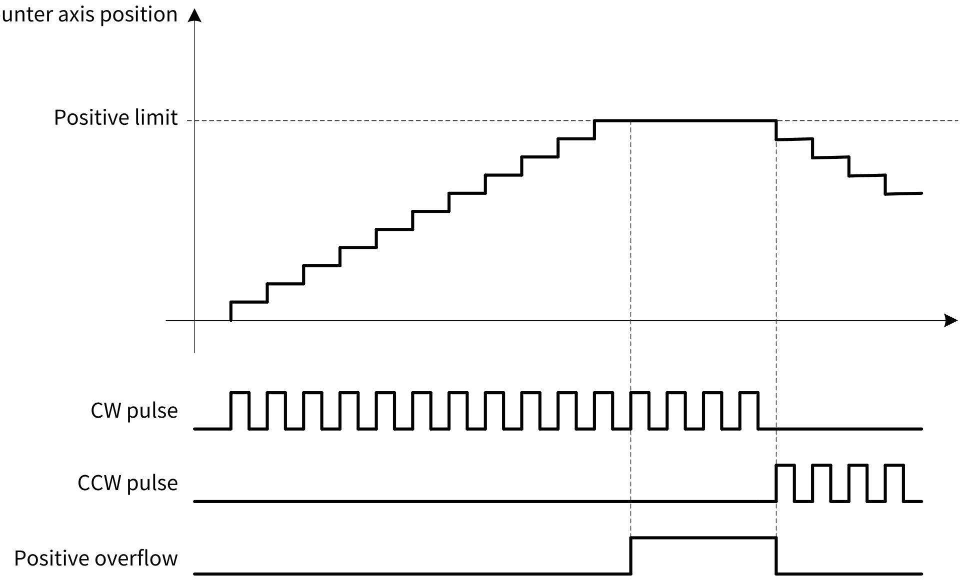

In linear mode, the high-speed counter operates in the closed interval of [negative limit, positive limit]. When the direction is negative, the count value decreases in the negative direction. After the negative limit is reached, the count value no longer decreases. When the direction is positive, the count value increases in the positive direction. After the positive limit is reached, the count value no longer increases.




Linear mode

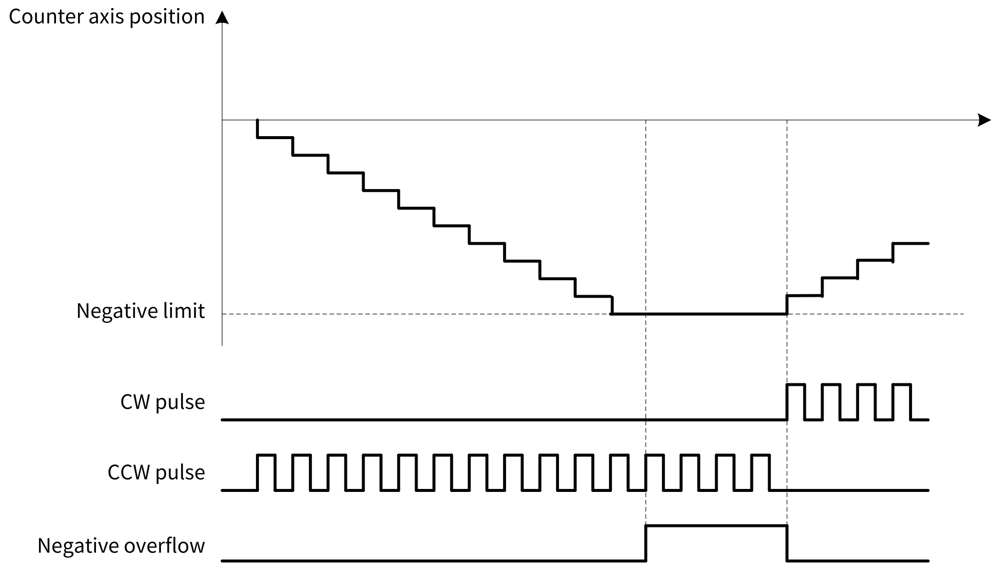
## CW pulse counting

In linear mode, input CW pulses. After the incremental count of the counter axis position reaches the limit, keep inputting CW pulses. The counter axis reports a positive overflow error, and the counter axis position value remains unchanged. Input CCW pulses. The counter axis position counts down, and positive overflow error is removed.




## CCW pulse counting

In linear mode, input CCW pulses. After the decremental count of the counter axis position reaches the limit, keep inputting CCW pulses. The counter axis reports a negative overflow error, and the counter axis position value remains unchanged. Input CW pulses. The counter axis position counts up, and the negative overflow error is removed.

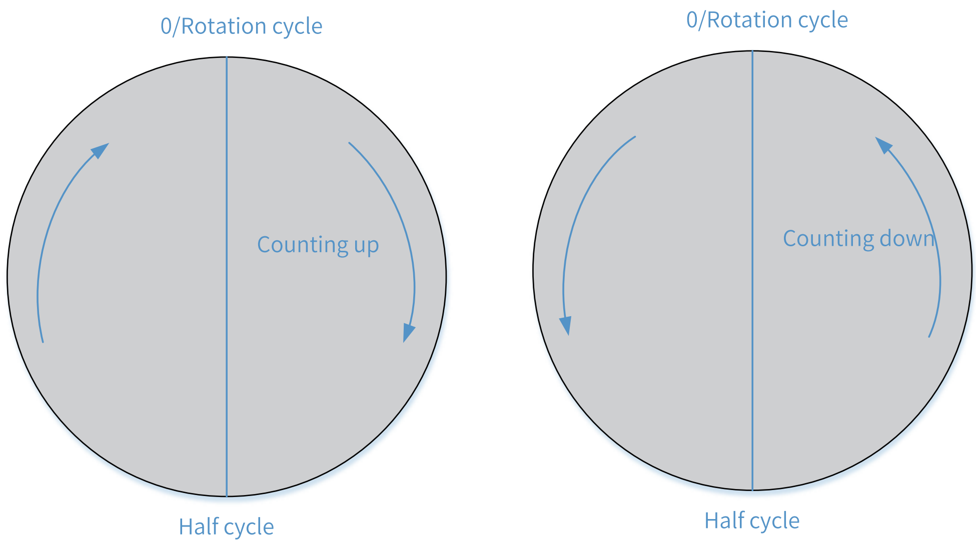



## 13.4.2 Rotary Mode

The position of the counter axis changes cyclically during the rotation cycle. In case of incremental count, the counter axis position turns 0 after reaching the maximum value in the rotation cycle; in case of decremental count, the counter axis position decreases from the maximum value in the rotation cycle after turning 0.

In rotary mode, you can set the rotation cycle of the counter axis in the interface, with user unit (Unit) as the cycle unit.

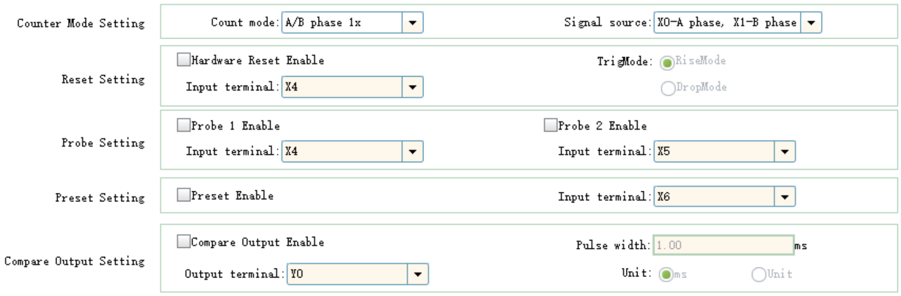
Since the high-speed counter is a 32-bit counter, the rotation cycle must be within the 32-bit integer range [–2147483648, +2147483647] after being converted to pulse units.

# 13.5 Setting Counter Parameters

## 13.5.1 Overview

Parameter settings mainly involve the count mode, probes, presetting, and position output comparison function.




## 13.5.2 Count Modes

### 13.5.2.1 Overview

Local encoder axes support multiple signal counting modes, including phase A/B (frequency multiplication by 1/2/4), CW/CCW, pulse+direction, and single-phase counting.

Signal sources: Different signal sources can be selected depending on the counting mode.


The supported input ports of signal sources in various counting modes are shown in the following table. One input port of signal source can be selected for different local encoder axes.

| Port<br>Mode | X0 | X1 | X2 | X3 | Internal 1 ms | Internal 1 μs |
|---|---|---|---|---|---|---|
| Phase A/B | Phase A | Phase B | Phase A | Phase B | x | x |
| CW/CCW | CW | CCW | CW | CCW | x | x |
| Pulse+direction | Pulse | Direction | Pulse | Direction | x | x |
| Single-phase counting | Pulse | Pulse | Pulse | Pulse | Pulse | Pulse |

***Note***

When two input signals are required in the selected working mode, X0 and X1 make up one group of input signals, while X2 and X3 make up the other group.

The above counting modes and signal sources can be arbitrarily selected for the four counters, and repeatedly used for different counters.

### 13.5.2.2 Phase A/B Mode

In phase A/B mode, the encoder generates two orthogonal phase pulse signals with a phase difference of 90°, that is, phase A signal and phase B signal. When the phase A signal leads the phase B signal, the counter counts up; when the phase B signal leads the phase A signal, the counter counts down.

## Phase A/B encoder wiring diagram

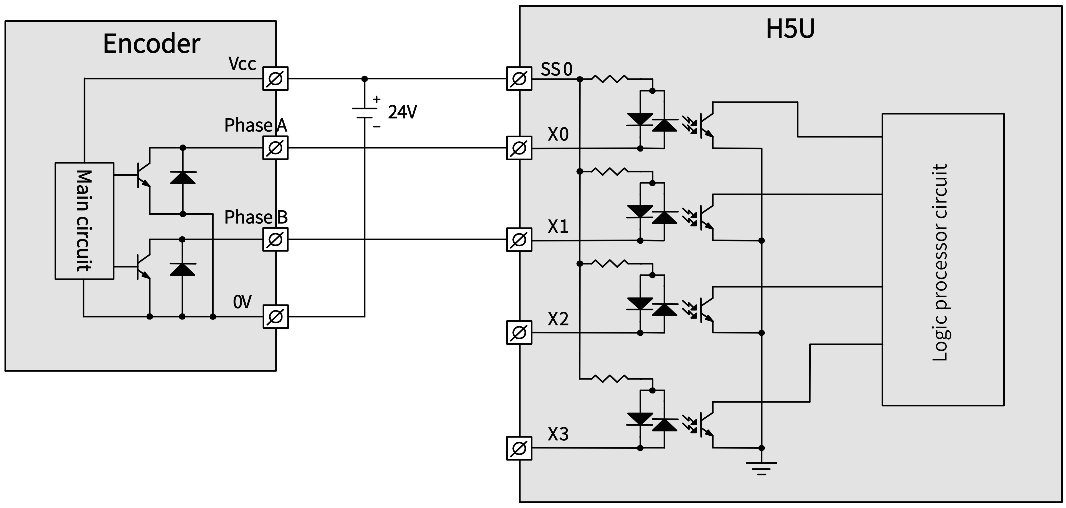



Figure 13-1 Sink Input Wiring

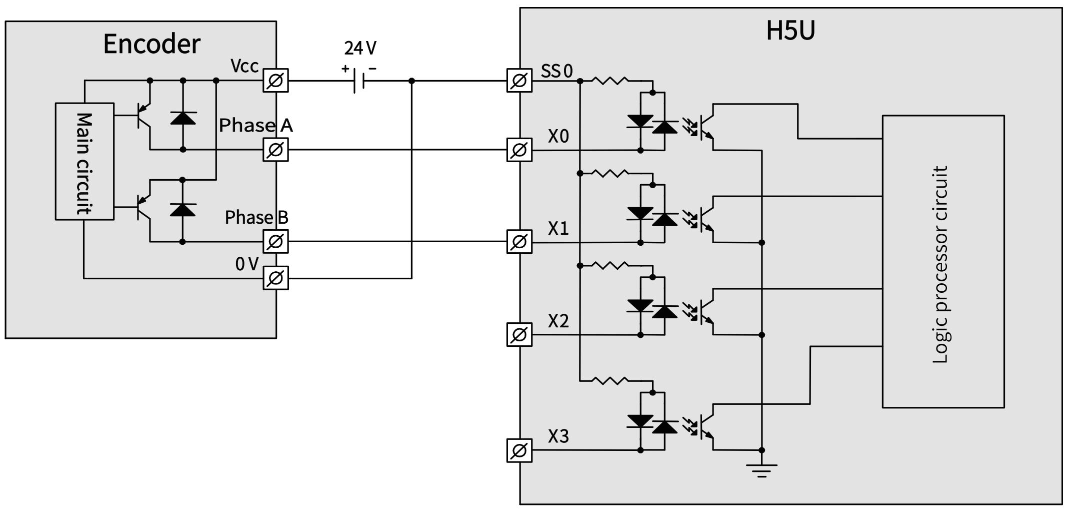
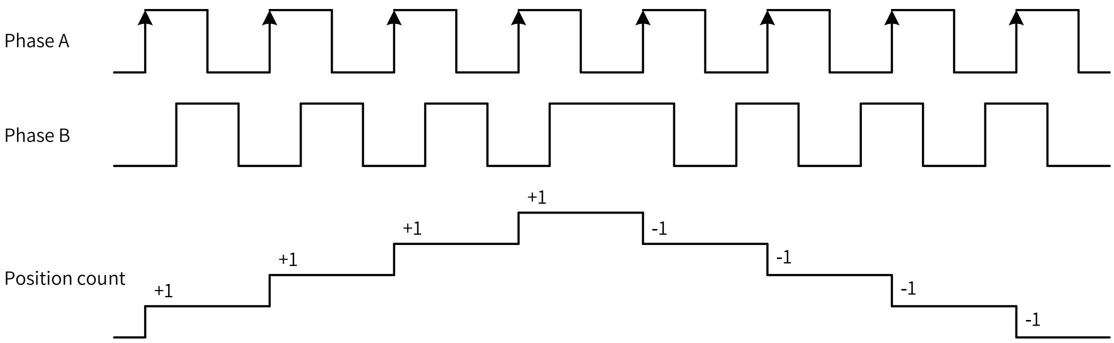


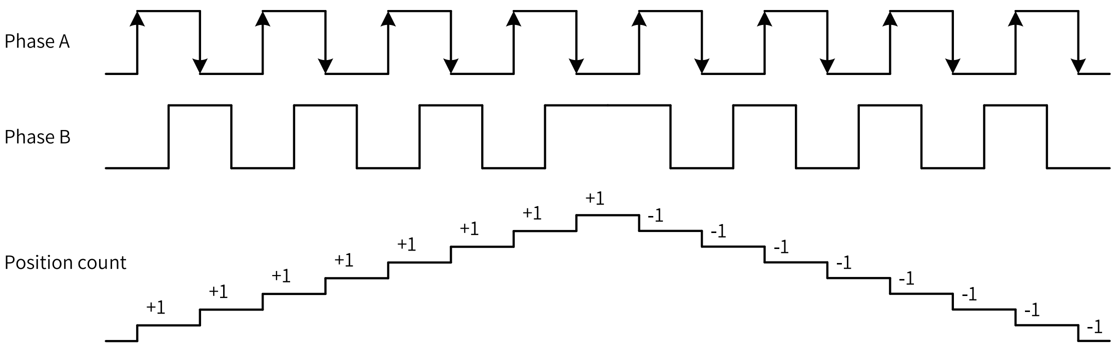

Figure 13-2 Source Input Wiring

The phase A/B pulse can be set to operate in frequency multiplication by 1, 2, or 4.

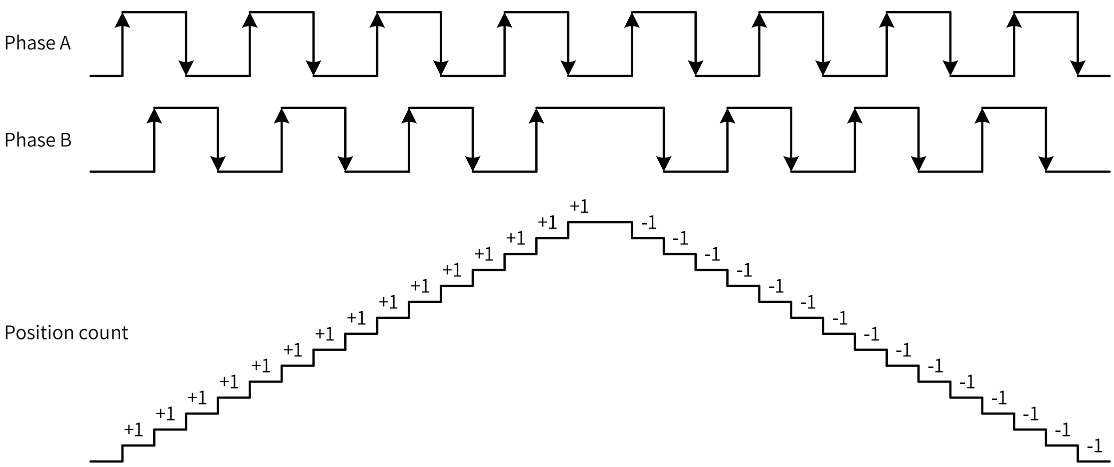
- In the mode of phase A/B frequency multiplication by 1, only the rising edge of phase A pulse is counted as shown in the following figure.




- In the mode of phase A/B frequency multiplication by 2, the rising and falling edges of phase A pulse are counted as shown in the following figure.

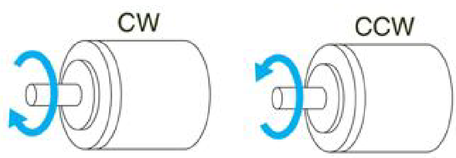



- In the mode of phase A/B frequency multiplication by 4, the rising and falling edges of the phase A pulse and the phase B pulse are counted as shown in the following figure.

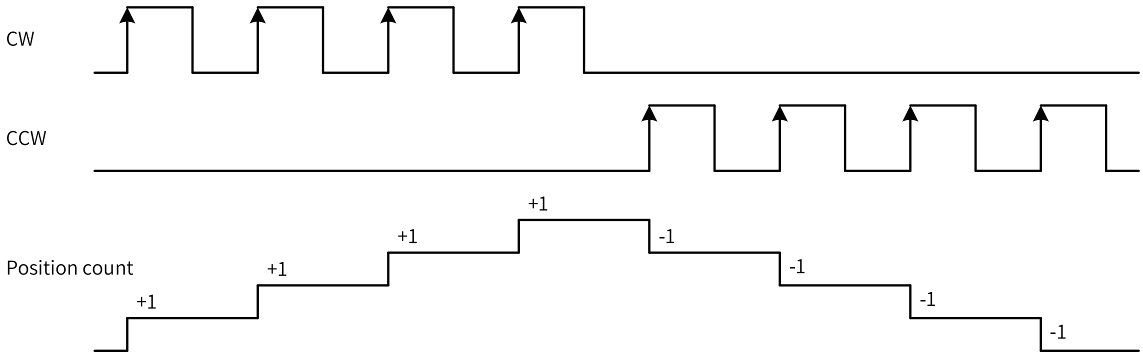



### 13.5.2.3 CW or CCW Mode

Clock Wise (CW) is the forward pulse signal, and Counter Clock Wise (CCW) is the reverse pulse signal. When the encoder is forward running, CW pulse signals are output; when the encoder is reverse running, CCW pulse signals are output.

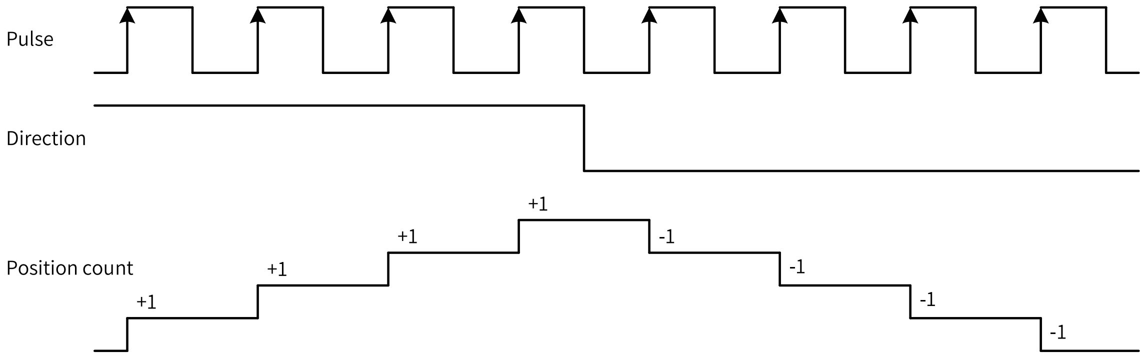


When the local encoder axis operates in this count mode, the high-speed counter counts up the CW signals and counts down the CCW signals, as shown in the following figure.



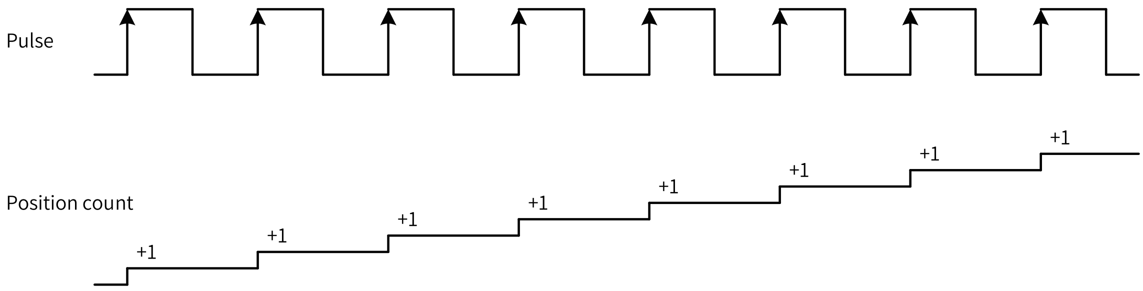

### 13.5.2.4 Pulse+Direction Mode

In this mode, when the direction signal is ON, the high-speed counter counts up the pulse signals; when the direction signal is OFF, the high-speed counter counts down the pulse signals, as shown in the following figure.




### 13.5.2.5 Single-phase Count

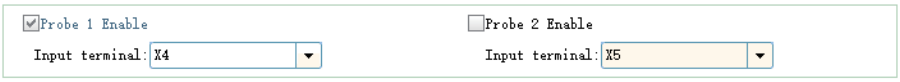
In this mode, the high-speed counter counts up the pulse signals. The position count is added with 1 when the rising edge of a pulse is input.




## 13.5.3 Probe Terminal Settings

Each counter supports two external inputs to latch the current value of the counter to realize the probe function. Enable the counter axis position latch of the external inputs by ticking the "Probe enable". The input terminal can be any of X0 to X7 inputs.

When the probe is enabled, read the probe position of the counter axis through the function block instruction HC_TouchProbe.




Note: For the probe functions supported by the Easy series models, see the specific model for more information.

| Series | Local Encoder Axis | Local Pulse Axis |
|---|---|---|
| Easy301 series | Each axis has only two probes. | Dual-axis mode: 2 probes<br>Single-axis mode: Y0, Y1, Y2, and Y3 support two probes. |
| Other models of the Easy series | Each axis has only one probe. | Dual-axis mode: 2 probes<br>Single-axis mode: Probes are not supported. |

## 13.5.4 Preset Terminal Settings

Enable the preset counter value of external inputs by ticking "Preset enable". The input terminal can be any of X0 to X7 inputs, with rising edge or falling edge as the trigger condition.

When the preset function is enabled, the encoder axis position is preset by external inputs through the function block instruction HC_Preset.


## 13.5.5 Comparison Output Terminal Settings

After "Comparison output enable" is selected, the hardware output can be realized when the positions are equal in comparison without software processing, featuring high real-time performance and microsecond-level output responses.

- After the comparison output function is enabled, in combination with function block instructions, the output controlled by the hardware circuit when the positions are equal in comparison is ON. The output terminal can be any of Y0 to Y3, and the pulse width when the output is ON can be measured in time units or user units (Unit).
- Each local encoder axis is equipped with one comparison output function, and the input terminal and output pulse width can be configured as needed.
- After configuration, the axis position comparison output is realized through the function block instructions HC_Compare, HC_ArrayCompare, and HC_StepCompare.
- When "ms" is selected as the unit, the time range for setting is 0.1 ms to 6553.5 ms. When "Unit" is selected as the unit, make sure that the set value is within the range of 1 to 65535 after being converted to pulse units.


The comparison output is directly output through the hardware control port, instead of software processing. Therefore, status of comparison output is not available in the Y element in the program.

The Y soft element and the comparison output control the output port in an OR relationship. If the Y element is continuously controlled to ON, the actual port output remains ON.

# 13.6 Counter Axis Instruction Application (H5U)

## 13.6.1 Overview

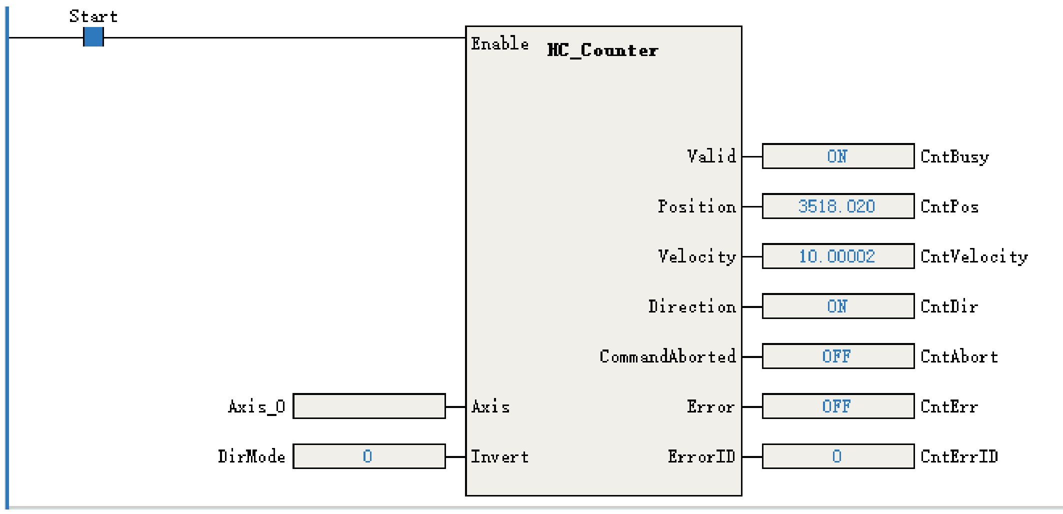
After a counter axis is set in AutoShop, the counter axis can be used in combination with function block instructions to implement functions such as axis position counting/velocity measurement, axis position presetting, and axis position latching and comparison.

## 13.6.2 Axis Position Count and Speed Measurement Instructions

The HC_Counter instruction can count the position and measure the velocity of the counter axis.

The counter axis position value (unit: Unit) is set according to the counter axis mode and changes within the range of the mode.

The counter axis velocity is the current real-time velocity (unit: Unit/s). The minimum velocity that can be measured by the counter axis is the velocity corresponding to 1 pulse of the counter within 1s. If 1 pulse of the counter corresponds to 0.01 Unit, the minimum velocity that can be measured is 0.01 Unit/s.

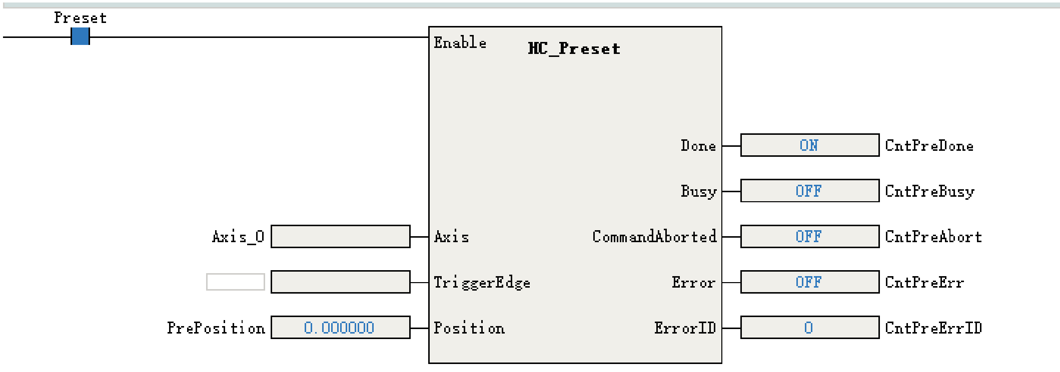



The parameter Invert in the instruction can be set to change the count direction. The modification on Invert takes effect only after this function block instruction is enabled again. The relationship between the Invert setting and the count direction is as follows.

| Invert | Phase A/B | Pulse+direction | CW/CCW | Single-phase counting |
|---|---|---|---|---|
| 0 | Incremental count if phase A leads phase B<br>Decremental count if Phase B leads Phase A | Decremental count for a low-level direction signal<br>Incremental count for a high-level direction signal | Incremental count for phase A<br>Decremental count for phase B | Incremental count |
| 1 | Decremental count if phase A leads phase B<br>Incremental count if phase B leads phase A | Incremental count for a low-level direction signal<br>Decremental count for a high-level direction signal | Decremental count for phase A<br>Incremental count for phase B | Decremental count |

## 13.6.3 Axis Position Preset Instructions

The instruction HC_Preset assigns the counter axis position according to the preset conditions.




The preset condition TriggerType can be set to the trigger by the rising edge of the instruction or by external X input.

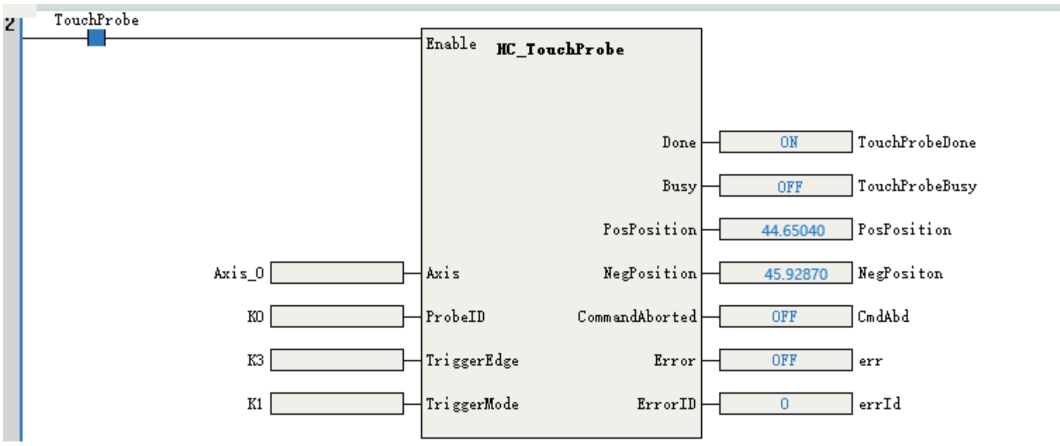
| TriggerType | Definition |
|---|---|
| 0 | Trigger by the rising edge of the instruction flow |
| 1 | Trigger by the rising edge of the external X |
| 2 | Trigger by the falling edge of the external X |
| 3 | Trigger by the rising or falling edge of the external X |

When the preset condition is set to the trigger by external X input, you need to tick "Preset function" in counter parameter settings and select the "Input terminal" and "Trigger Condition". The input terminal can be any of X0 to X7, with rising edge or falling edge as the optional trigger condition.

## 13.6.4 Probe Instructions

The function block instruction HC_TouchProbe can latch the counter axis position value when the external input trigger condition is valid.

Each counter axis supports two probes. During use, you need to tick the corresponding probe function in counter parameter settings and select "Input terminal" and "Trigger Condition". The input terminal can be any of X0 to X7.




The parameter ProbeID specifies the number of the probe used by the counter.

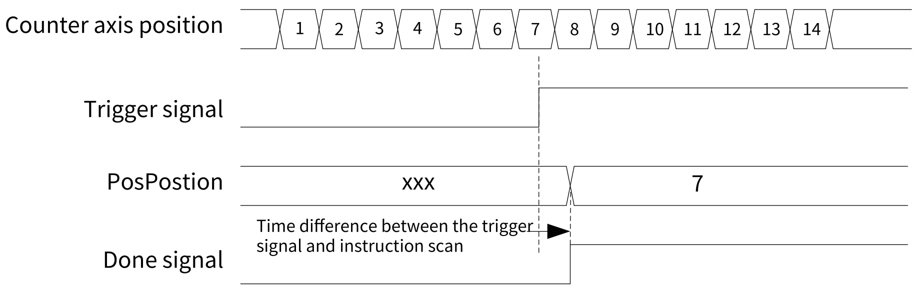
| ProbeID | Definition |
|---|---|
| 0 | Indicates that probe 1 is used. |
| 1 | Indicates that probe 2 is used. |

The parameter TriggerEdge specifies the probe trigger edge. The rising edge trigger position is latched in the output parameter PosPosition, and the falling edge trigger position is latched in the output parameter NegPosition.

| TriggerEdge | Definition |
|---|---|
| 1 | Trigger by the rising edge of the external X |
| 2 | Trigger by the falling edge of the external X |
| 3 | Trigger by the rising or falling edge of the external X |

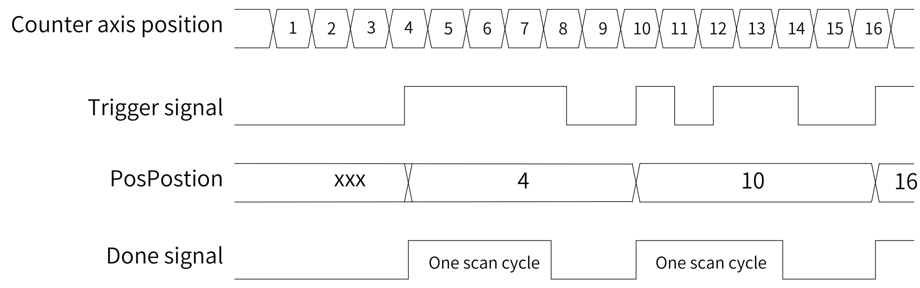
TriggerMode in the instruction can be set to the single trigger or continuous trigger.

- If the single trigger mode is used, when the function block instruction flow and the external input trigger condition are valid, the counter axis position is latched once, and the Done signal is output. The counter axis position is latched in real time based on the trigger edge, which is not affected by program execution. During instruction execution, affected by the scan cycle, when the program scans and runs to the latched instruction, it updates the latched position to the output parameter of the instruction.



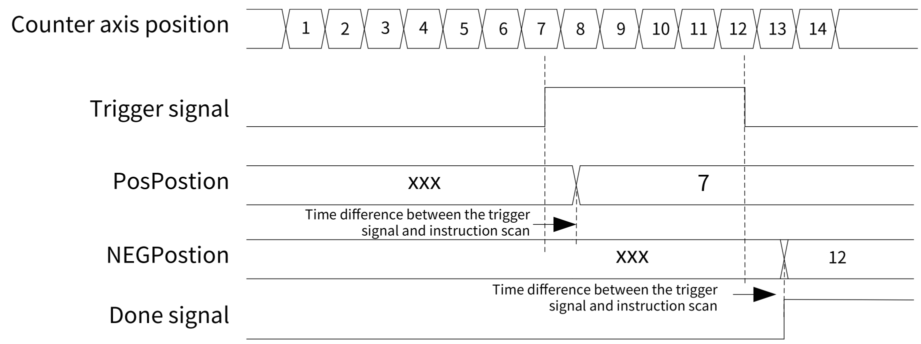

Single triggering on the rising edge

- If the continuous trigger mode is used, when the function block instruction flow and the external input trigger condition are valid, the counter axis position is latched, and the Done signal that is active for one scan cycle is output. When the Done signal becomes OFF and the external input trigger condition is valid, the counter axis position continues to be latched and the Done signal that is active for one scan cycle is output. During the scan cycle in which the Done signal is active, if the external input trigger condition is valid, the counter axis position is not latched at this time.

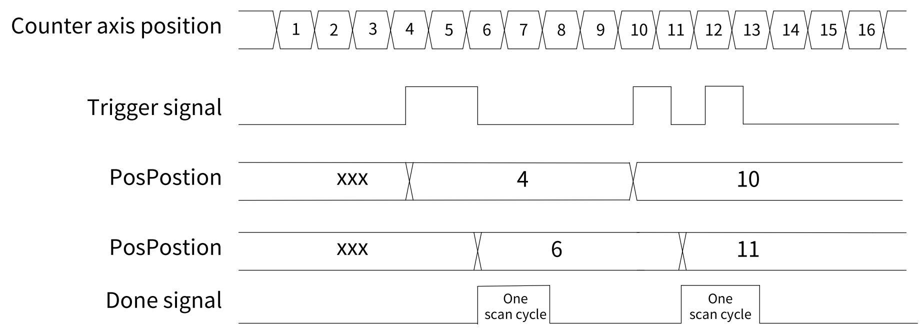



Continuous triggering on the rising edge

- When the dual-edge trigger mode is used, the Done signal is output after the instruction is triggered on both the rising and falling edges to complete the latch. In single trigger mode, the Done signal remains active until the instruction execution is completed; in continuous trigger mode, the Done signal is active for one scan cycle, and the latch signal is not responded within the scan cycle when the Done signal is active.




Single triggering on both the rising and falling edges



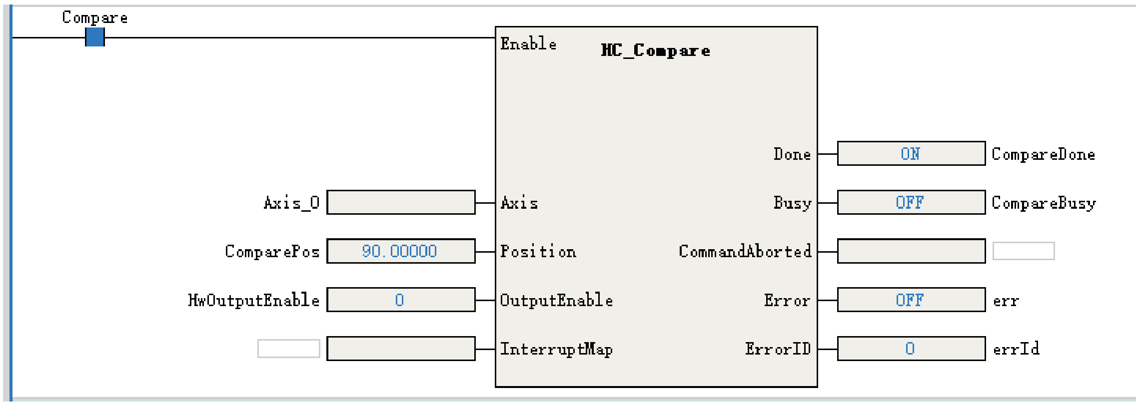

Continuous triggering on both the rising and falling edges

## 13.6.5 Comparison Instructions

The instructions HC_Compare, HC_StepCompare, and HC_ArrayCompare can compare the counter axis position with a single position, equally-spaced positions continuously, or multiple positions continuously.

### HC_Compare

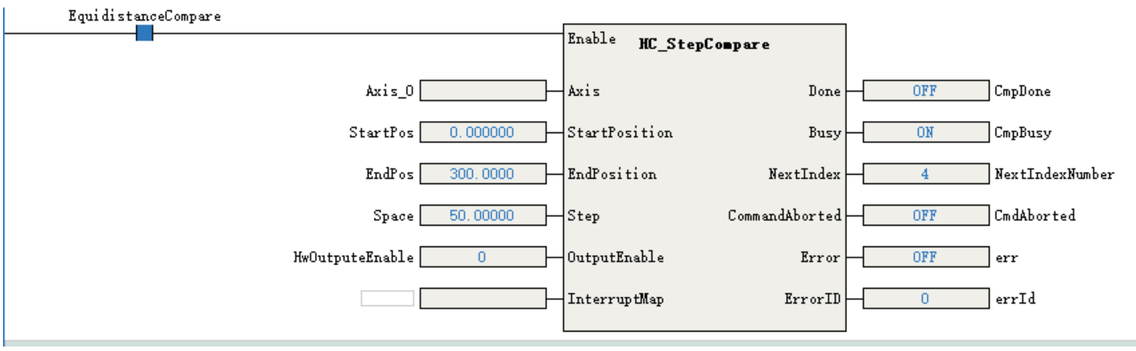
The instruction compares the counter axis position with a single position. When the instruction flow is active, the Done signal is output after the counter axis position reaches the comparison position.

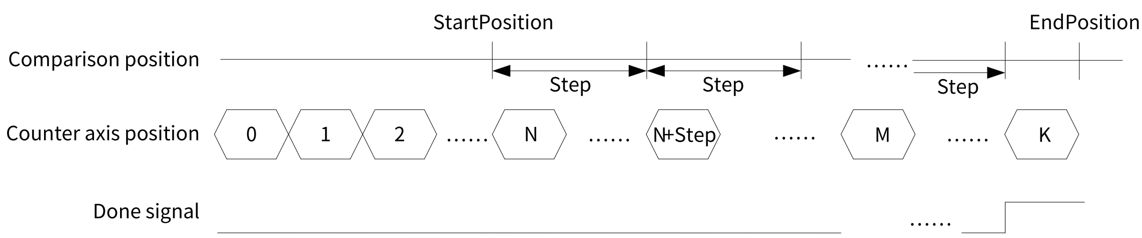



## HC_StepCompare

This instruction compares the counter axis position with equally-spaced positions continuously. When the instruction flow is active, the counter axis position is compared with the position specified by StartPosition. When they are equal, the comparison position increases or decreases by a value specified by Step and then is compared with the counter axis position. The Done signal of one cycle is not output after they are equal in each comparison, but after the last comparison position is compared.

- If the StartPosition is less than the EndPostion, when the positions are equal in each comparison, the comparison position increases by a value specified by Step. When the current comparison position added with the value specified by Step is greater than the EndPosition, the current comparison position is the last one.
- If the StartPosition is greater than the EndPostion, when the positions are equal in each comparison, the comparison position decreases by a value specified by Step. When the current comparison position minus the value specified by Step is less than the EndPosition, the current comparison position is the last one.
- The output parameter NextIndex indicates the index of the next comparison point, that is, the number of completed comparison points.

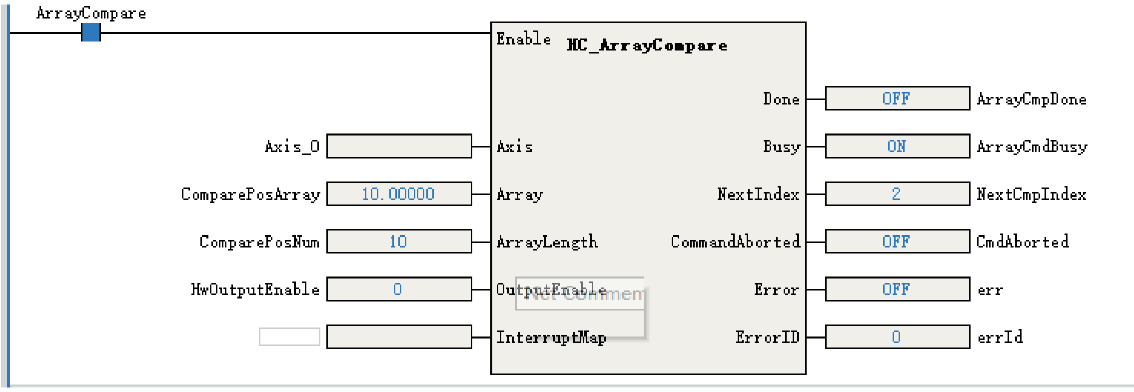


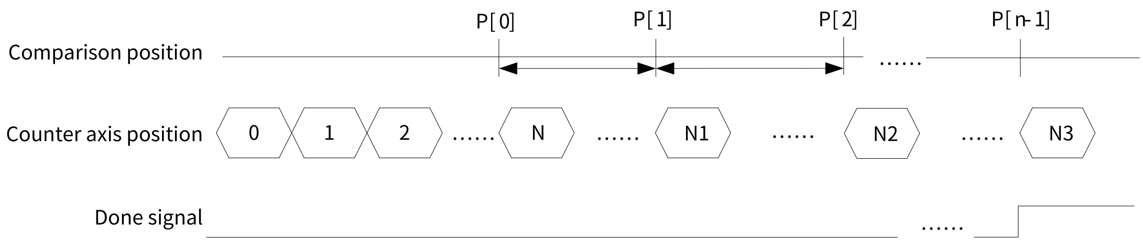



## HC_ArrayCompare

This instruction compares the counter axis position with multiple positions in an array continuously. When the instruction flow is active, the counter axis position is compared with the first position in the array. If they are equal, the counter axis position is compared with the next position value in the array. After the last comparison position is compared, the Done signal is output.

- ArrayLength in the instruction specifies the array length. After all the positions in the array are compared, the Done signal is continuously output and the comparison with multiple positions is completed.
- The output parameter NextIndex indicates the index of the next comparison point, that is, the number of completed comparison points.



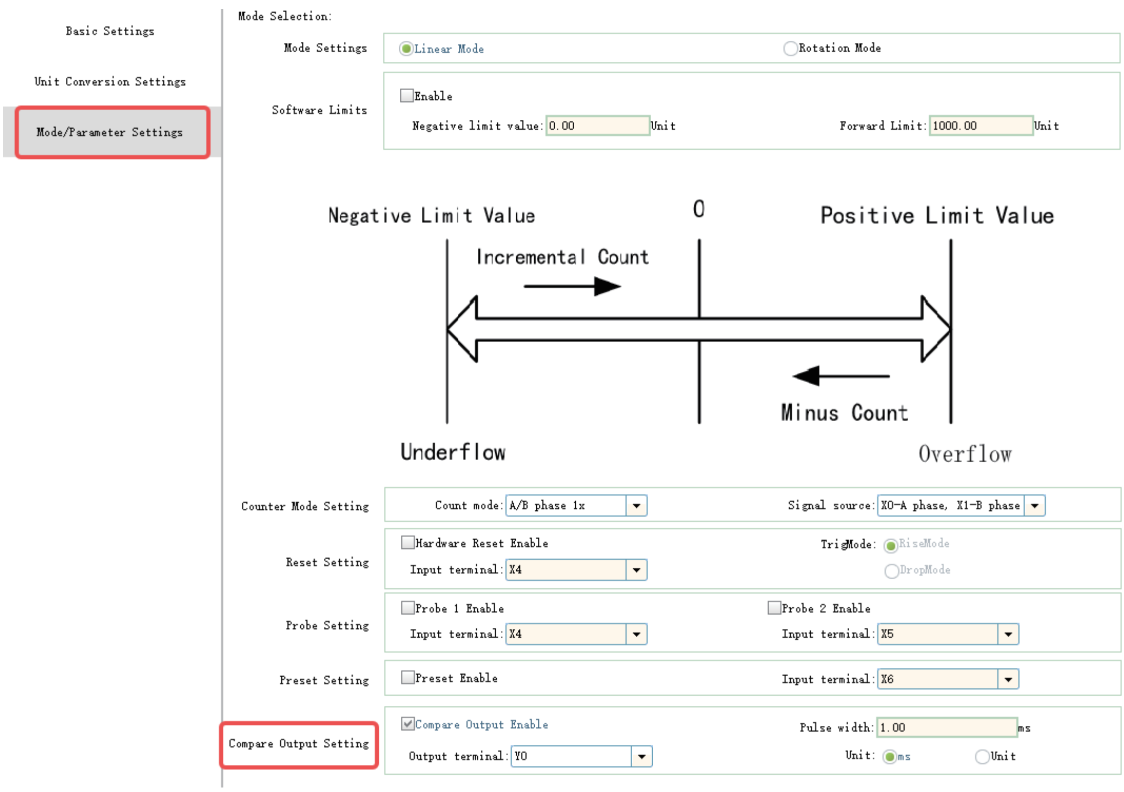

## 13.6.6 High-speed Hardware Comparison Output

The counter axis can realize the position comparison hardware output. When the counter axis and the comparison position are equal, the output directly controlled by the hardware circuit is ON, and the output delay is less than 1 μs.

### Setting the comparison output function of the counter axis

In the parameter setting interface of the counter axis, tick "Comparison output enable".

The output terminal can be any of Y0 to Y3. The output width is set as the pulse width when the output is ON, for which the unit can be time unit or user unit (Unit).



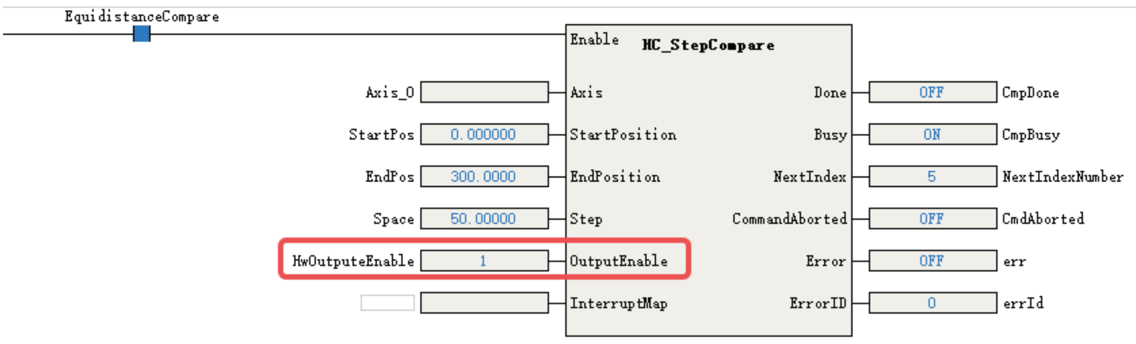

## *Note*

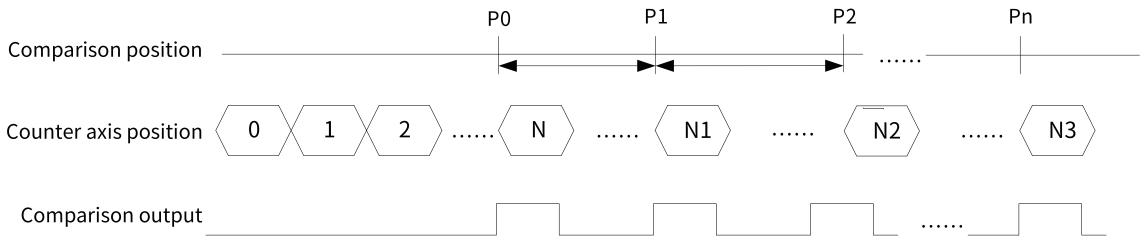
When the unit of pulse output width is set to time, the time accuracy of pulse output width is 100 µs, and the maximum output width is 6500 ms. When the unit of pulse output width is set to user unit (Unit), the maximum output width is equivalent to 65535 pulses.

## Enabling the OutputEnable parameter in the comparison instructions

Use MC_Compare, MC_StepCompare, and MC_ArrayCompare comparison instructions to set OutputEnable to 1, that is, associate hardware outputs when the instruction executes the comparison for equality.

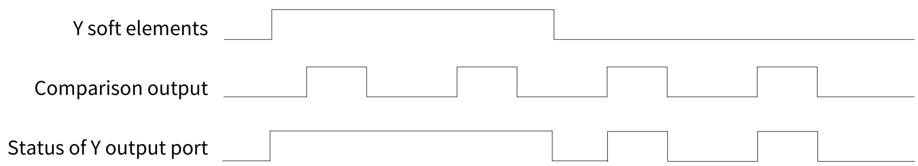
When the instruction executes the comparison for equality, the output terminal set directly through the control of hardware circuit is ON, and the output turns OFF after the continuous width output.






## Note

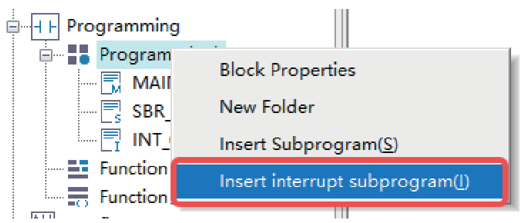
High-speed comparison hardware output is directly output through the hardware control port. Therefore, status of comparison output is not available in the Y element in the program. The Y element and the comparison output control the output port in an OR relationship. If the Y element is continuously controlled as ON, the actual port output remains ON.



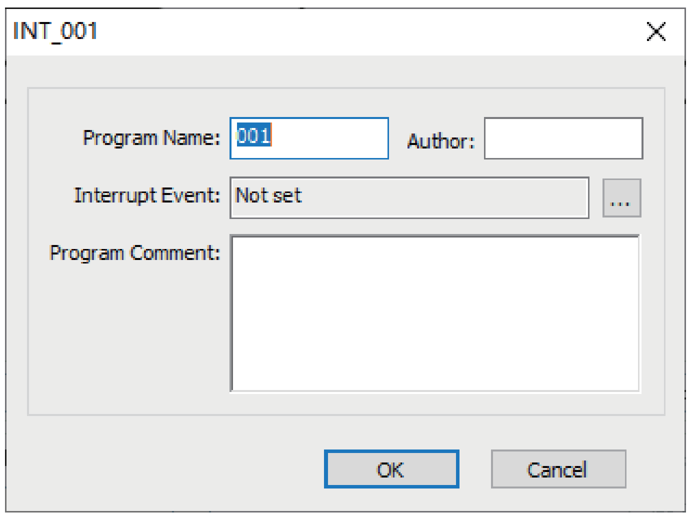

## 13.6.7 Comparison Interruption

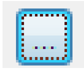
When the counter axes are compared for equality, comparison interruption can be associated and the interrupt subprogram can be executed. The operation steps are as follows.

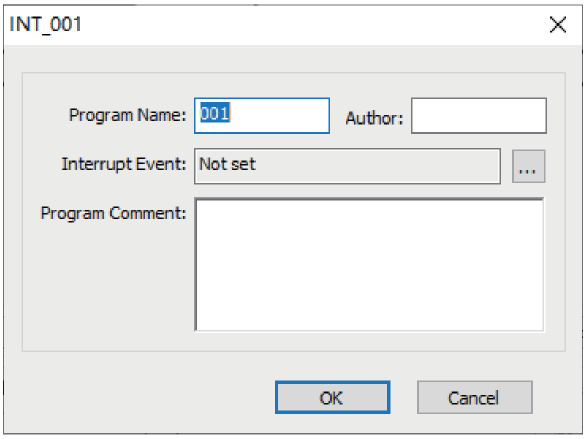
1. Under the item "Programming" in "Project Manager", right-click the "POU", and select "Insert interrupt subprogram".

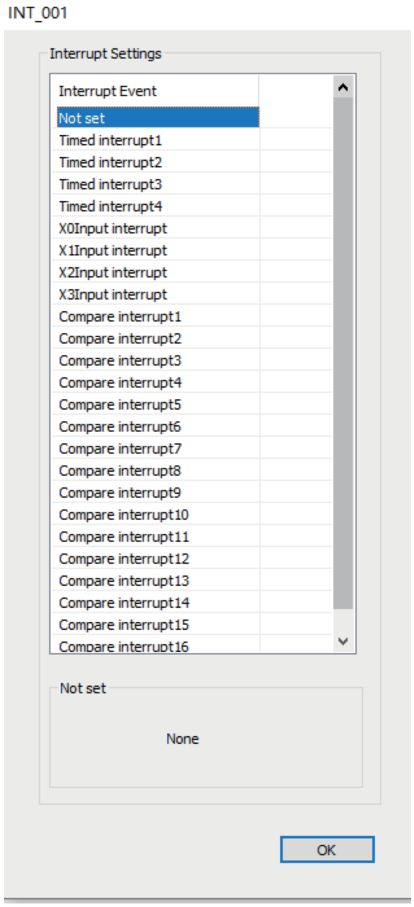



2. Right-click the inserted interrupt subprogram (such as INT_001 in the figure above) and select "Properties" to open the interrupt subprogram settings page as shown in the following figure.

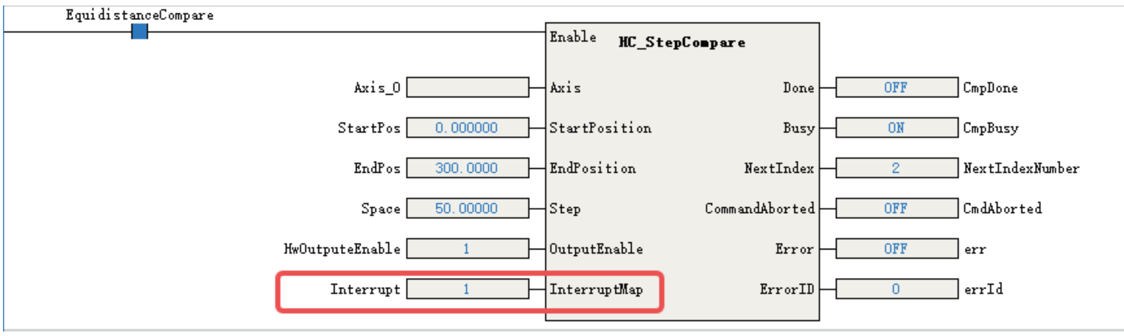


3. Click the  icon after the "Interrupt Event" field, select "Comparison interrupt", and then write interrupt subprograms in INT_001.




4. Call MC_Compare, MC_StepCompare, and MC_ArrayCompare instructions in the main program or subprogram to associate the parameter InterruptMap with the comparison interruption number, that is, setting the parameter InterruptMap as the comparison interruption number. EI is enabled in the program, and when the instruction executes the comparison for equality, the comparison of corresponding interrupt subprograms will be triggered.



# 13.7 Counter Axis Instruction Application (Easy)

## 13.7.1 Overview

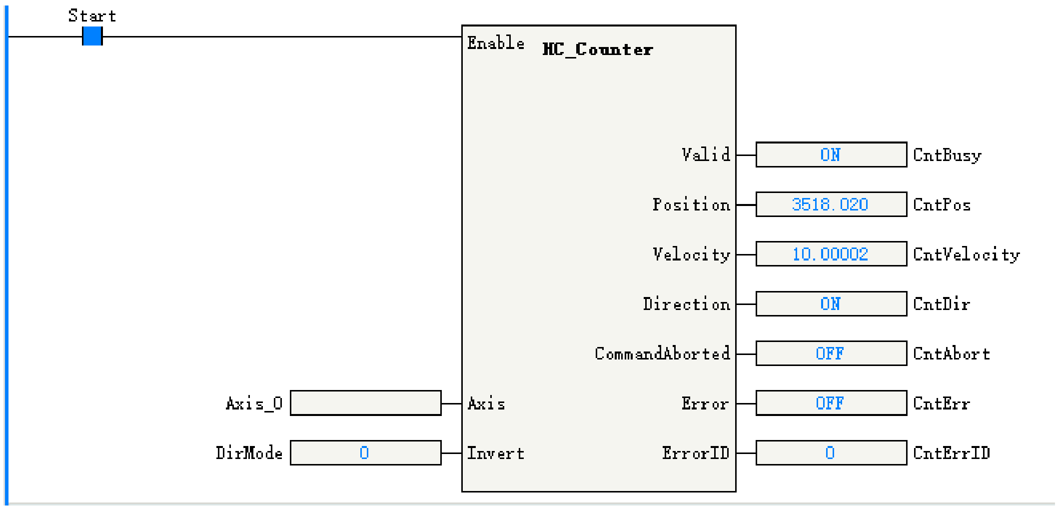
After a counter axis is set in AutoShop, the counter axis can be used in combination with function block instructions to implement functions such as axis position counting/velocity measurement, axis position presetting, and axis position latching and comparison.

## 13.7.2 Axis Position Count and Speed Measurement Instructions

The instruction ENC_Counter implements position counting and velocity measurement of the counter axis.

The counter axis position value (unit: Unit) is set according to the counter axis mode and changes within the range of the mode.

The counter axis velocity is the current real-time velocity (unit: Unit/s). The minimum velocity that can be measured by the counter axis is the velocity corresponding to 1 pulse of the counter within 1s. If 1 pulse of the counter corresponds to 0.01 Unit, the minimum velocity that can be measured is 0.01 Unit/s.

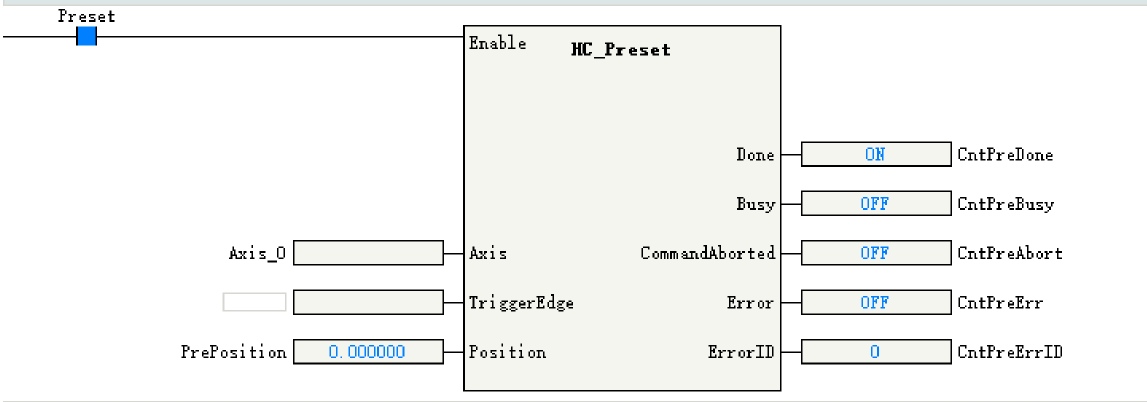



The parameter Direction in the instruction can be set to change the count direction. The modification on Direction takes effect only after this function block instruction is enabled again. The relationship between the Direction setting and the count direction is as follows.

| Direction | Phase A/B | Pulse+direction | CW/CCW | Single-phase counting |
|---|---|---|---|---|
| 0 | Incremental count if phase A leads phase B<br>Decremental count if phase B leads phase A | Decremental count for a low-level direction signal<br>Incremental count for a high-level direction signal | Incremental count for phase A<br>Decremental count for phase B | Incremental count |
| 1 | Decremental count if phase A leads phase B<br>Incremental count if phase B leads phase A | Incremental count for a low-level direction signal<br>Decremental count for a high-level direction signal | Decremental count for phase A<br>Incremental count for phase B | Decremental count |

### 13.7.3 Axis Position Preset Instructions

The instruction ENC_Preset assigns the counter axis position according to the preset conditions.




The preset condition TrigerMode can be set to the trigger by the rising edge of the instruction or by external X input.

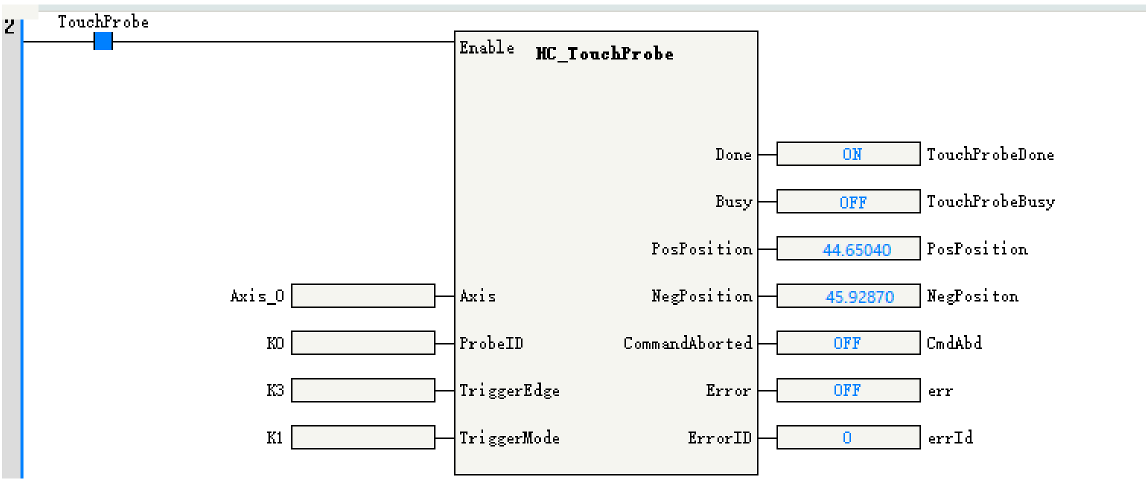
| TrigerMode | Definition |
|---|---|
| 0 | Trigger by the rising edge of the instruction flow |
| 1 | Trigger by the rising edge of the external X |
| 2 | Trigger by the falling edge of the external X |
| 3 | Trigger by the rising or falling edge of the external X |

When the preset condition is set to the trigger by external X input, you need to tick "Preset function" in counter parameter settings and select the "Input terminal" and "Trigger Condition". The input terminal can be any of X0 to X7, with rising edge or falling edge as the optional trigger condition.

### 13.7.4 Probe Instructions

The function block instruction ENC_TouchProbe can latch the counter axis position value when the external input trigger condition is valid.

Each counter axis supports two probes. During use, you need to tick the corresponding probe function in counter parameter settings and select "Input terminal" and "Trigger Condition". The input terminal can be any of X0 to X7.



The parameter ProbeID specifies the number of the probe used by the counter.

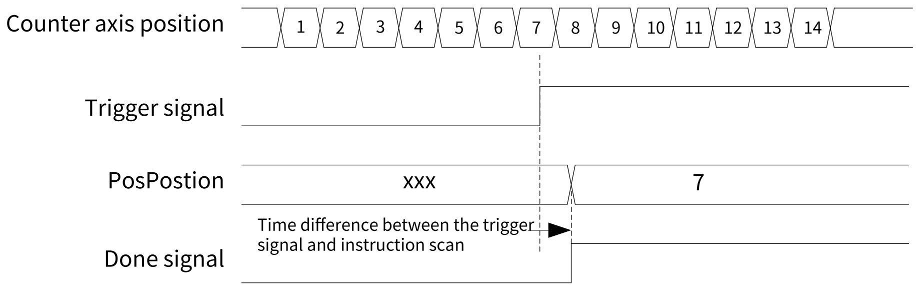
| ProbeID | Definition |
|---|---|
| 0 | Indicates that probe 1 is used. |

The parameter TriggerEdge specifies the probe trigger edge. The rising edge trigger position is latched in the output parameter PosPosition, and the falling edge trigger position is latched in the output parameter NegPosition.

| TriggerEdge | Definition |
|---|---|
| 0 | Trigger by the rising edge of the external X |
| 1 | Trigger by the falling edge of the external X |
| 2 | Trigger by the rising or falling edge of the external X |

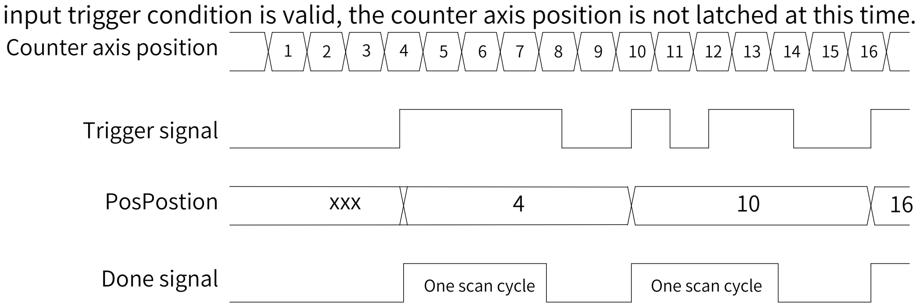
TriggerMode in the instruction can be set to the single trigger or continuous trigger.

- If the single trigger mode is used, when the function block instruction flow and the external input trigger condition are valid, the counter axis position is latched once, and the Done signal is output. The counter axis position is latched in real time based on the trigger edge, which is not affected by program execution. During instruction execution, affected by the scan cycle, when the program scans and runs to the latched instruction, it updates the latched position to the output parameter of the instruction.



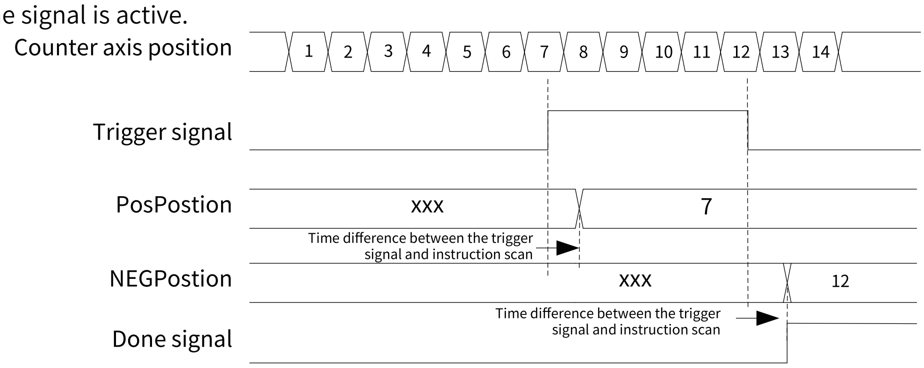

Single triggering on the rising edge

- If the continuous trigger mode is used, when the function block instruction flow and the external input trigger condition are valid, the counter axis position is latched, and the Done signal that is active for one scan cycle is output. When the Done signal becomes OFF and the external input trigger condition is valid, the counter axis position continues to be latched and the Done signal that is active for one scan cycle is output. During the scan cycle in which the Done signal is active, if the external input trigger condition is valid, the counter axis position is not latched at this time.

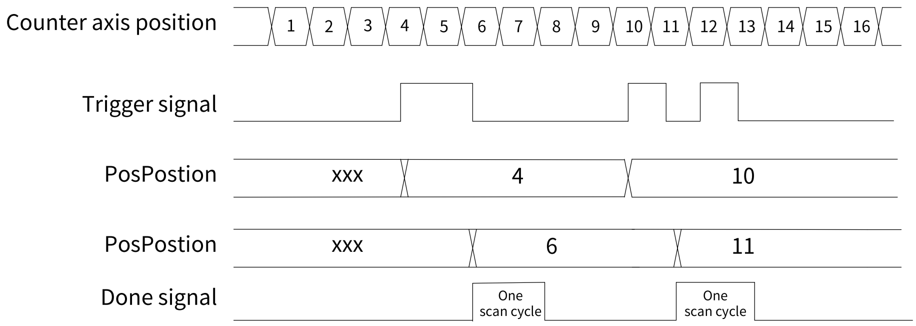



Continuous triggering on the rising edge

- When the dual-edge trigger mode is used, the Done signal is output after the instruction is triggered on both the rising and falling edges to complete the latch. In single trigger mode, the Done signal remains active until the instruction execution is completed; in continuous trigger mode, the Done signal is active for one scan cycle, and the latch signal is not responded within the scan cycle when the Done signal is active.




Single triggering on both the rising and falling edges




Continuous triggering on both the rising and falling edges

When WindowOnly is set to ON, the window setting is enabled and the probe is only active if the encoder axis is in the window confined by FirstPosition and LastPosition.

### 13.7.5 Comparison Instructions

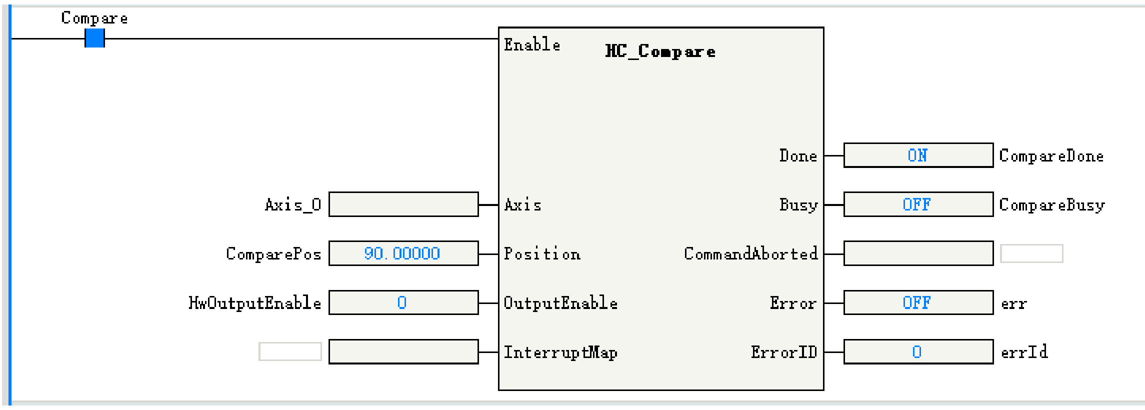
The instructions ENC_Compare, ENC_StepCompare, and ENC_ArrayCompare can compare the counter axis position with a single position, equally-spaced positions continuously, or multiple positions continuously.

#### ENC_Compare

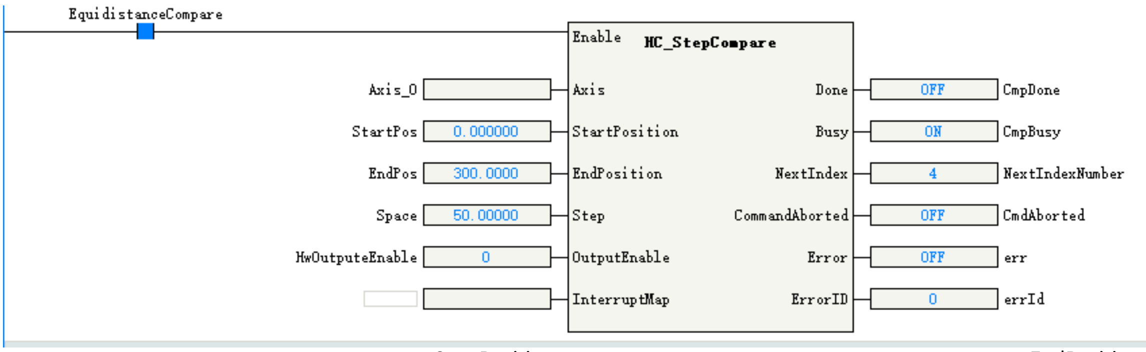
The instruction compares the counter axis position with a single position. When the instruction flow is active, the Done signal is output after the counter axis position reaches the comparison position.

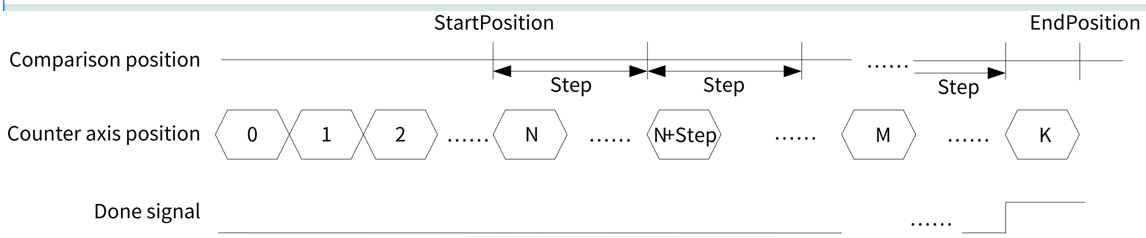
#### ENC_StepCompare

This instruction compares the counter axis position with equally-spaced positions continuously. When the instruction flow is active, the counter axis position is compared with the position specified by StartPosition. When they are equal, the comparison position increases or decreases by a value specified by Step and then is compared with the counter axis position. The Done signal of one cycle is not output after they are equal in each comparison, but after the last comparison position is compared.




- If the StartPosition is less than the EndPostion, when the positions are equal in each comparison, the comparison position increases by a value specified by Step. When the current comparison position added with the value specified by Step is greater than the EndPosition, the current comparison position is the last one.
- If the StartPosition is greater than the EndPostion, when the positions are equal in each comparison, the comparison position decreases by a value specified by Step. When the current comparison position minus the value specified by Step is less than the EndPosition, the current comparison position is the last one.

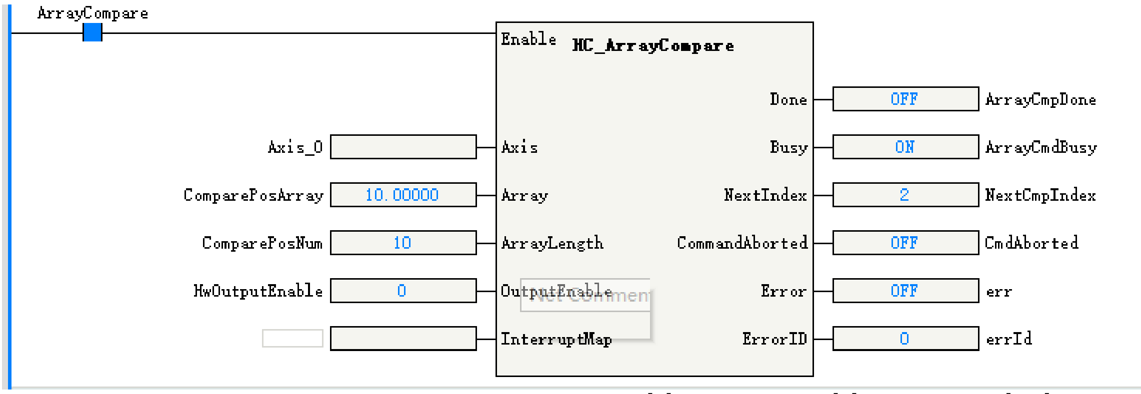


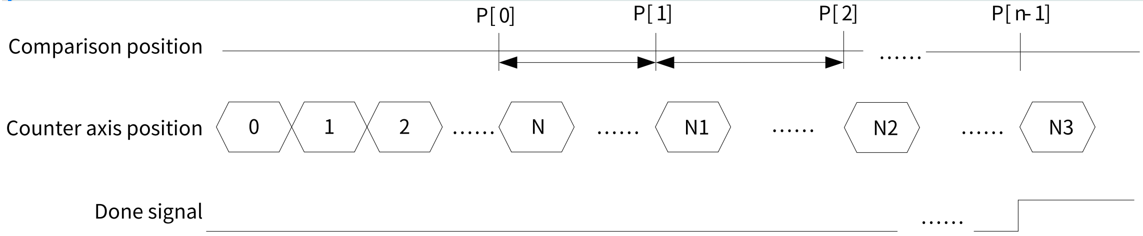




## ENC_ArrayCompare

This instruction compares the counter axis position with multiple positions in an array continuously. When the instruction flow is active, the counter axis position is compared with the first position in the array. If they are equal, the counter axis position is compared with the next position value in the array. After the last comparison position is compared, the Done signal is output.

- Size in the instruction specifies the array length. After all the positions in the array are compared, the Done signal is continuously output and the comparison with multiple positions is completed.
- The output parameter Index indicates the index of the next comparison point, that is, the number of completed comparison points.



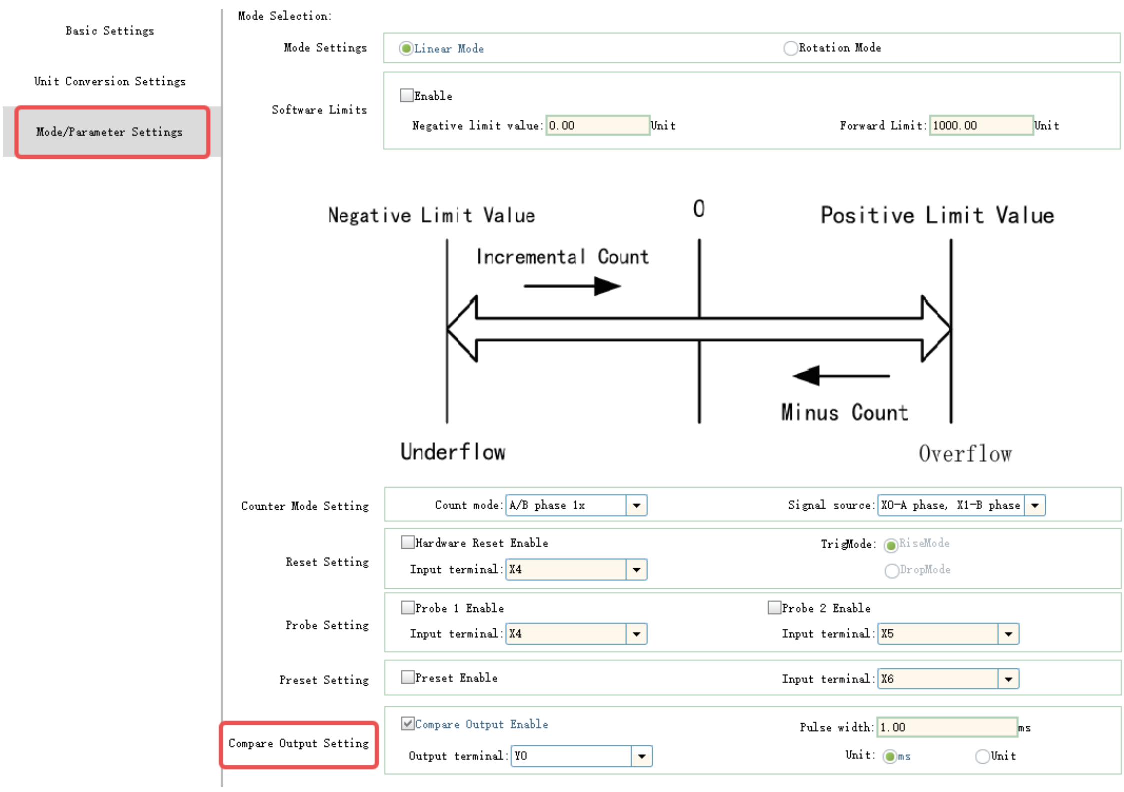

## 13.7.6 High-speed Hardware Comparison Output

The counter axis can realize the position comparison hardware output. When the counter axis and the comparison position are equal, the output directly controlled by the hardware circuit is ON, and the output delay is less than 1 μs.

### Setting the comparison output function of the counter axis

In the parameter setting interface of the counter axis, tick "Comparison output enable".

The output terminal can be any of Y0 to Y3. The output width is set as the pulse width when the output is ON, for which the unit can be time unit or user unit (Unit).



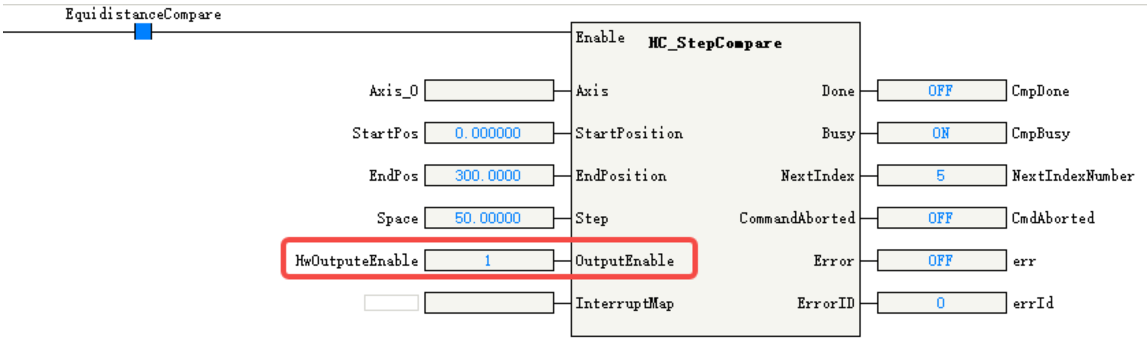

### *Note*

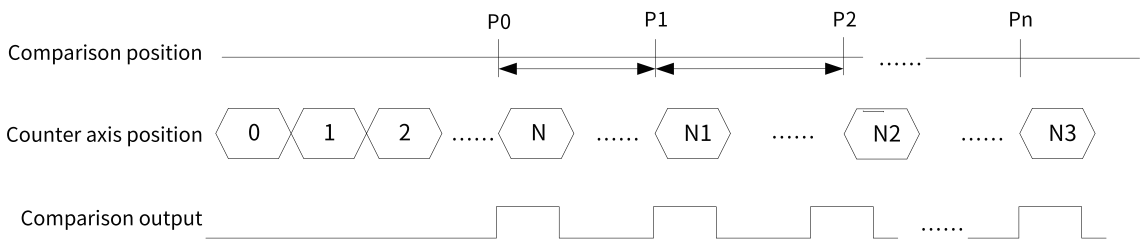
When the unit of pulse output width is set to time, the time accuracy of pulse output width is 100 μs, and the maximum output width is 6500 ms. When the unit of pulse output width is set to user unit (Unit), the maximum output width is equivalent to 65535 pulses.

## Enabling the OutputEnable parameter in the comparison instructions

Use ENC_Compare, ENC_StepCompare, and ENC_ArrayCompare comparison instructions to set OutputEnable to 1, that is, associate hardware outputs when the instruction executes the comparison for equality.

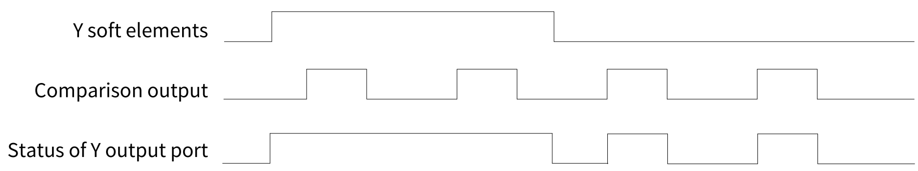
When the instruction executes the comparison for equality, the output terminal set directly through the control of hardware circuit is ON, and the output turns OFF after the continuous width output.






### *Note*

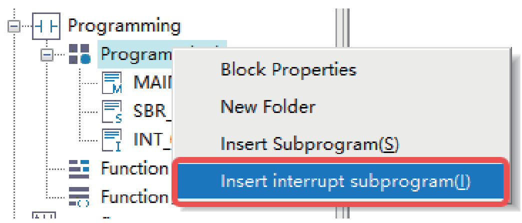
High-speed comparison hardware output is directly output through the hardware control port. Therefore, status of comparison output is not available in the Y element in the program. The Y element and the comparison output control the output port in an OR relationship. If the Y element is continuously controlled as ON, the actual port output remains ON.



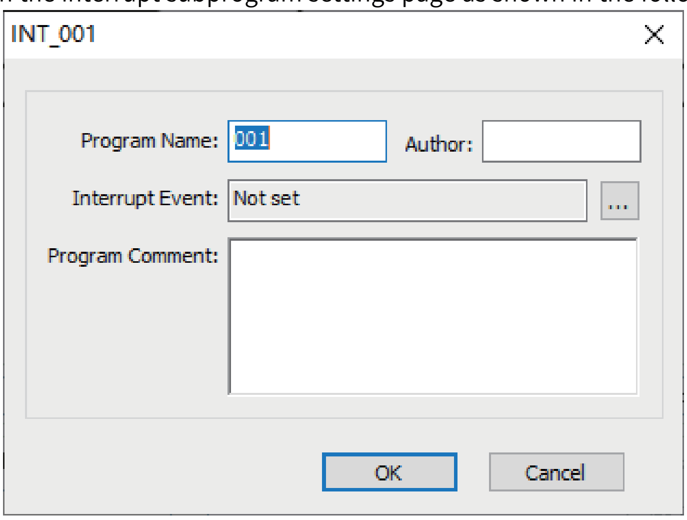

## 13.7.7 Comparison Interruption

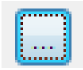
When the counter axes are compared for equality, comparison interruption can be associated and the interrupt subprogram can be executed. The operation steps are as follows.

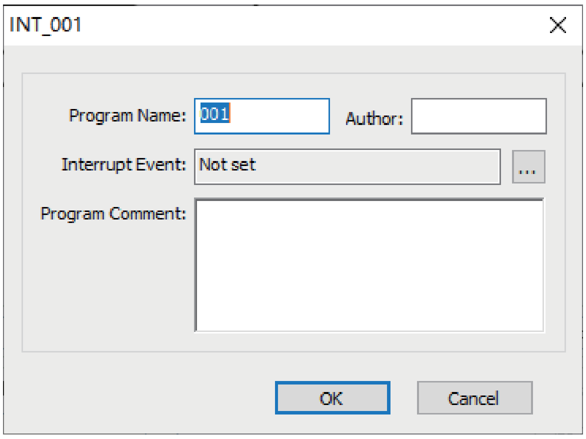
1. Under the item "Programming" in "Project Manager", right-click the "POU", and select "Insert interrupt subprogram".

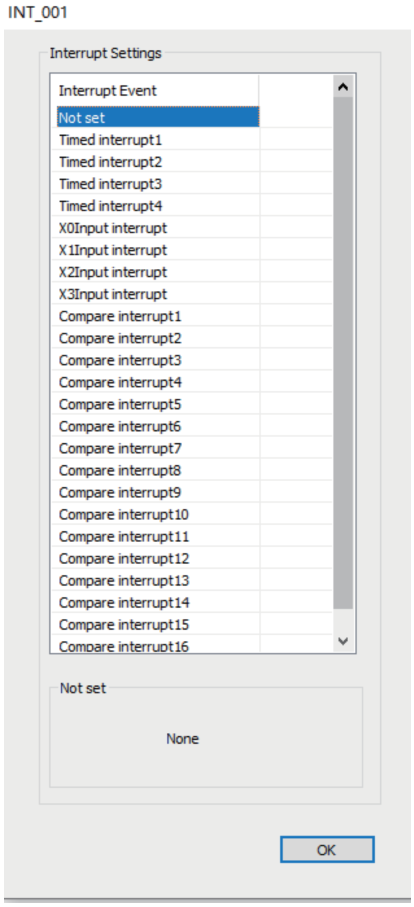



2. Right-click the inserted interrupt subprogram (such as INT_001 in the figure above) and select "Properties" to open the interrupt subprogram settings page as shown in the following figure.

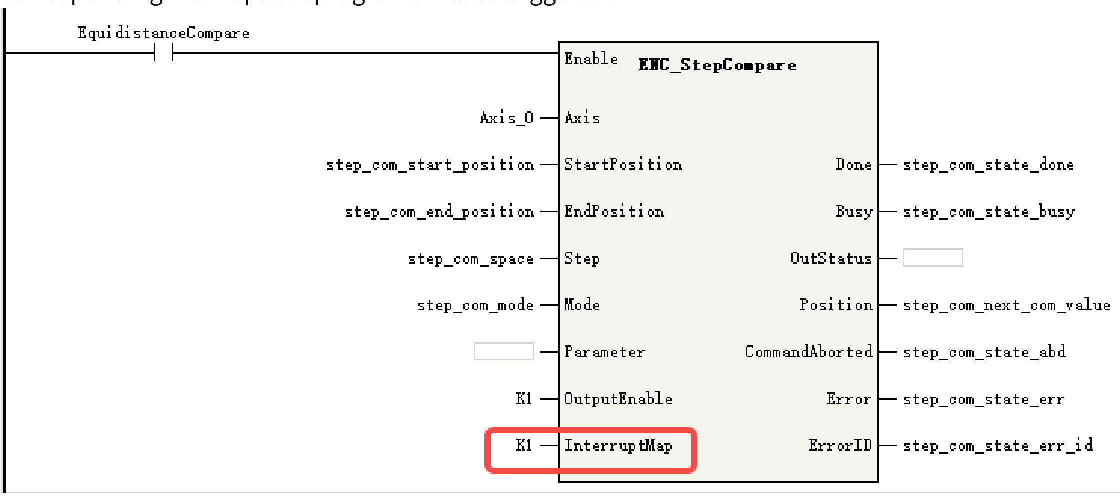


3. Click the  icon after the "Interrupt Event" field, select "Comparison interrupt", and then write interrupt subprograms in INT_001.




4. Call ENC_Compare, ENC_StepCompare, and ENC_ArrayCompare instructions in the main program or subprogram to associate the parameter InterruptMap with the comparison interruption number, that is, setting the parameter InterruptMap as the comparison interruption number. EI is enabled in the program, and when the instruction executes the comparison for equality, the comparison of corresponding interrupt subprograms will be triggered.



## 13.7.8 Setting the Gear Ratio of the Axis

The PLC reconfigures the gear ratio of the local encoder axis before the local encoder axis enables count after power-on, program download, or a RUN/STOP operation.

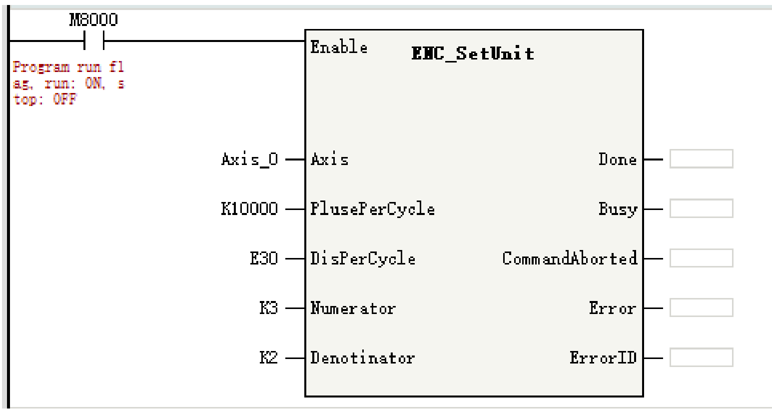
The equation for calculating the gear ratio of the local encoder axis is:

$$\text{Gear ratio} = \frac{PlusePreCycle \times Numerator}{DisPerCycle \times Denotinator}$$

For example, to realize that parameters of the local encoder axis are automatically modified to the following after the PLC is powered on:

| Parameter | Value |
|---|---|
| Number of pulses in one turn by encoder | 10000 |
| Amount of movement of the worktable in a circle | 30 |
| Gear ratio numerator | 3 |
| Gear ratio denominator | 2 |

You are recommended to add the following program to the PLC to trigger this instruction with M8000.




### *Note*

When the program is running, calling this instruction re-initializes the local encoder axis and causes an abrupt change to the feedback position of the local encoder axis.

## 13.7.9 Setting the Linear/Rotary Mode of the Axis

The PLC reconfigures the linear/rotary mode of the local encoder axis before the local encoder axis enables count after power-on, program download, or a RUN/STOP operation.

- When LineRotateMode is set to 0, the local encoder axis is in linear mode.
  In linear mode, when SoftLimitEnable is set to OFF, the limit is disabled. When SoftLimitEnable is set to ON means the limit is enabled, in which case PLimit represents the positive limit, and NLimit represents the negative limit.
- When LineRotateMode is set to 1, the local encoder axis is in rotary mode. In this case, Rotation represents the rotation cycle.

For example, to realize that the local encoder axis automatically switches to the linear mode after the PLC is powered on, and the limit is enabled with a positive limit of +100 and a negative limit of –10, the program is as follows.

# 14 Interpolation Function

## 14.1 Introduction to the Interpolation Function

### 14.1.1 Overview

The space rectangular coordinate system is adopted for interpolation, which supports linear interpolation and circular interpolation, and is performed in the form of axis groups.

- Each axis group can control up to four motion control axes (bus servo axes or local pulse axes), including three coordinate axes X, Y, and Z, and one auxiliary axis.
- The H5U supports up to eight axis groups, each of which can contain two axes (X and Y), three axes (X, Y, and Z), or four axes (X, Y, Z, and auxiliary).
- The Easy series models support different number of axes. See the specific model for the axis group supported.
- Linear and circular interpolation support BufferMode. Each axis group allows up to eight curves to be buffered, and the transition mode between curves can be set separately (see *"14.3.2 Interrupt +No Transition" on page 478* for more information on buffering and transition).

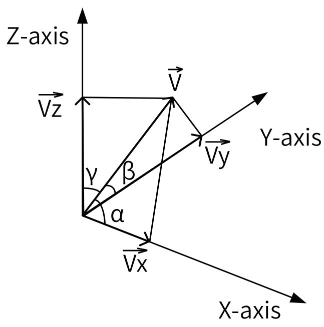



Figure 14-1 Space rectangular coordinate system

In the preceding figure, Vx, Vy, and Vz represent the velocities of the three coordinate axes, respectively, which are also the actual running velocities of the servo axes. V represents the real-time velocity of the interpolation curve. α, β, and γ represent the angles between the velocity of the interpolation curve and the coordinate axis, respectively.

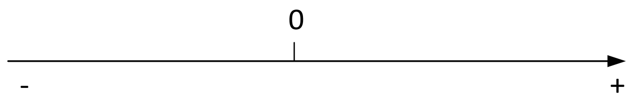



Figure 14-2 Rectangular coordinate system of the auxiliary axis

During linear interpolation, the motion control axes representing the three coordinate axes of X, Y, and Z move along the coordinate axes, while the auxiliary axis moves along a straight line from the start point to the end point.

During circular interpolation, you can choose one of the X-Y, Y-Z, and X-Z axis planes for circular interpolation, in which case if the axis group contains other axes, they will move along a straight line from the start point to the end point.

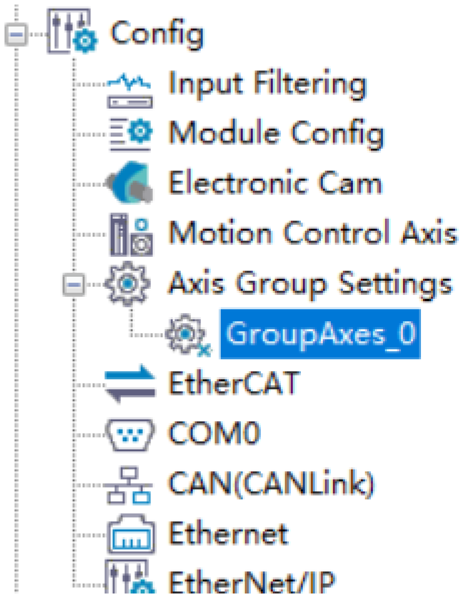
## 14.1.2 List of Axis Group Control Instructions

The following table lists axis group control instructions. See *H5U and Easy Series Programmable Logic Controllers Instructions Guide* for detailed usage of related instructions.

| Instruction | Name |
|---|---|
| MC_MoveLinear | Linear interpolation |
| MC_MoveCircular | Circular interpolation |
| MC_MoveEllipse | Ellipse interpolation |
| MC_GroupStop | Stop the axis group operation. |
| MC_GroupPause | Pause the axis group operation. |

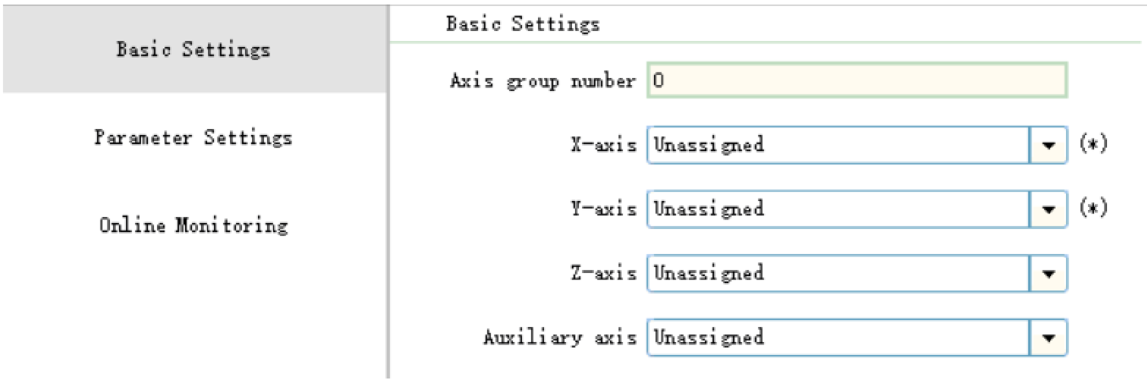
## 14.1.3 Configuration Interface

The menu "Axis Group Settings" is located under the node "Config". After creating an axis group, double-click the axis group to open the configuration interface of the axis group.




The interface of "Axis Group Settings" comprises three parts: "Basic setting", "Settings", and "Online monitoring".

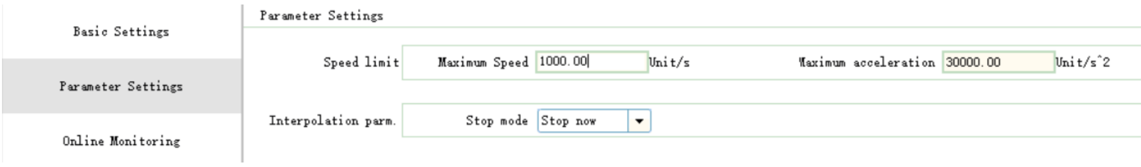
### Basic setting




- "Axis group number": Specifies the number of an axis group.

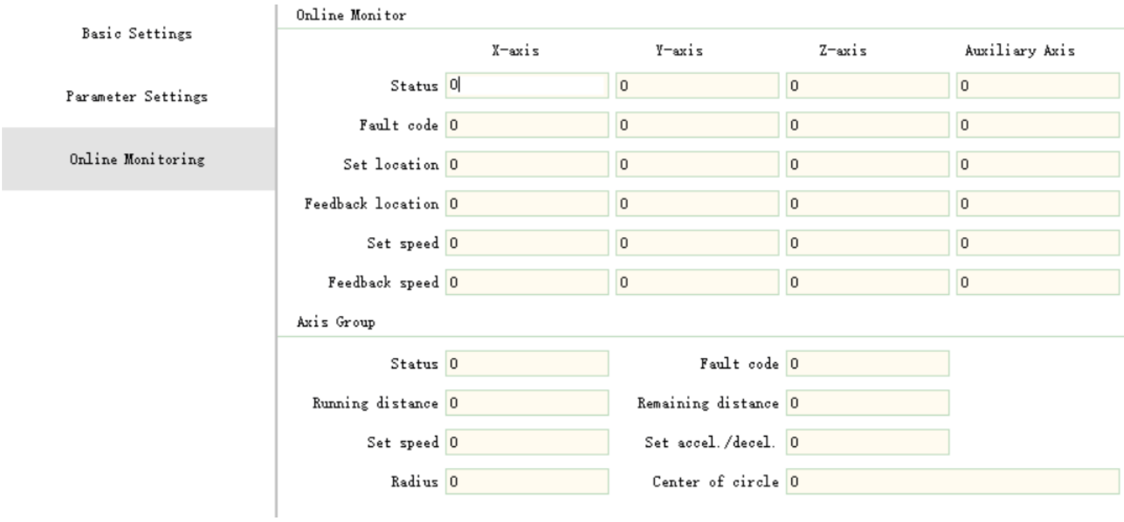
- Selection of coordinate axes: You can select coordinate axes from the corresponding drop-down lists, in which the X-axis and Y-axis are required, and the Z-axis and auxiliary axis are optional. One axis can exist in different axis groups.

## Settings




- "MaxVel": Specifies the maximum interpolation velocity of a space straight line in the linear interpolation mode, or the maximum linear velocity of a circular arc in the circular interpolation mode.
- "Max. acceleration": Specifies the maximum interpolation acceleration rate of a space straight line in the linear interpolation mode, or the maximum linear acceleration rate of a circular arc in the circular interpolation mode.
- "Stop mode": Specifies the stop mode when the axis group encounters an error.

## Online monitoring




- "MaxVel": Specifies the maximum interpolation linear velocity of a space straight line in the linear interpolation mode, or the maximum linear velocity of a circular arc in the circular interpolation mode.
- "Max. acceleration": Specifies the maximum interpolation acceleration rate of a space straight line in the linear interpolation mode, or the maximum acceleration rate of a circular arc in the circular interpolation mode.
- "Stop mode": Specifies the stop mode when the axis group encounters an error.

Table 14–1 Online monitoring parameters

| Parameter | Description |
|---|---|
| Status | The status of a single-axis PLCOpen state machine<br>0: PowerOff<br>1: ErrorStop<br>2: Stopping<br>3: StandStill<br>4: DiscreteMotion<br>5: ContinuousMotion<br>7: Homing<br>8: SynchronizedMotion |
| Fault code | The fault code when a single axis is in the ErrorStop state |
| Setting position | Real-time target position for a single axis |
| Feedback position | Real-time feedback position for a single axis |
| Setting speed | Real-time velocity reference for a single axis |
| Feedback speed | Real-time feedback velocity for a single axis |

Table 14–2 Axis group monitoring parameters

| Name | Description |
|---|---|
| Status | The status of an axis group<br>0: Init<br>The axis configuration in the axis group is not completed.<br>1: Disabled<br>Not all axes in the axis group are enabled.<br>2: Single Stop<br>An axis in the axis group calls the instruction MC_Gtop.<br>3: Single Homing<br>An axis in the axis group calls the instruction MC_Home.<br>4: Single motion<br>An axis in the axis group calls single-axis motion instructions such as MC_MoveAbsolute.<br>5: ErrorStop<br>An axis in the axis group is in a fault state.<br>6: StandStill<br>All axes in the axis group are in the StandStill state.<br>7: Stopping<br>The instruction MC_GroupStop is called.<br>8: Synchronous Motion<br>A linear interpolation or circular interpolation instruction is called. |
| Fault code | The fault code when the axis group fails due to error of a single axis |
| Operation distance | In linear interpolation mode, it indicates the distance at which a space straight line moves after the instruction is executed.<br>In circular interpolation mode, it indicates the length of a circular arc in which the circular arc moves after the instruction is executed. |

| Name | Description |
| --- | --- |
| Remaining distance | In linear interpolation mode, it indicates the left distance for this section of a space straight line after the instruction is executed.<br>In circular interpolation mode, it indicates the length of a space circular arc left after the instruction is executed. |
| Setting speed | In linear interpolation mode, it indicates the interpolation velocity of a space straight line.<br>In circular interpolation mode, it indicates the linear velocity of a circular arc. |
| Setting acceleration/deceleration | The change rate of the velocity reference |
| Radius | The radius of a circular arc during circular interpolation |
| Center | The center of a circular arc during circular interpolation |

# 14.2 Interpolation Operations

## 14.2.1 Overview

To properly execute an interpolation instruction, you need to first create an axis group and enable axes in the axis group. The following figure shows the basic process.

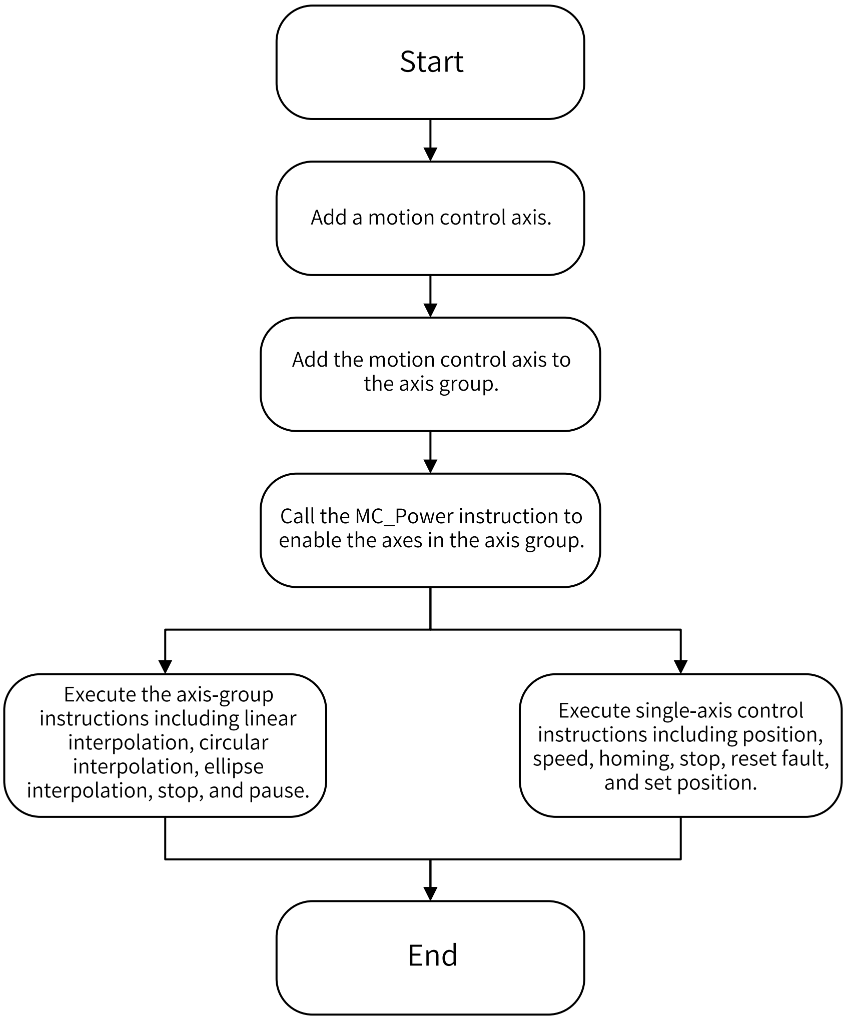



Figure 14-3 Flow chart of interpolation operation

***Note***

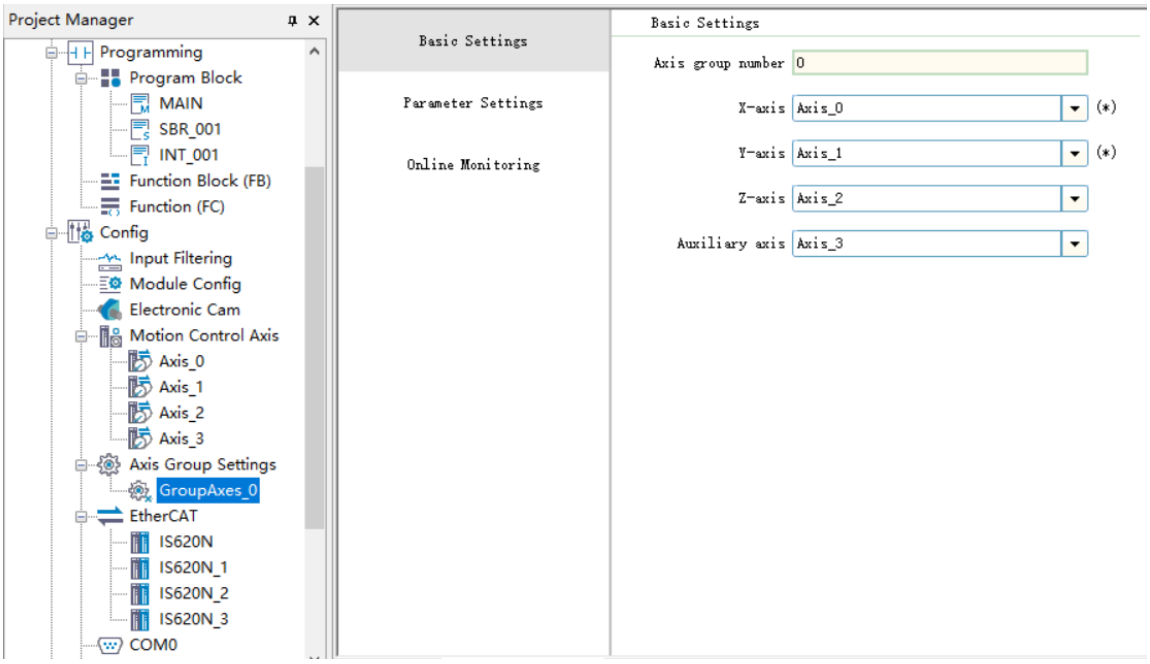
Even after an axis group is created, axes in the axis group can still execute single-axis motion and control instructions. However, motion instructions for a single axis and interpolation instructions for an axis group are mutually exclusive. These instructions cannot be activated at the same time or interrupt each other.

This section describes the basic interpolation procedures based on a routine that combines Axis_0, Axis_1, Axis_2, and Axis_3 into an axis group to perform related actions.

Detailed information on the configuration of motion control axes can be found in the section "Motion Control".

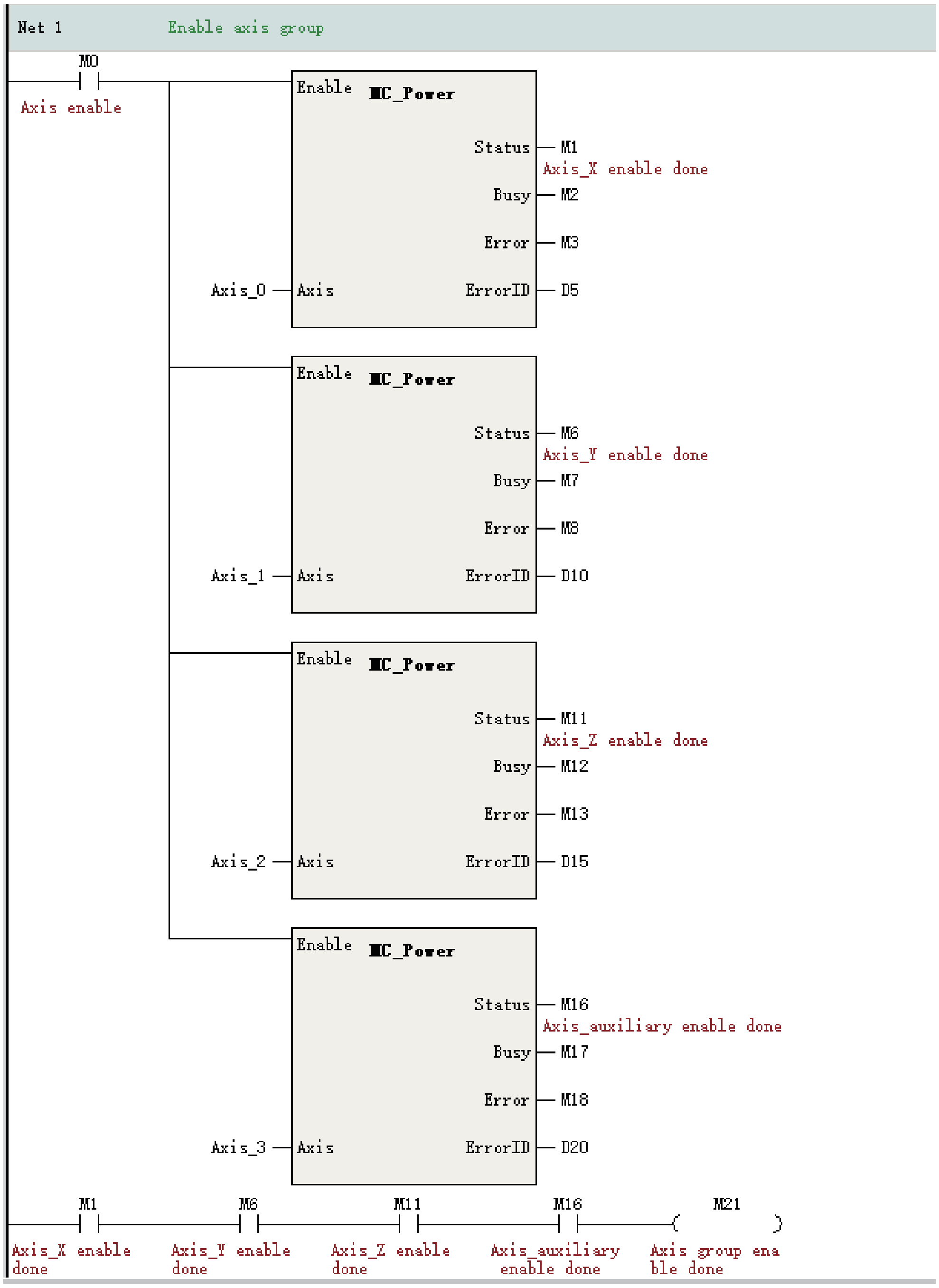
## 14.2.2 Creating an Axis Group

Right-click "Axis Group Settings", and select "Add Axis Group". After creating an axis group, you can choose the coordinate axes and auxiliary axis and set relevant parameters.




## 14.2.3 Enabling an Axis Group

Each single axis in the axis group is enabled and disabled through the instruction MC_Power. The axis group control instruction can only be executed if all axes in the axis group are enabled.




## 14.2.4 Linear Interpolation

The linear interpolation of an axis group is implemented by the instruction MC_MoveLinear.
When all axes in the axis group are in the StandStill state, the Execute is triggered, the axis group starts to implement linear interpolation, and all axes in the axis group switch to the Synchronized Motion state. In this case, the single-axis motion instructions such as MC_MoveAbsolute and MC_Stop must not be executed.

After the linear interpolation is completed, all axes in the axis group return to the StandStill state, in which case single-axis motion instructions such as MC_MoveAbsolute and MC_Stop can be executed again.

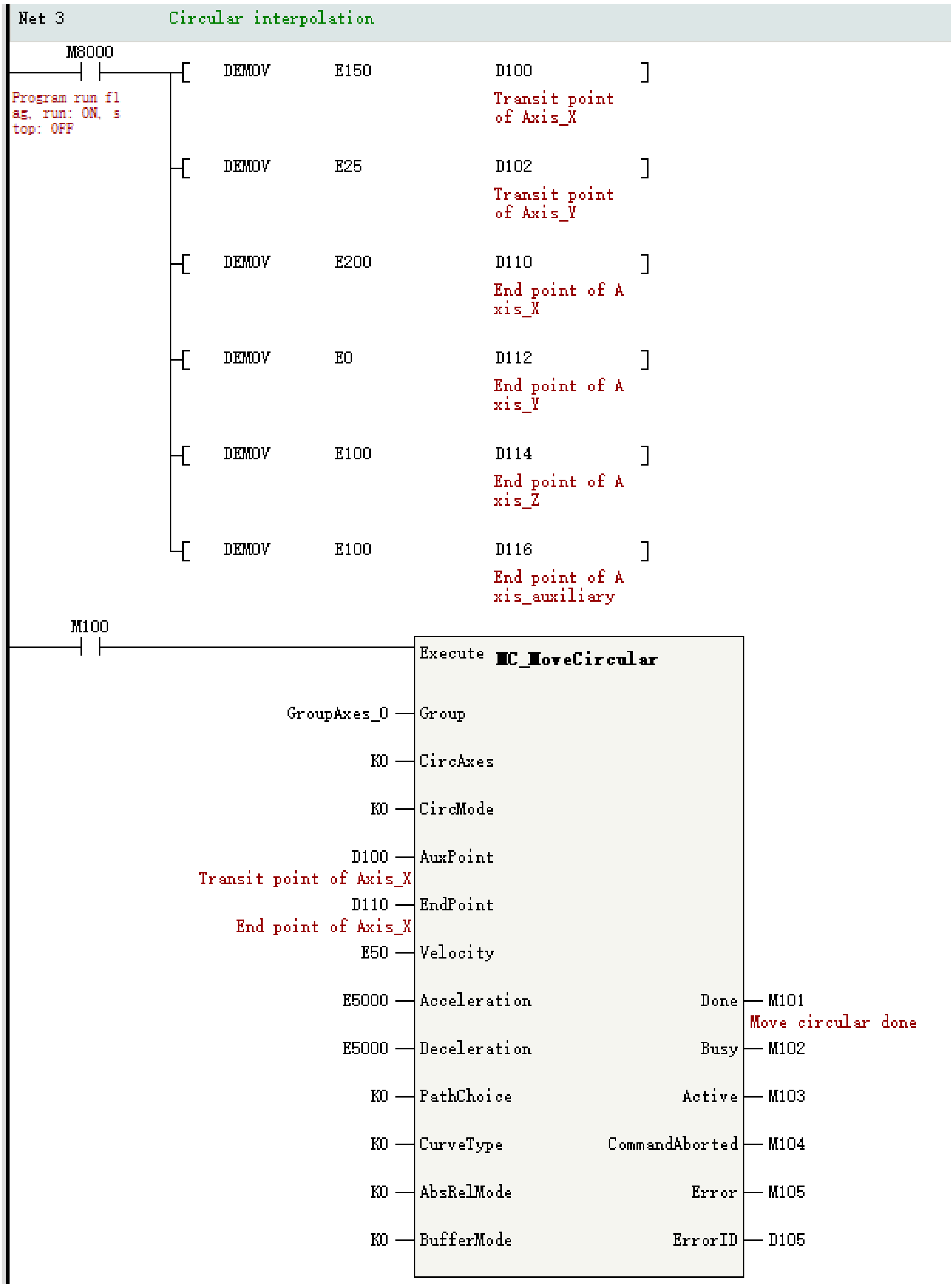
### Example

This routine uses absolute positioning to position the X-axis, Y-axis, and Z-axis to the position (100,100,100), and the auxiliary axis to the position 50.

## 14.2.5 Circular Interpolation

Circular interpolation of an axis group is implemented by the instruction MC_MoveCircular. The conversion rules for PLCOpen state machines are the same as those for linear interpolation.
This routine implements circular interpolation of the X-Y axis plane while the Z-axis and auxiliary axis making synchronous linear motion. The circular interpolation is implemented in the border point mode, that is, with absolute positioning, first passing through the border point (150,25) and then reaching the position (200,0). The Z-axis and auxiliary axis reach the position 100.

For specific parameters related to the circular arc instructions, see *H5U and Easy Series Programmable Logic Controllers Instructions Guide*.




## 14.2.6 Axis Group Stop

Stop the execution of the interpolation curve by the instruction MC_GroupStop.

The execution of the interpolation instruction is interrupted on the rising edge of Execute, and the CommandAborted output of the interpolation instruction is valid.

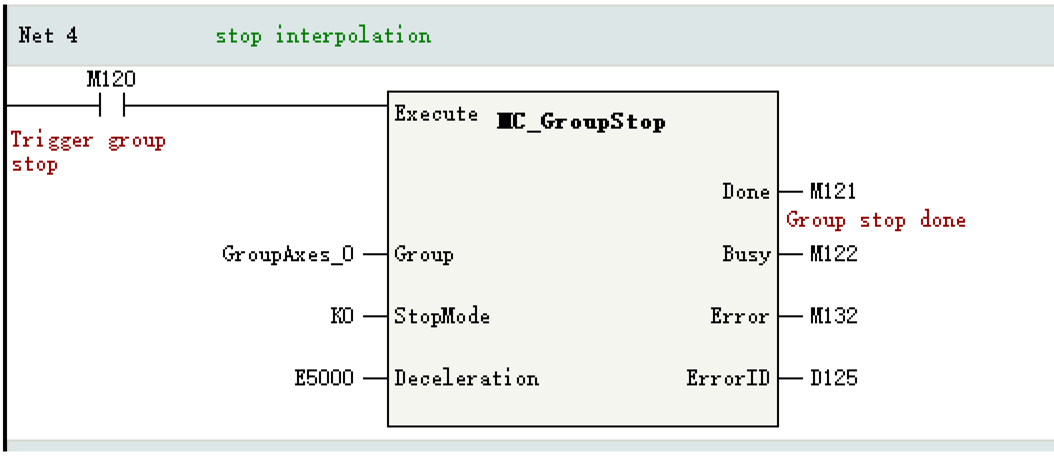
Interpolation instructions cannot be triggered when Execute is TRUE. Execute must be set to False to re-execute a new interpolation instruction.

This instruction can only be called when all axes in the axis group are in the StandStill or Synchronized Motion state. Axes are in the Synchronized Motion state while the Execute of the instruction is true.

MC_GroupStop can only stop the operation of an interpolation curve, rather than that of single-axis motion instructions such as MC_MoveAbsolute.

## Example

In this routine, the following instruction is called during linear interpolation or circular interpolation to stop the operation of an interpolation curve. With the decelerate-to-stop mode in use, the deceleration to stop is 5000.



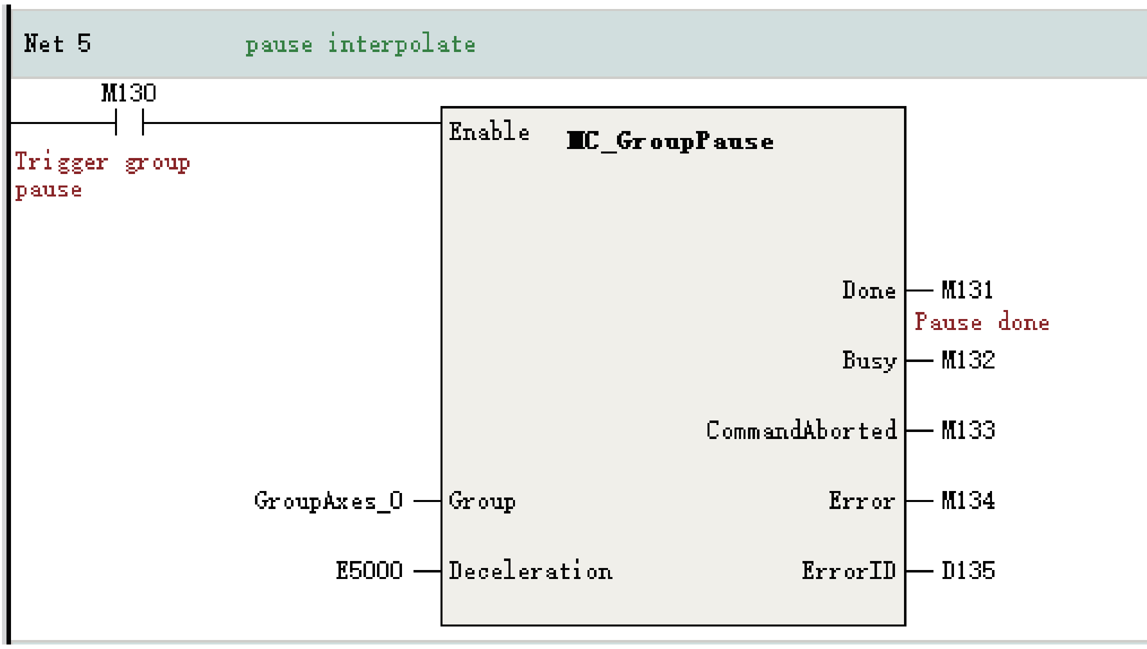

## 14.2.7 Axis Group Pause

The interpolation curve is paused by the instruction MC_GroupPause.
Pause the interpolation curve when Enable is TRUE and resume the execution when Enable is False.

MC_GroupPause can only pause the operation of an interpolation curve, rather than that of single-axis motion instructions such as MC_MoveAbsolute.

## Example

In this routine, the following instruction is called during line or circular interpolation to pause the operation of the interpolation curve, and the deceleration to pause is 5000.

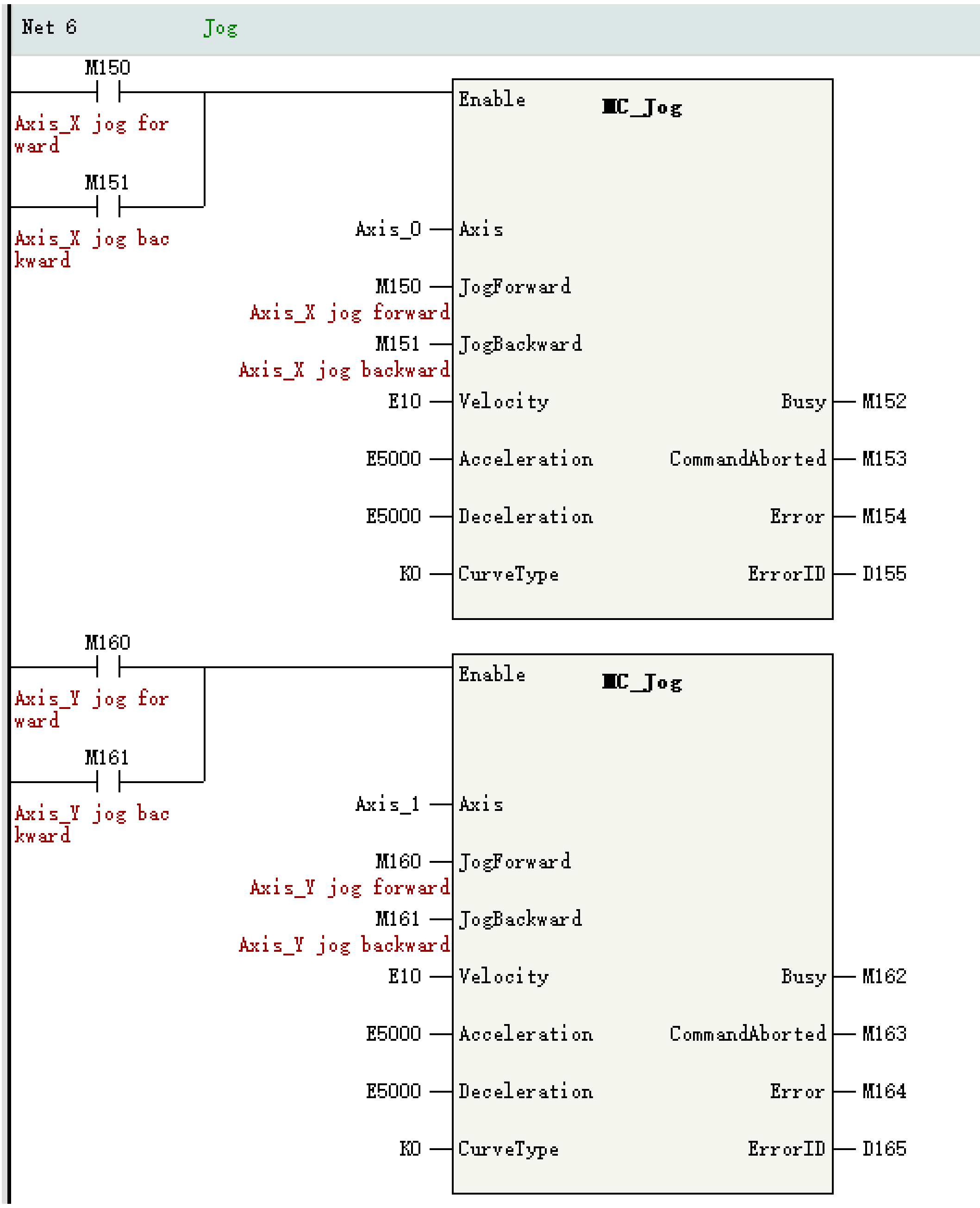



## 14.2.8 Single-axis Motion

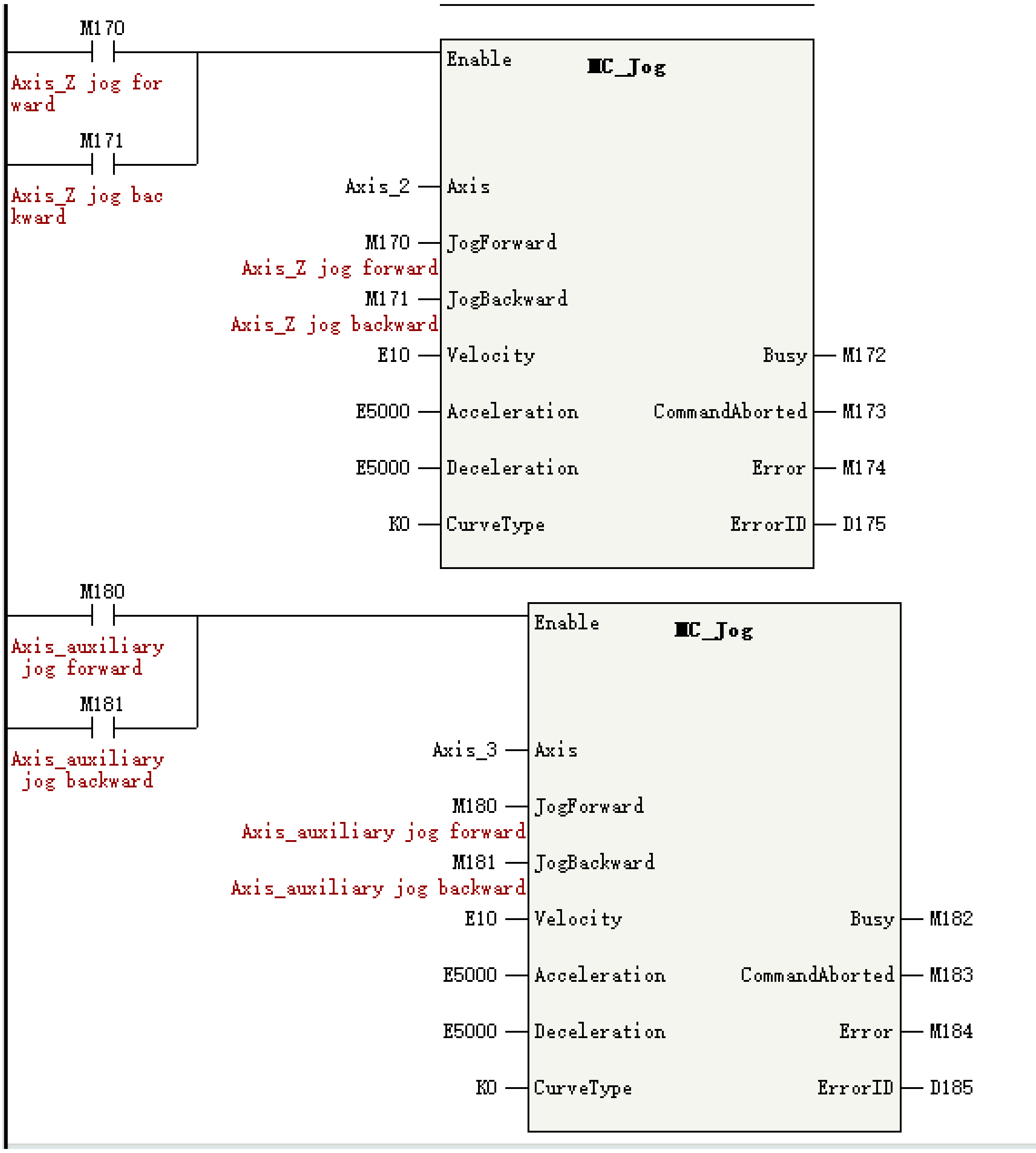
When the single-axis PLCOpen state machine is in the Synchronized Motion state due to the execution of the interpolation action, the single-axis instructions such as MC_MoveAbsolute and MC_Stop must not be executed. When the axis is in the StandStill state, the single-axis motion instructions, such as MC_MoveAbsolute, MC_MoveRelative, and MC_Jog, can be called to control the single-axis operation.

### Example

In this routine, when no interpolation instruction is executed for the axis group, the jogging of the single axis is realized through the instruction MC_Jog.

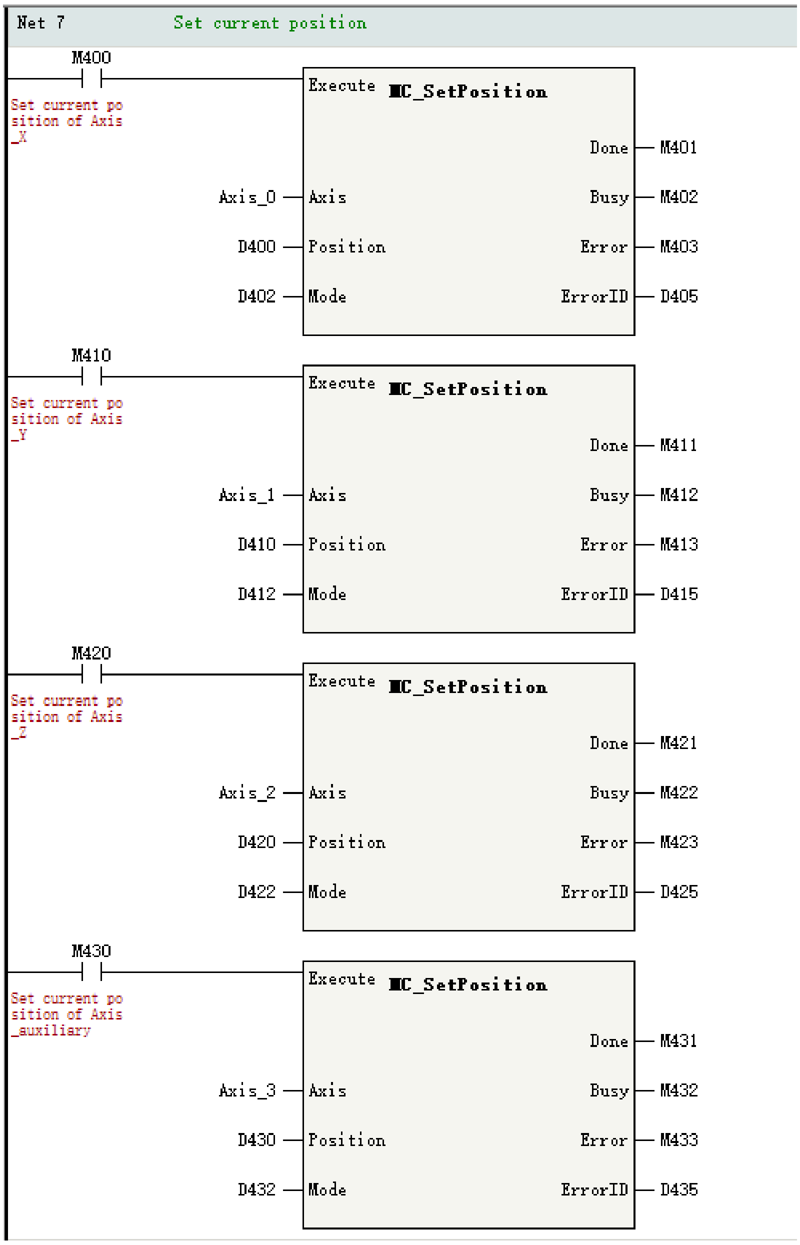


Net 6
Jog
M150
Axis_X jog forward
M151
Axis_X jog backward
MC_Jog
Enable
Axis_0
Axis
M150
JogForward
Axis_X jog forward
M151
JogBackward
Axis_X jog backward
E10
Velocity
Busy
M152
E5000
Acceleration
CommandAborted
M153
E5000
Deceleration
Error
M154
K0
CurveType
ErrorID
D155
M160
Axis_Y jog forward
M161
Axis_Y jog backward
MC_Jog
Enable
Axis_1
Axis
M160
JogForward
Axis_Y jog forward
M161
JogBackward
Axis_Y jog backward
E10
Velocity
Busy
M162
E5000
Acceleration
CommandAborted
M163
E5000
Deceleration
Error
M164
K0
CurveType
ErrorID
D165




## 14.2.9 Setting the Current Position

Set the current position through the instruction MC_SetPosition.



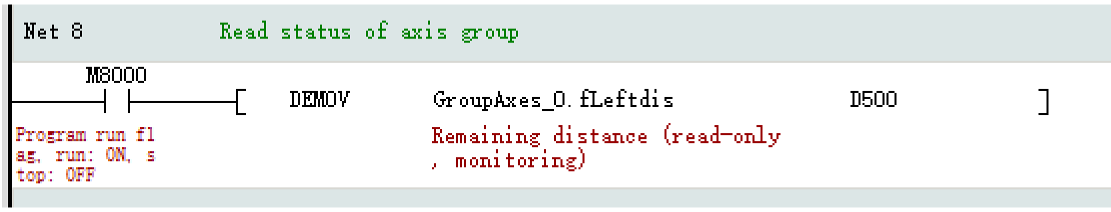

## 14.2.10 Reading the Current Status

### Single-axis status

The status, feedback position, feedback velocity, and feedback torque of the PLCOpen state machine of a single axis are obtained through instructions MC_ReadStatus, MC_ReadActPosition, MC_ReadActVelocity, and MC_ReadActTorque. The status of a single axis can also be accessed through the system variables of the axis. See *"12.4 Online Monitoring" on page 409* for details.

### The status of an axis group

Access the state of an axis group through its system variables.

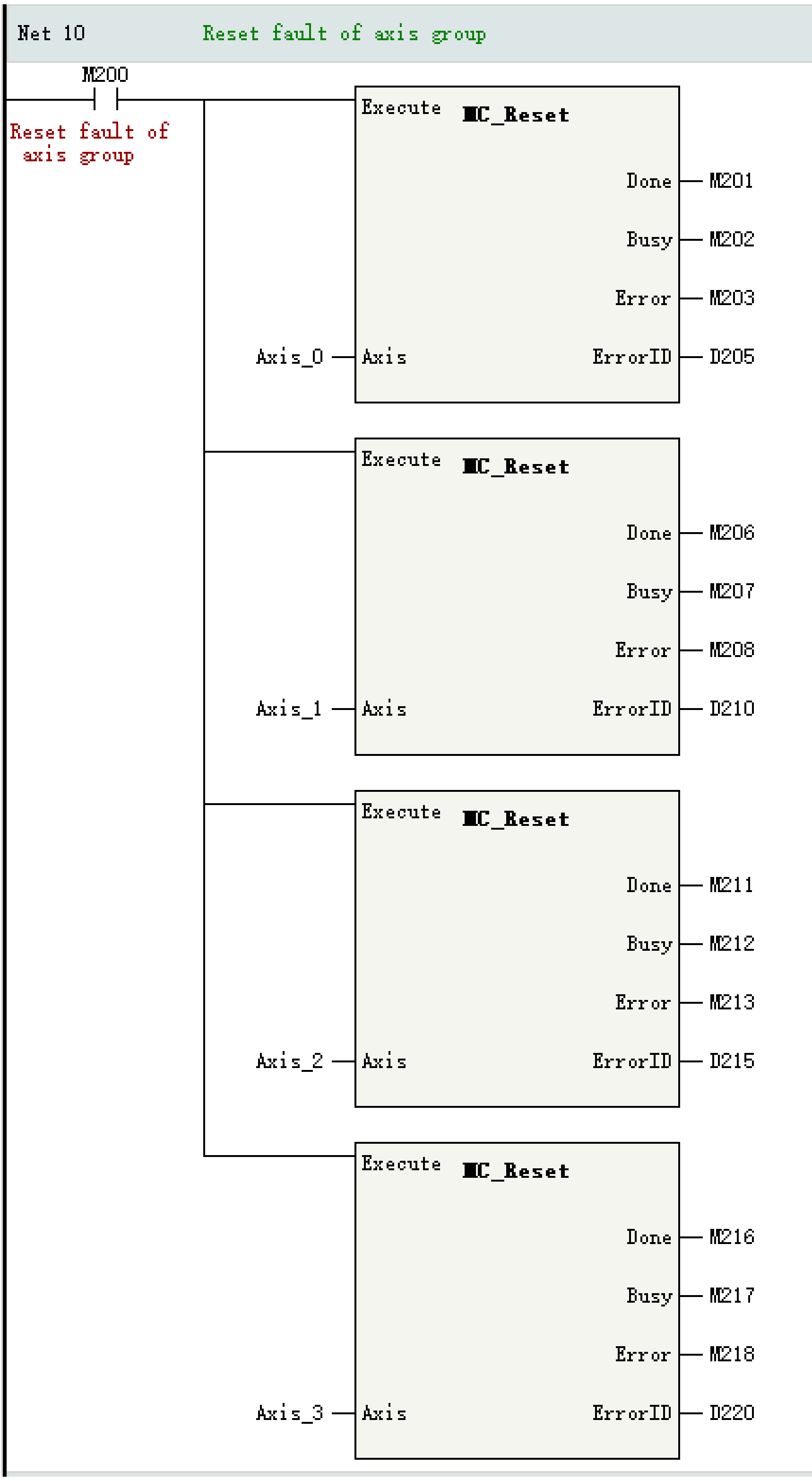



## 14.2.11 Resetting Axis Group Faults

When a single axis enters the fault state, the fault of the axis can be reset through the instruction MC_Reset, and only by resetting the single-axis fault can the fault of the entire axis group be removed.

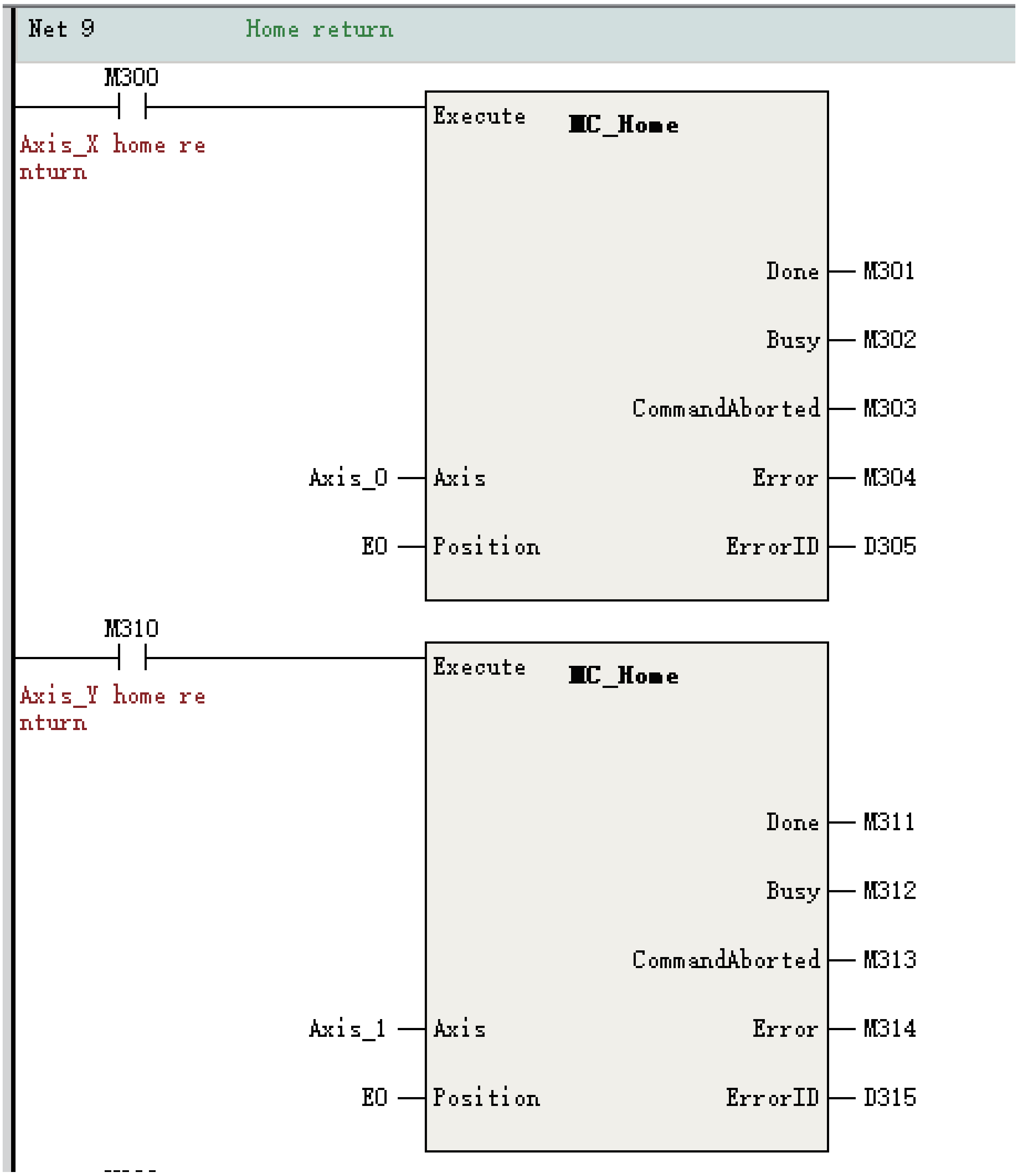
### Example

In this routine, M200 is triggered to reset the fault of the axis group.

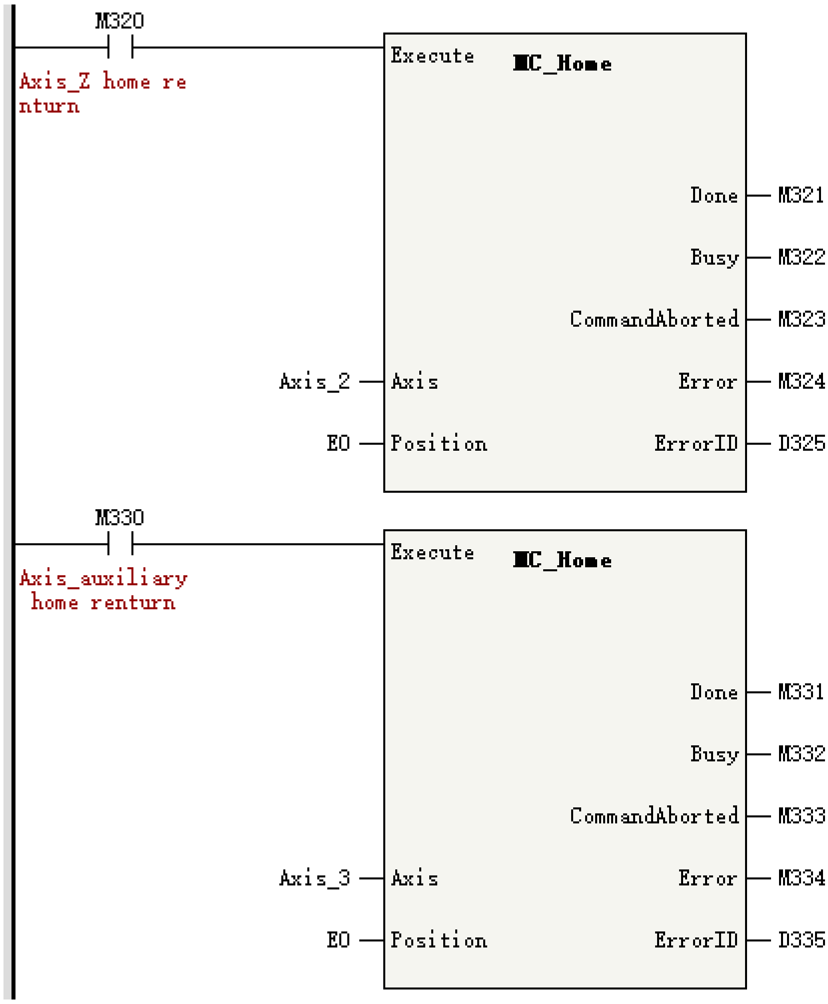



## 14.2.12 Homing

The homing for an axis group can be realized through single homing. The following is the single homing implemented by the instruction MC_Home.



Net 9
Home return
M300
Axis_X home re
nturn
Execute
MC_Home
Done
M301
Busy
M302
CommandAborted
M303
Axis_0
Axis
Error
M304
E0
Position
ErrorID
D305
M310
Axis_Y home re
nturn
Execute
MC_Home
Done
M311
Busy
M312
CommandAborted
M313
Axis_1
Axis
Error
M314
E0
Position
ErrorID
D315




# 14.3 Buffer and Transition

## 14.3.1 Overview

The buffer mode refers to the process of executing instructions when multiple interpolation instructions are started at the same time.

The transition mode refers to the way when multiple curves switch between each other.

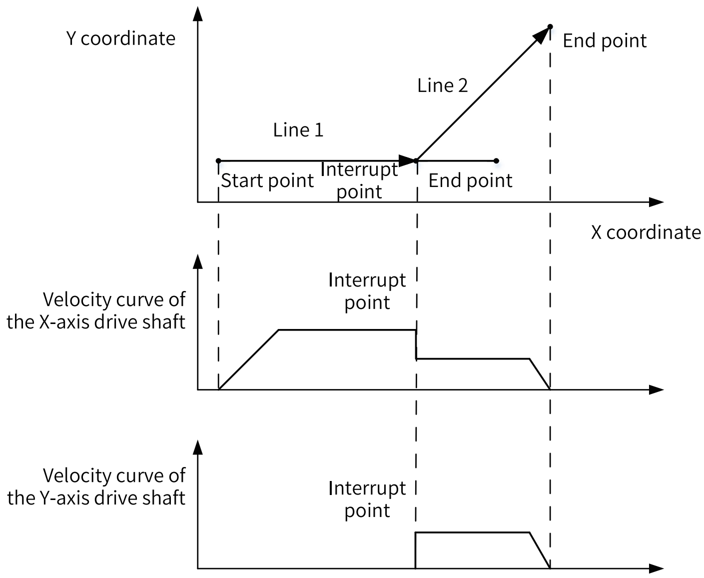
The following four combined buffer and transition modes are supported.

| No. | Buffer Mode | Description |
|---|---|---|
| 0 | Interrupt+No transition | Immediately switch to the next function block. There is no transition curve. |
| 1 | Buffer+No transition | Execute the buffered function block after the first segment of deceleration is completed. There is no transition curve. |
| 2 | Previous Velocity+No transition | Move to the end of the first segment at the current velocity and start the second segment at the rate of the first segment. |
| 3 | Additional angle transition | Add acceleration of the second segment when deceleration starts in the first segment. There is a transition curve. |

## 14.3.2 Interrupt+No Transition

The first interpolation instruction is executed first, and the second interpolation instruction is triggered before the first straight line is completed. If the BufferMode of the second interpolation instruction is set to "Interrupt+No Transition", the second interpolation instruction immediately interrupts the first interpolation instruction and starts implementing a new interpolation curve.

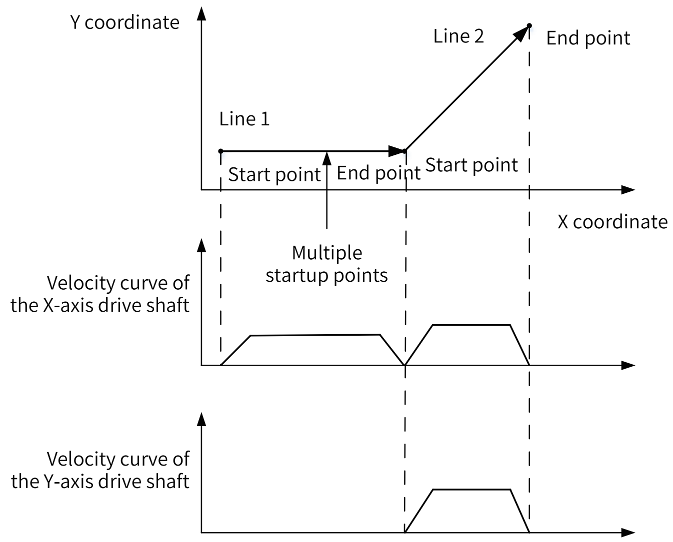
At the interrupt point, the new curve remains at the same velocity rate, and the velocities of the X-axis, Y-axis are re-decomposed, as shown in the following figure.




## 14.3.3 Buffer+No Transition

The first interpolation instruction is executed first, and the second interpolation instruction is triggered before the first straight line is completed. If the BufferMode of the second interpolation instruction is set to "Buffer+No Transition", the interpolator will continue to execute the first interpolation instruction.

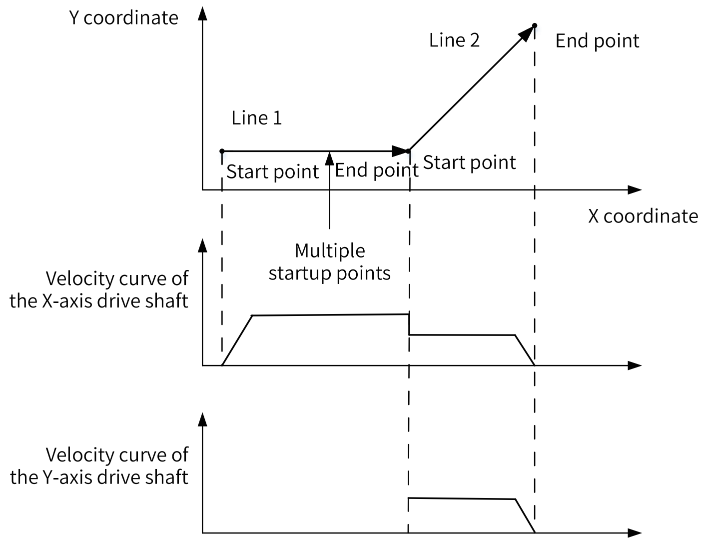
After the first interpolation instruction is executed and an active Done signal is output, the execution of the second interpolation instruction will begin, as shown in the following figure.



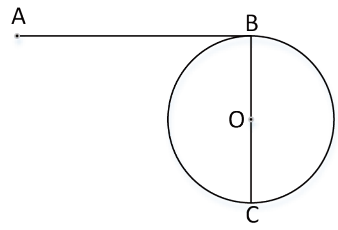

## 14.3.4 Previous Velocity+No Transition

The first interpolation instruction is executed first, and the second interpolation instruction is triggered before the first straight line is completed. If the BufferMode of the second interpolation instruction is set to "Previous Velocity+No Transition", the interpolator will attempt to maintain the target velocity of the first instruction to implement a full straight line.

After the first interpolation instruction is executed and an active Done signal is output, the execution of the second interpolation instruction will begin. The velocity rate will remain unchanged at the switching point, and the velocities of the coordinate axes will be redistributed. The following figure shows the details.

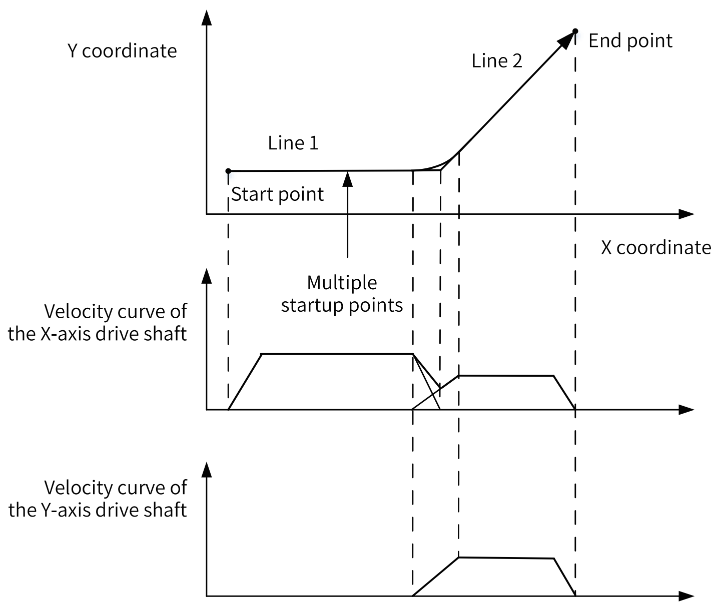



This mode is particularly suitable for switching between straight lines and circular arcs with the straight lines on the tangent line of the arcs, and can be used to maintain the constant velocity of an interpolation curve.




### 14.3.5 Additional Angle Transition

The first interpolation instruction is executed first, and the second interpolation instruction is triggered before the first straight line is completed. If the BufferMode of the second interpolation instruction is set to the additional angle mode, the interpolator will initiate the second interpolation instruction when it detects that the first straight line has begun to perform deceleration, and the final velocity of each coordinate axis is the sum of the velocities of the two instructions, as shown in the following figure.




## 14.4 Methods of Handling Single-Axis Configuration Parameters in Interpolation

Some of the configuration parameters in the interpolation are different from the single-axis configuration parameters, as shown in the following table.

| Single-axis configuration parameters | Handling Methods in Interpolation |
|---|---|
| Gear ratio setting | The gear ratio of a single axis in an axis group is set on the interface "Unit conversion setting" of the single axis. |
| Encoder mode selection | The encoder mode of the drive can be set to incremental or absolute. Set this parameter in the interface "Mode/Parameter setting" of a single axis. |

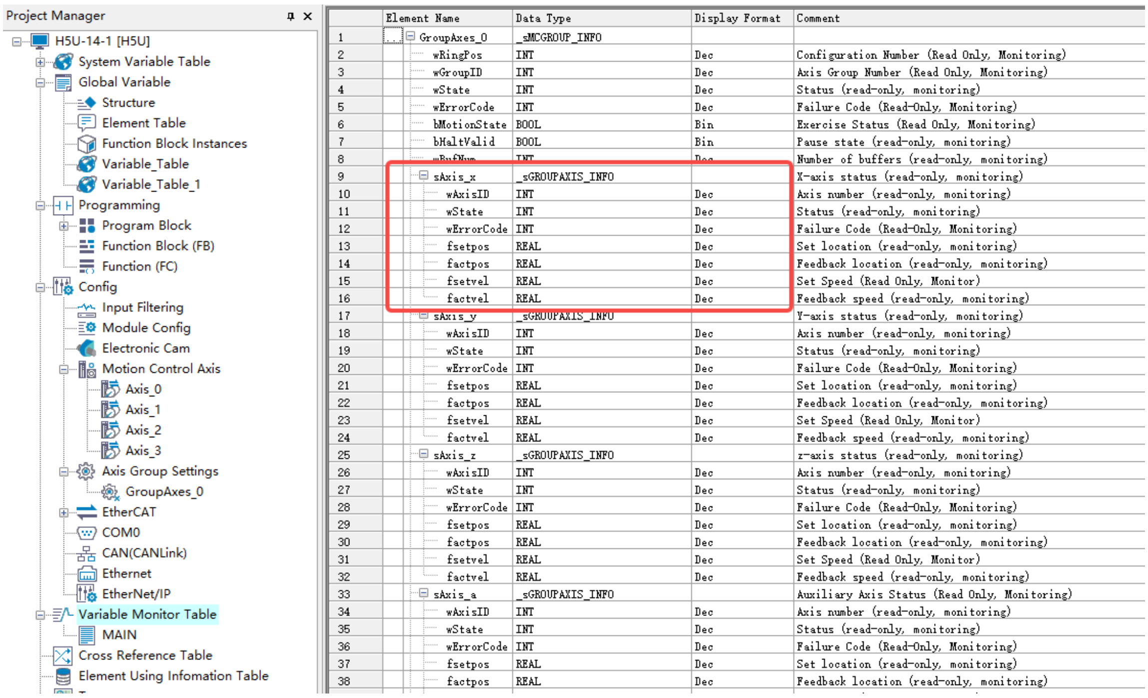
| Single-axis configuration parameters | Handling Methods in Interpolation |
|---|---|
| Mode setting | Modes of axes in an axis group are divided into linear mode and ring mode according to the working conditions, and the interpolation instructions only support the linear mode. |
| Limit handling | Axes in the interpolation instructions support both software limits and hardware limits. |
| Following error | Axes in interpolation instructions support following errors. |
| Velocity limit | The velocity in an interpolation instruction is limited by the maximum velocity of a single axis, not by the maximum acceleration rate. |
| Torque limit | Not involved. |

# 14.5 System Variables

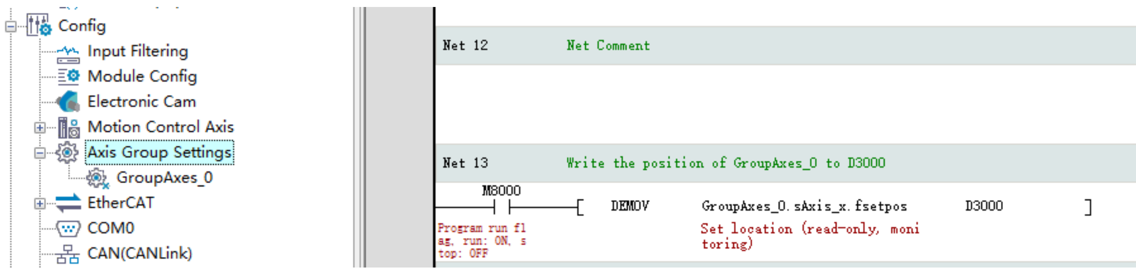
## 14.5.1 _sGROUPAXIS_INFO for Status of Coordinate Axes within Axis Group

| Name | Type | Description |
|---|---|---|
| wAxisID | INT16 | Axis ID |
| wState | INT16 | The status of an axis' PLCOpen state machine<br>0: PowerOff<br>1: ErrorStop<br>2: Stopping<br>3: StandStill<br>4: DiscreteMotion<br>5: ContinuousMotion<br>7: Homing<br>8: SynchronizedMotion |
| wErrorCode | INT16 | The fault code of an axis |
| fsetpos | REAL | Position reference |
| factpos | REAL | Feedback position |
| fsetvel | REAL | Velocity reference |
| factvel | REAL | Feedback velocity |

This system variable exists in the axis group _sMCGROUP_INFO and is used to represent the state of individual axes within the axis group.




For example, write the position reference of the X-axis into the D3000 in the PLC:



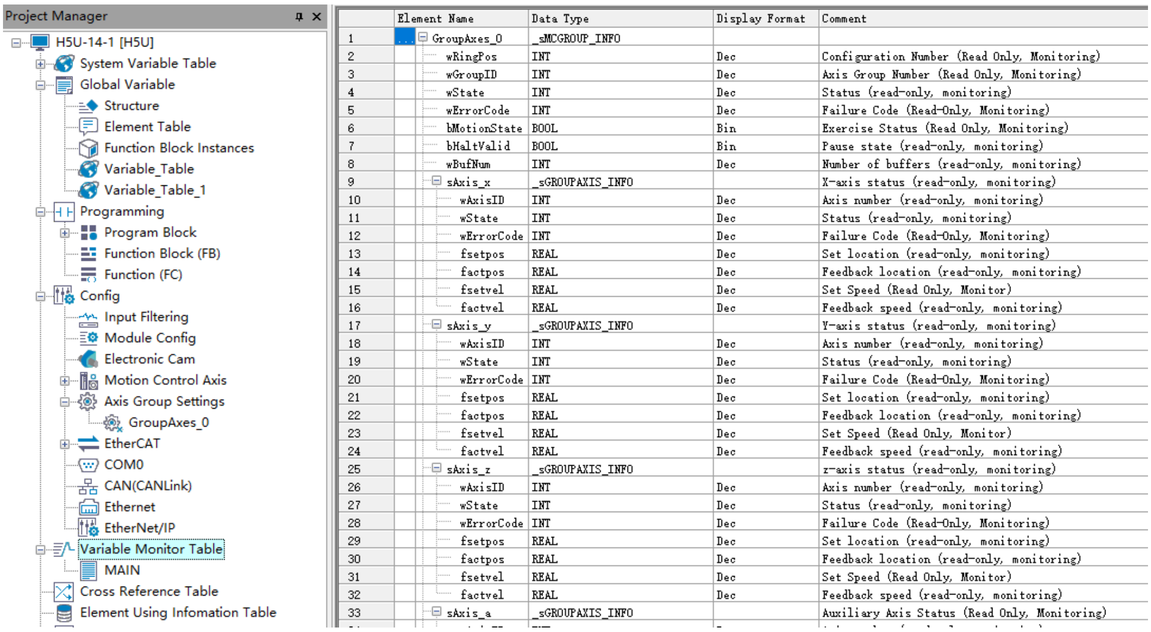

## 14.5.2 _sMCGROUP_INFO for Axis Group Status

| Name | Type | Description |
|---|---|---|
| wRingPos | INT16 | Axis group number |
| wGroupID | INT16 | Axis number |

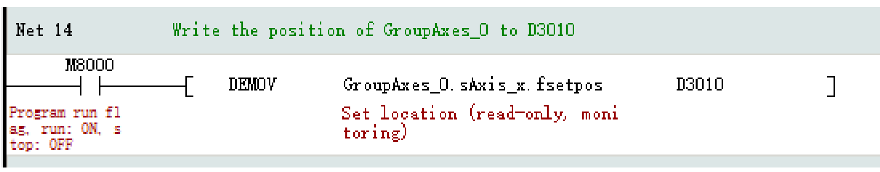
| Name | Type | Description |
| --- | --- | --- |
| wState | INT16 | Axis group status<br>0: Init<br>The axis configuration in the axis group is not completed.<br>1: Disabled<br>Not all axes in the axis group are enabled.<br>2: Single Stop<br>An axis in the axis group calls the instruction MC_Gtop.<br>3: Single Homing<br>An axis in the axis group calls the instruction MC_Home.<br>4: Single motion<br>An axis in the axis group calls single-axis motion instructions such as MC_MoveAbsolute.<br>5: ErrorStop<br>An axis in the axis group is in a fault state.<br>6: StandStill<br>All axes in the axis group are in the StandStill state.<br>7: Stopping<br>The instruction MC_GroupStop is called.<br>8: Synchronous Motion<br>A linear interpolation or circular interpolation instruction is called. |
| wErrorCode | INT16 | Fault code |
| bMotionState | BOOL | Motion status<br>FALSE: Not in motion<br>TRUE: In motion |
| bHaltValid | BOOL | Halt status<br>FALSE: Halt not applied<br>TRUE: Halt applied |
| wBufNum | INT16 | The number of buffered curves |
| sAxis_x | _sGROUPAXIS_INFO | The status of the X-axis |
| sAxis_y | _sGROUPAXIS_INFO | The status of the Y-axis |
| sAxis_z | _sGROUPAXIS_INFO | The status of the Z-axis |
| sAxis_a | _sGROUPAXIS_INFO | The status of the auxiliary axis |
| fSetvel | REAL | Velocity reference<br>In linear interpolation mode, it indicates the interpolation velocity of a space straight line.<br>In circular interpolation mode, it indicates the linear velocity of a circular arc. |
| fSetacc_dec | REAL | Acceleration/deceleration reference<br>Indicates the change rate of setvel. |
| fSetvel_buf | REAL | The velocity reference of a buffered curve<br>In linear interpolation mode, it indicates the interpolation velocity of a space straight line.<br>In circular interpolation mode, it indicates the linear velocity of a circular arc. |

| Name | Type | Description |
|---|---|---|
| fSetacc_dec_buf | REAL | The acceleration/deceleration reference of a buffered curve<br>Indicates the change rate of fSetvel_buf |
| fSetdis | REAL | Distance reference<br>In linear interpolation mode, it indicates the distance at which a space straight line moves after the instruction is executed.<br>In circular interpolation mode, it indicates the length of a circular arc in which the circular arc moves after the instruction is executed. |
| fLeftdis | REAL | Left distance<br>In linear interpolation mode, it indicates the left distance for this section of a space straight line after the instruction is executed.<br>In circular interpolation mode, it indicates the length of a space circular arc left after the instruction is executed. |
| fCenter_x | REAL | The coordinates of point X at the center of a circular arc during circular interpolation |
| fCenter_y | REAL | The coordinates of point Y at the center of a circular arc during circular interpolation |
| fCenter_z | REAL | The coordinates of point Z at the center of a circular arc during circular interpolation |
| fRadius | REAL | The radius of a circular arc during circular interpolation |
| fStartAng | REAL | The start angle during circular interpolation |
| fSetAng | REAL | The motion angle during circular interpolation |

This system variable is used to indicate the status of the entire axis group:




For example, write the X-axis coordinates of the center of an axis group to D3010:

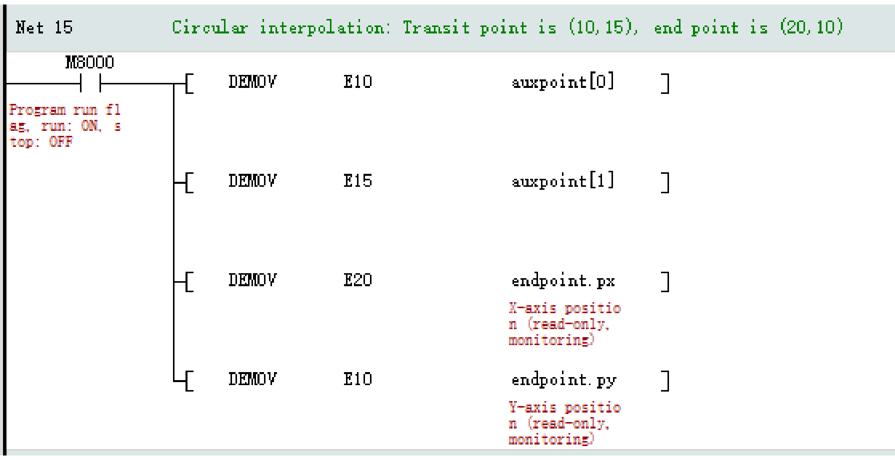


## 14.5.3 _sGROUPPOS_INFO for Target Positions of Coordinate Axes within Axis Group

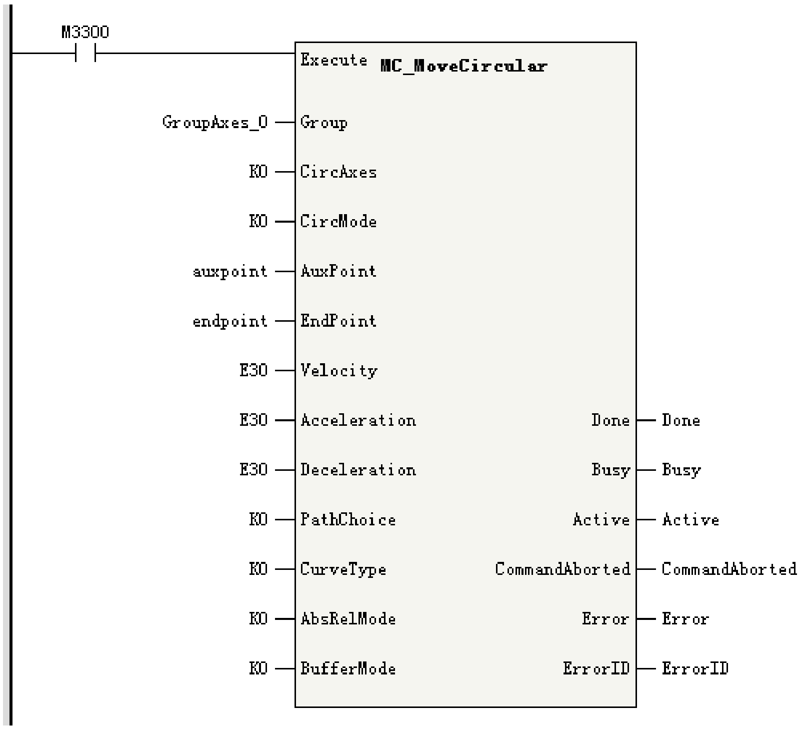
| Name | Type | Description |
|---|---|---|
| px | REAL | The position of the X-axis |
| py | REAL | The position of the Y-axis |
| pz | REAL | The position of the Z-axis |
| pa | REAL | The position of the auxiliary axis |

This structure sets the target position of a circular arc as an input parameter to the MC_MoveCircular.

1. Create a global variable
2. Assign values to the global variable




3. Call the instruction MC_MoveCircular



# 14.6 Fault Codes

When a fault occurs during use of the interpolation functions, see the fault codes listed in the following table for troubleshooting.

| Fault Code | Description | Solution |
|---|---|---|
| 9400 | The number of axis groups exceeds the maximum value. | Check whether the number of axis groups is greater than 8. |
| 9401 | An axis in the axis group is in a fault state. | Check whether an axis in the axis group has entered the ErrorStop state.<br>Troubleshoot the fault based on the fault code of each axis. |
| 9402 | The number of buffered interpolation instructions is greater than 8. | Check whether the number of buffered interpolation instructions is greater than 8. |
| 9403 | The axis is reused. | Locate the reused axis and replace it with an unused axis. |
| 9404 | Failed to create the axis group. | The X-axis and Y-axis cannot be empty.<br>Check whether the X-axis or Y-axis does not exist or is not specified. |
| 9405 | The specified Z-axis does not exist. | Check whether the axis specified by AxisID_z exists. |
| 9406 | The specified auxiliary axis does not exist. | Check whether the axis specified by AxisID_a exists. |
| 9407 | The axis group ID is duplicate. | Check whether GroupID is duplicate. |
| 9408 | Axis configuration failed. | Check whether any axis in the axis group fails to be configured. If yes, check whether the PCB software and the background match. |
| 9409 | The axis ID is less than 0. | Check whether the ID of an axis in the axis group is less than 0. |
| 9410 | The axis group is not released because the MC_SetAxesGroup instruction is triggered repeatedly in a short time period. | Do not re-trigger the MC_SetAxesGroup instruction while its Busy signal output is still active. |
| 9411 | Instruction MC_GroupStop was interrupted. | Check whether an instruction with higher priority is called while the MC_GroupStop instruction is still active. |
| 9412 | The circular interpolation instruction CircAxes is out of range. | Check whether the value of CircAxes of the circular interpolation instruction is out of range. |
| 9413 | The circular interpolation instruction CircMode is out of range. | Check whether the value of CircMode of the circular interpolation instruction is out of range. |
| 9414 | The circular interpolation instruction PathChoice is out of range. | Check whether the value of PathChoice of the circular interpolation instruction is out of range. |
| 9415 | The stop instruction StopMode is out of range. | Check whether the value of StopMode of the stop instruction is out of range. |
| 9416 | The X-axis is set to ring mode. | Do not set the motion control axis to the ring mode in an interpolation instruction. |
| 9417 | The Y-axis is set to ring mode. | Do not set the motion control axis to the ring mode in an interpolation instruction. |
| 9418 | The Z-axis is set to ring mode. | Do not set the motion control axis to the ring mode in an interpolation instruction. |
| 9419 | The auxiliary axis is set to ring mode. | Do not set the motion control axis to the ring mode in an interpolation instruction. |
| 9420 | The circular interpolation instruction is triggered repeatedly. | Do not re-trigger the same circular interpolation instruction while its Busy signal output is still active. |
| 9421 | The linear interpolation instruction is triggered repeatedly. | Do not re-trigger the same linear interpolation instruction while its Busy signal output is still active. |
| 9422 | Failed to obtain the axis group. | Check whether the axis group specified by GroupID has been created by calling MC_SetAxesGroup. |

| Fault Code | Description | Solution |
|---|---|---|
| 9423 | Axis configuration failed. | Check whether an instruction is triggered when axis configuration is not completed.<br>Check whether the communication state of all axes in the axis group is "Axis ready". |
| 9424 | An axis is disabled. | Do not call the interpolation instruction when any axis is in Disabled state. |
| 9425 | An axis is executing single-axis motion instructions. | Do not call the interpolation instruction when any axis is executing single-axis motion instructions and not in StandStill state. |
| 9426 | An axis is in Stopping state. | Do not call the interpolation instruction when any axis is in Stopping state after the MC_Stop instruction is executed. |
| 9427 | The axis group is in a stopped state. | Do not call the interpolation instruction while the MC_GroupStop instruction is still active. |
| 9428 | An axis is in Homing state. | Do not call the interpolation instruction when any axis is in Homing state after the MC_Home instruction is executed. |
| 9429 | An axis is executing the position setting instruction. | Do not call the interpolation instruction when any axis is setting the current position by executing the MC_SetPosition instruction. |
| 9430 | An axis is in commissioning state. | Do not call the interpolation instruction when any axis is in commissioning state. |
| 9431 | An axis enters the commissioning state during interpolation, which interrupts the instruction execution of other axes. | Check whether any axis enters the commissioning state during interpolation. |
| 9432 | Failed to request the memory. | Check whether the memory runs out.<br>Contact the manufacturer. |
| 9433 | The target velocity is 0 or less. | Ensure that the target velocity of the instruction is greater than 0. |
| 9434 | The target acceleration rate is 0 or less. | Ensure that the target acceleration rate of the instruction is greater than 0. |
| 9435 | The target deceleration rate is 0 or less. | Ensure that the target deceleration rate of the instruction is greater than 0. |
| 9436 | The curve type is set beyond the range. | Check whether the curve type is set to a value other than the T-shaped curve for the interpolation instruction. |
| 9437 | AbsRelMode is set incorrectly. | Check whether the parameter is set to a value other than the absolute positioning and relative positioning modes. |
| 9438 | BufferMode is set incorrectly. | Check whether the value of BufferMode is out of range. |
| 9439 | InsertMode is set incorrectly. | Check whether the value of InsertMode is proper. |
| 9440 | An axis stops due to a fault. | Locate the faulty axis and rectify the fault based on the fault code. |
| 9441 | Instruction MC_GroupStop is called repeatedly. | Do not re-trigger an MC_GroupStop instruction or call other MC_GroupStop instructions while an MC_GroupStop instruction is still active. |
| 9442 | The data buffer is not empty. | Contact Inovance for technical support. |
| 9443 | No circle can be drawn. | - |
| 9444 | The start point, end point, and border point in the circular interpolation instruction are the same point, and no circle can be drawn. | Check the input parameters of the circular interpolation instruction and ensure that the start point, end point, and border point can form a circle. |
| 9445 | The instruction buffer is full. | Contact Inovance for technical support. |
| 9446 | The velocity of the X-axis exceeds the maximum allowable velocity. | Ensure that the target velocity of the X-axis is not greater than the maximum allowable velocity. |
| 9447 | The Y-axis exceeds the maximum velocity. | Ensure that the target velocity of the Y-axis is not greater than the maximum allowable velocity. |
| 9448 | The Z-axis exceeds the maximum velocity. | The velocity of the Z-axis exceeds the maximum allowable velocity. |

| Fault Code | Description | Solution |
|---|---|---|
| 9449 | The auxiliary axis exceeds the maximum velocity. | Ensure that the target velocity of the auxiliary axis is not greater than the maximum allowable velocity. |
| 9450 | Failed to obtain the number of axis groups. | Update the background software to the latest version. |
| 9451 | Internal fault | Contact the manufacturer. |
| 9452 | The instruction is called when the axis is in StandStill state. | Do not call this instruction when the axis is in StandStill state. |
| 9453 | The maximum allowable velocity is exceeded. | Ensure that the target velocity of the instruction is not greater than the maximum velocity specified on the axis group configuration interface. |
| 9454 | The maximum allowable acceleration/ deceleration rate is exceeded. | Ensure that the target acceleration (deceleration) rate of the instruction is not greater than the maximum acceleration (deceleration) rate specified on the axis group configuration interface. |
| 9455 | Axis group becomes faulty due to an error reported by the linear interpolation instruction. | Identify the first linear interpolation instruction that reports the error and troubleshoot the fault based on the fault code. |
| 9456 | The axis group becomes faulty due to an error reported by the circular interpolation instruction. | Identify the first circular interpolation instruction that reports the error and troubleshoot the fault based on the fault code. |
| 9457 | The axis group becomes faulty due to an error reported by the axis group stop instruction. | Identify the first axis group stop instruction that reports the error and troubleshoot the fault based on the fault code. |
| 9458 | The axis group becomes faulty due to an error reported by the axis group pause instruction. | Identify the first axis group pause instruction that reports the error and troubleshoot the fault based on the fault code. |

# 15 Bus Encoder Axes

## 15.1 Introduction to Bus Encoder Axes

Bus encoder axes support a maximum input pulse frequency of 200 kHz is supported, use the GR10-2HCE module as the driver, and can count three forms of pulses: phase A/B, pulse+direction, and CW/CCW.
Up to eight bus encoder axes can be configured. One GR10-2HCE module has two channels, each of which can be assigned for one axis.

Bus encoder axes can also work with the DI and DO terminals of the GR10-2HCE module to implement position presetting, probe, gating, and comparison output.

The feedback position of the GR10-2HCE module in pulses is sent to the PLC through PDOs, and the feedback position within the PLC is finally provided to users in the form of REAL data type through the conversion of gear ratios, which can also be used as the master axis of a cam or gear.

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***Note***

The software of the GR10-2HCE module must be version V2.2.0.0 or later versions.

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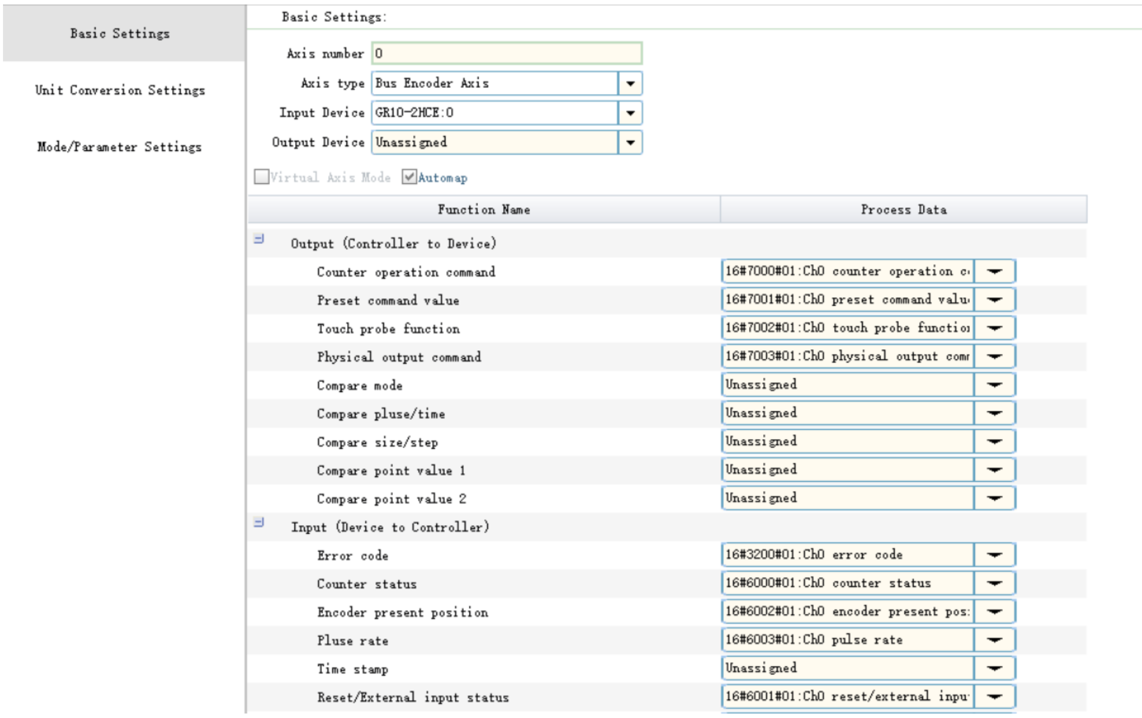
## 15.2 Software Configuration

### 15.2.1 Basic Settings

Bus encoder axes represent a category of motion control axes that require the user to enable EtherCAT communication and add the GR10–2HCE module before enabling a bus encoder axis.
The configuration interface of a bus encoder axis is shown in the following figure.




## Operating panel description

- Axis No: Each bus encoder axis has an axis number, which is the unique identifier of the encoder axis and is automatically assigned when the configuration is established.
- Axis type: Bus encoder axis.
- Input device: With H5U series PLC as an example, a bus encoder axis needs to be used with the GR10-2HCE module. Each GR10-2HCE module supports two counting channels. You can select a channel as required during device selection.
- Output device: Not supported.
- Automatic mapping: After "Automatic mapping" is ticked, the I/O variable of an axis and the PDO of the GR10-2HCE module will be automatically associated. If this option is not ticked, you can manually configure the mapping.

## Variable mapping

The correspondence between the I/O variables of a bus encoder axis and the PDO of the GR10-2HCE module is shown in the following table.

Table 15–1 Output variable mapping

| Variable | Channel 0 Object Dictionary | Channel 1 Object Dictionary | Description |
|---|---|---|---|
| Counter operation command | 7000h:1 | 7000h:2 | Encoder control word |
| Preset command value | 7001h:1 | 7001h:2 | Preset position |
| Touch probe function | 7002h:1 | 7002h:2 | Probe control word |
| Physical output command | 7003h:1 | 7003h:2 | DO terminal control word |
| Compare mode | 7003h:3 | 7003h:11 | Comparison output mode |
| Compare pulse/time | 7003h:5 | 7003h:13 | Comparison output pulses/time |
| Compare size/step | 7003h:6 | 7003h:14 | Comparison output array length/step |

| Variable | Channel 0 Object Dictionary | Channel 1 Object Dictionary | Description |
|---|---|---|---|
| Compare point value 1 | 7008h:1 | 7009h:1 | Comparison output value 1 |
| Compare point value 2 | 7008h:2 | 7009h:2 | Comparison output value 2 |

Table 15–2 Input variable mapping

| Variable | Channel 0 Object Dictionary | Channel 1 Object Dictionary | Description |
|---|---|---|---|
| Error code | 3200h:1 | 3200h:2 | Fault code |
| Counter status | 6000h:1 | 6000h:2 | Counter status |
| Encoder present position | 6002h:1 | 6002h:2 | Encoder feedback position |
| Pulse rate | 6003h:1 | 6003h:2 | Pulse frequency |
| Time stamp | 6009h:1 | 6009h:2 | Time stamp |
| Physical input status | 6001h:1 | 6001h:2 | DI terminal status |
| Touch probe status | 6004h:1 | 6004h:2 | Probe status |
| Touch probe pos 1 pos value | 6005h:1 | 6005h:2 | Probe 1 position on the rising edge |
| Touch probe pos 1 neg value | 6006h:1 | 6006h:2 | Probe 1 position on the falling edge |
| Touch probe pos 2 pos value | 6007h:1 | 6007h:2 | Touch probe 2 positive edge |
| Touch probe pos 2 neg value | 6008h:1 | 6008h:2 | Probe 2 position on the falling edge |
| Physical output status | 600Eh:1 | 600Eh:2 | DO terminal status |
| Compare error code | 6003h:3 | 6003h:5 | Comparison output fault code |
| Current compare number/ position | 6003h:7 | 6003h:9 | Comparison output current group subscript/position |

## 15.2.2 Unit Conversion

The following table lists parameters that need to be set for unit conversion.

| Parameter | Function |
|---|---|
| The number of pulses in one turn by motor/encode | Set the number of pulses required for the motor to rotate one turn according to the encoder resolution. |
| With gear change mechanisms | Specify whether gear change mechanisms are in use or not. |
| Amount of movement in one turn by motor/encoder | The workpiece movement amount per turn of the motor when no gear change mechanism is in use |
| Amount of movement of the worktable in a circle | The workpiece movement amount per turn of the worktable when gear change mechanisms are in use |
| Gear ratio on the motor/encoder side | Set a gear ratio on the motor/encoder side. |
| Gear ratio on the worktable side | Set a gear ratio on the worktable side. |

The module GR10-2HCE counts in pulses, while the encoder axis instructions use common measurement units in operation, such as millimeters, degrees, and inches, which are known as user units (Unit). The conversion between the two units is divided into the following modes:

1. Without gear change mechanisms
   When gear change mechanisms are not in use, the conversion equation from user unit to pulse unit is as follows.

$$\text{Number of pulses (unit: pulse)} = \frac{\text{Number of pulses per revolution of the motor/encoder [DINT]}}{\text{Distance per revolution of the workbench [REAL]}} \times \text{Distance (unit: Unit)}$$

Take the Inovance 23-bit encoder as an example. The set parameters are as follows.

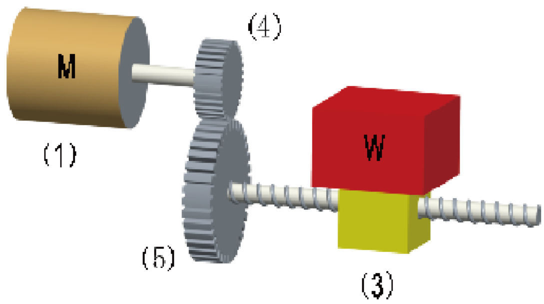
Number of pulses in one turn by motor/encode = 8388608

Workpiece movement amount per turn of the motor/encoder = 1

When the motor rotates by 10 revolutions, the number of pulses counted by the 2HCE module is 83886080, and the encoder axis instruction counts to the position increment of 10 Unit.

2. With gear change mechanisms

- Typical working condition in linear mode is shown in the following figure.

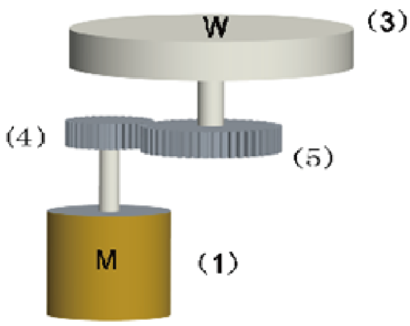



Where, (1) is the motor/encoder; (3) is the worktable; (4) is the gear ratio denominator; (5) is the gear ratio numerator.

The calculation equation from user unit to pulse unit is as follows.

$$\text{Number of pulses (unit: pulse)} = \frac{\text{Number of pulses per revolution of the motor/encoder [DINT] x Gear ratio numerator [DINT]}}{\text{Distance per revolution of the workbench [REAL] x Gear ratio denominator [DINT]}} \times \text{Distance (unit: Unit)}$$

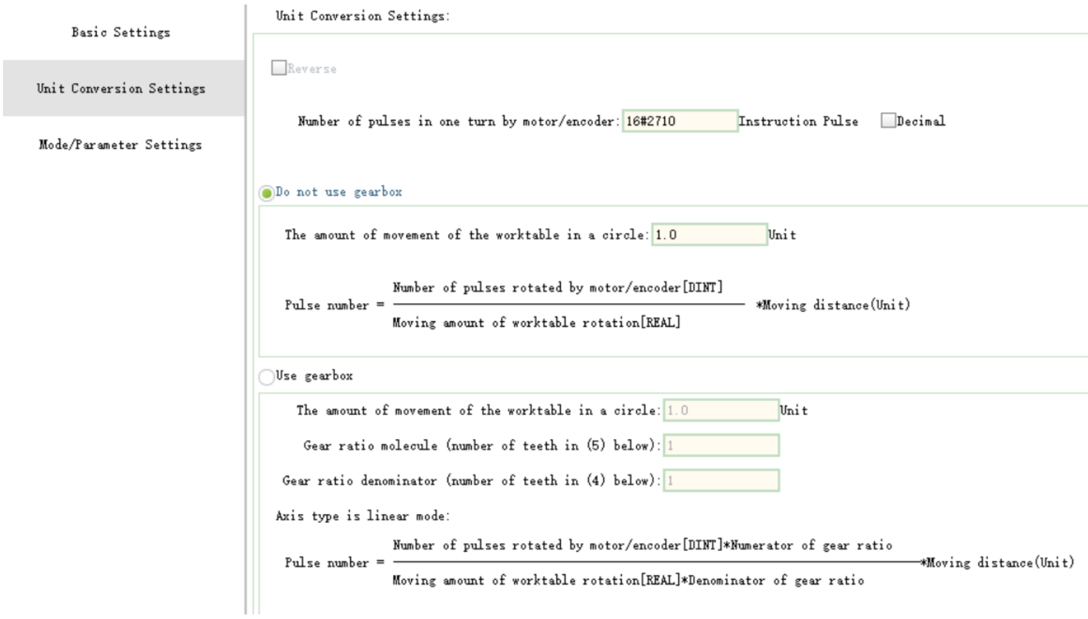
- Typical working condition in rotary mode is shown in the following figure.




Where, (1) is the motor/encoder; (3) is the worktable; (4) is the gear ratio denominator; (5) is the gear ratio numerator.

The calculation equation from user unit to pulse unit is as follows.

$$\text{Number of pulses (unit: pulse)} = \frac{\text{Number of pulses per revolution of the motor/encoder [DINT] x Gear ratio numerator [DINT]}}{\text{Distance per revolution of the workbench [REAL] x Gear ratio denominator [DINT]}} \times \text{Distance (unit: Unit)}$$




## 15.2.3 Mode/Parameter Settings

### 15.2.3.1 Configuration Interface

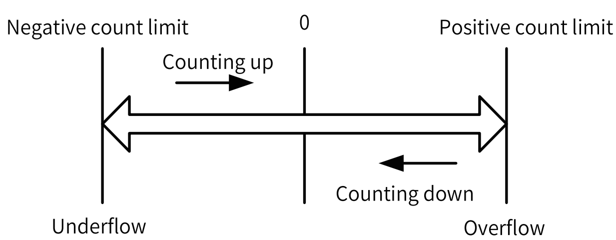
The following figure shows the mode and parameter configuration interface.

### 15.2.3.2 Selection of Linear or Rotary Mode

## Linear mode

You can enable or disable software limits.

When the software limit is enabled, positive and negative limits can be set, and the counter will stop counting when reaching the limits, and display an out-of-limit mark. When the positive limit is reached, the output of the encoder axis system variable bPLimit is valid. When the negative limit is reached, the output of the encoder axis system variable bNLimit is valid.




If the software limit is not enabled, the count value of GR10-2HCE ranges between –2147483648 and +2147483647, jumps to –2147483648 when the positive count reaches +2147483647, and jumps to +2147483647 when the negative count reaches –2147483648.

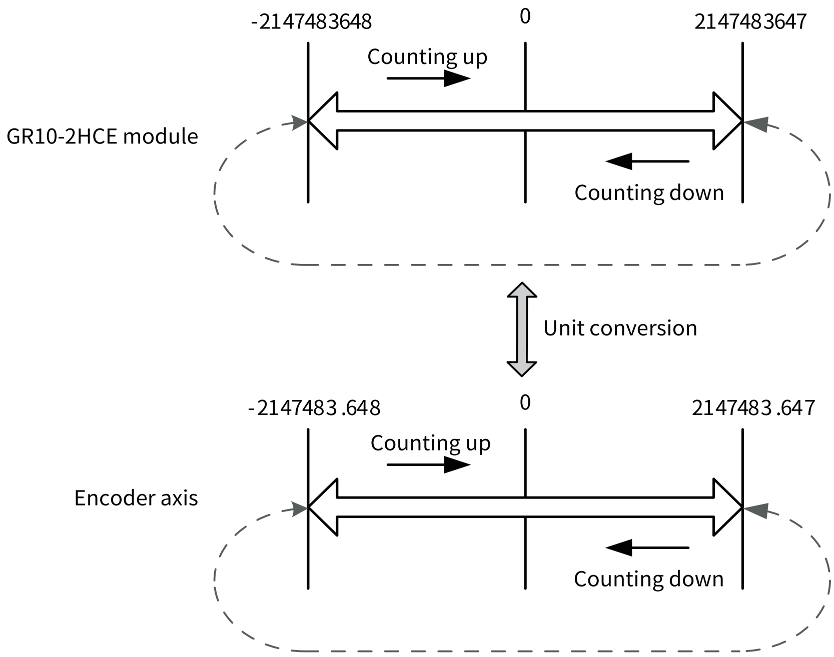
In this case, the range that the bus encoder axis can count needs to be calculated according to the scheme described in *"15.2.2 Unit Conversion" on page 491*.

Example

**Example**

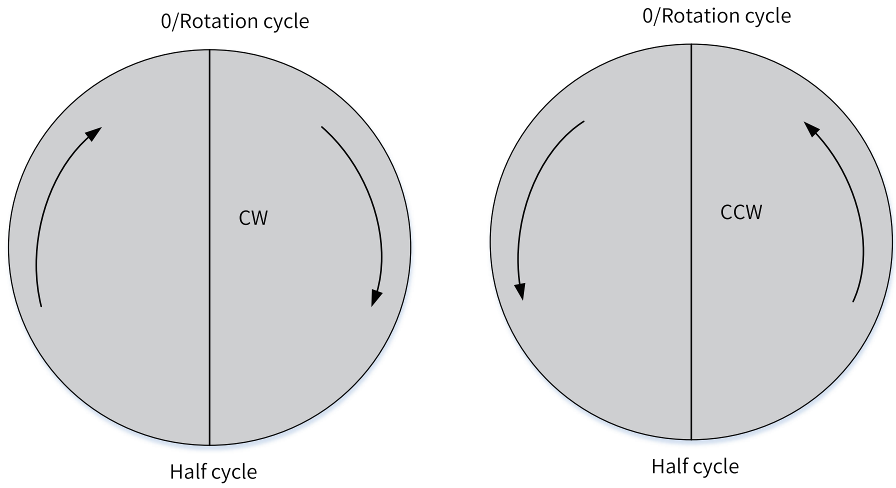
Number of pulses in one turn by motor/encoder = 1000

Amount of movement in one turn by motor/encoder = 1




## Rotary mode

In rotary mode, you can set the ring period. The counter counts in a reciprocating cycle between 0 and the ring period.

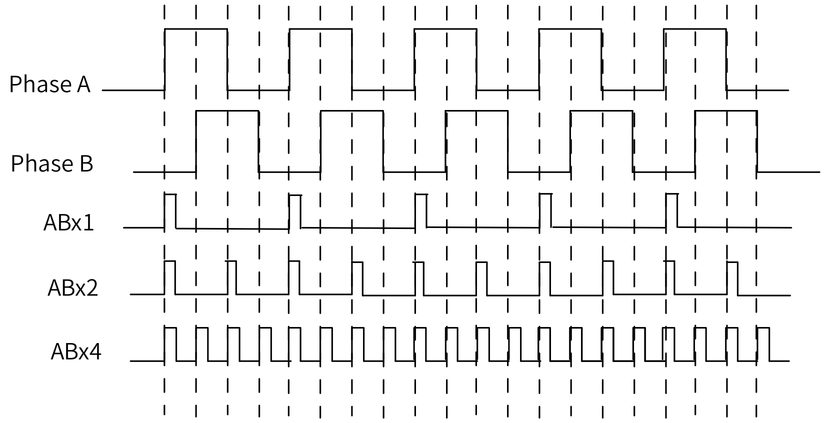


### 15.2.3.3 Counter Mode Selection

## Count modes

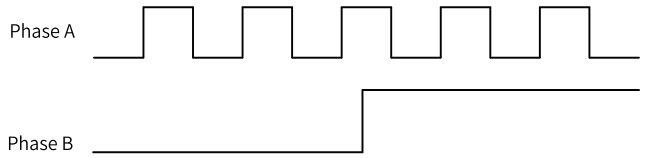
Five count modes are supported: phase A/B 1-frequency multiplication, phase A/B 2-frequency multiplication, phase A/B 4-frequency multiplication, pulse+direction, and CW/CCW.

1. Phase A/B pulse



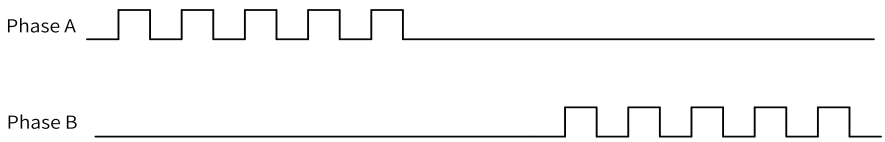

2. Pulse+direction

Phase A is used as the counter's pulse input, and phase B is used as the counter's count direction control input.




3. CW/CCW mode

For CW/CCW mode, under positive logic, the counter counts up on the rising edge that inputs pulse A and counts down on the rising edge that inputs pulse B.




## Count logic

Count logic is used to set the logic of the count direction. The logic is as follows.

| Pulse Mode | Positive Logic | Negative Logic |
| --- | --- | --- |
| Phase A/B | Incremental count if phase A leads phase B<br>Decremental count if phase B leads phase A | Decremental count if phase A leads phase B<br>Incremental count if phase B leads phase A |
| Pulse+direction | Incremental count if phase B is at a high level<br>Decremental count if phase B is at a low level | Decremental count if phase B is at a high level<br>Incremental count if phase B is at a low level |
| CW/CCW | Incremental count if it is phase A pulse input<br>Decremental count if it is phase B pulse input | Decremental count if it is phase A pulse input<br>Incremental count if it is phase B pulse input |

### 15.2.3.4 Frequency Sampling Period

It is used to set the calculation period of the pulse frequency.

### 15.2.3.5 Input Filter Time

It is used to set the filter time of DI terminals and ABZ input signals.

### 15.2.3.6 Input Terminal Function Selection

Each counting channel can be independently configured with four DI terminals. The functions that can be allocated for each terminal are shown in the following table.

| Terminal | Optional Function | Default |
| --- | --- | --- |
| Xn0 | 0: Common input<br>1: Probe function 1<br>3: Reset<br>4: Preset<br>5: Gating | Probe function 1 |
| Xn1 | 0: Common input<br>2: Probe function 2<br>3: Reset<br>4: Preset<br>5: Gating | Probe function 2 |
| Xn2 | 0: Common input<br>3: Reset<br>4: Preset<br>5: Gating | Common input |
| Xn3 | 0: Common input<br>3: Reset<br>4: Preset<br>5: Gating | Common input |

- Common input

When a terminal is allocated with the common input function, its status can be obtained through the system variable iDIStatus or the instruction ENC_ReadStatus.

- Probe function
  When a terminal is allocated with the probe function, you need to call the instruction ENC_TouchProbe to implement the probe function. For details, see the explanation of this instruction.
- Preset function
  When a terminal is allocated with the preset function, you need to call the instruction ENC_Preset to implement the counter preset function. When the input signal of the DI terminal is active, the value of the counter will be set to the preset value of parameter Position of the instruction ENC_Preset.

---

***Note***

If multiple terminals are configured with a preset function, the preset function is activated when one of the input terminals receives an active signal.

---

- Gating function
  If the DI terminal signal is set as a gating signal, the gating function is enabled, in which case the counter is enabled to start counting only after the parameter Enable of ENC_Counter is ON and the gating input signal is active. If the DI terminal signal is not set as a gating signal, and the gating function is not enabled, then the counter starts counting after the parameter Enable of ENC_Counter is ON.

---

***Note***

If multiple terminal input signals are used as gate signals, these gate signals must be active at the same time for the counter to start counting.

---

#### 15.2.3.7 Output Terminal Function Selection

Each counting channel can be independently configured with three DO terminals. The functions that can be allocated for each terminal are shown in the following table.

| Terminal | Optional Function | Default |
|---|---|---|
| Yn0 | 0: Common output<br>3: One-dimensional comparison output<br>4: Two-dimensional comparison output (only supported by channel 0) | 3: One-dimensional comparison output |
| Yn1 | 0: Common output | 0: Common output |
| Yn2 | 0: Common output | 0: Common output |

- Common output
  When a DO terminal is set to a common output terminal, its status can be controlled by the instruction ENC_DigitalOutput. See description of the instruction ENC_DigitalOutput for detailed usage.
- One-dimensional comparison output mode

When a terminal is allocated with the one-dimensional comparison output function, the step comparison output or array comparison output functions can be performed. See instructions ENC_StepCompare and ENC_ArrayCompare for detailed guidance.

- Two-dimensional comparison output mode
  When a bus encoder axis is bound to channel 0 of the GR10-2HCE module, the output terminal Y00 can be allocated with the two-dimensional comparison output function. See the instruction ENC_GroupArrayCompare for detailed usage.

# 15.3 System Variables

Table 15–3 _sPoint2D: Structure of coordinate points in a two-dimensional coordinate system

| Variable | Type | Function |
|---|---|---|
| px | REAL | Coordinate points on X-axis |
| py | REAL | Coordinate points on Y-axis |

Table 15–4 _sENC_PDO: PDOs of the bus encoder axis

| Variable | Type | Function |
|---|---|---|
| iControlWord | INT | Control word |
| iStatusWord | INT | Status word |
| dPresetPosition | DINT | Preset position |
| dActualPositionValue | DINT | Feedback position |
| dActualVelocityValue | DINT | Feedback velocity |
| dTimeStamp | DINT | Time stamp |
| iDOControlWord | INT | DO terminal control word |
| iDOStatusWord | INT | DO terminal status word |
| iCompareMode | INT | Comparison output mode |
| dCompare_Pluse_Time | DINT | Comparison output pulses/time |
| dCompare_Size_Step | DINT | Comparison output array length/step |
| dCompareValue_1 | DINT | Comparison output comparison value 1 |
| dCompareValue_2 | DINT | Comparison output comparison value 2 |
| dCompareAct_Num_Pos | DINT | Next position/comparison value of comparison output |
| iCompareErrorCode | INT | Fault code of comparison output |
| iDIStatus | INT | DI terminal status |
| iTouchProbeFunc | INT | Probe control word |
| iTouchProbeStatus | INT | Probe status word |
| dPos1PosValue | DINT | Probe 1 position latched on the rising edge |
| dPos2PosValue | DINT | Probe 2 position latched on the rising edge |
| dPos1NegValue | DINT | Probe 1 position latched on the falling edge |
| dPos2NegValue | DINT | Probe 2 position latched on the falling edge |
| iErrorCode | INT | Fault code |

Table 15–5 _sENC_CONFIG: General configuration parameters for encoder axes

| Variable | Type | Function |
|---|---|---|
| bLimitEnable | BOOL | Limit enable |
| fUnits | REAL | Gear ratio |

| Variable | Type | Function |
|---|---|---|
| iRingMode | INT | Linear/ring mode<br>0: Linear mode<br>1: Ring mode |
| fNegLimitPos | REAL | Negative limit in linear mode |
| fForLimitPos | REAL | Positive limit in linear mode |
| fRotationPeriod | REAL | Rotation cycle in rotary mode |

Table 15–6 _sENC_EXT_AXIS: System variables of the bus encoder axis

| Variable | Type | Function |
|---|---|---|
| bEnable | BOOL | Count state of the encoder<br>OFF: Stop counting<br>ON: Enable counting |
| bActDir | BOOL | Count direction<br>OFF: Forward (incremental count)<br>ON: Reverse (decremental count) |
| bPLimit | BOOL | Arrival at the positive limit<br>OFF: Disabled<br>ON: Enabled |
| bNlimit | BOOL | Arrival at the negative limit<br>OFF: Disabled<br>ON: Enabled |
| iConfigAddress | INT | Configuration address |
| iAxisID | INT | Axis No. |
| fPosition | REAL | Feedback position (user unit) |
| fVelocity | REAL | Feedback velocity (user unit) |
| dPosition | DINT | Feedback position (pulse unit) |
| dFrequency | DINT | Pulse frequency (pulse unit) |
| iAxisState | INT | Statuses of the axis<br>0: Stop counting<br>1: Fault state of the axis<br>5: Enable counting |
| iConfigState | INT | Configuration statuses of the axis<br>1: Init (axis in the initialization state)<br>2: Configure finish (reading of configuration data completed)<br>3: Sync finish (synchronized with EtherCAT tasks)<br>4: Wait communication (communication with the drive established)<br>5: Slave ready (initialization completed for the servo drive controlled by axes)<br>6: Axis ready (communication established) |
| iAxisError | INT | Axis fault code |
| iSlaveAxisError | INT | Drive fault code |
| sCounter | _sENC_CNT | Reservation for compatibility with the local encoder axis |

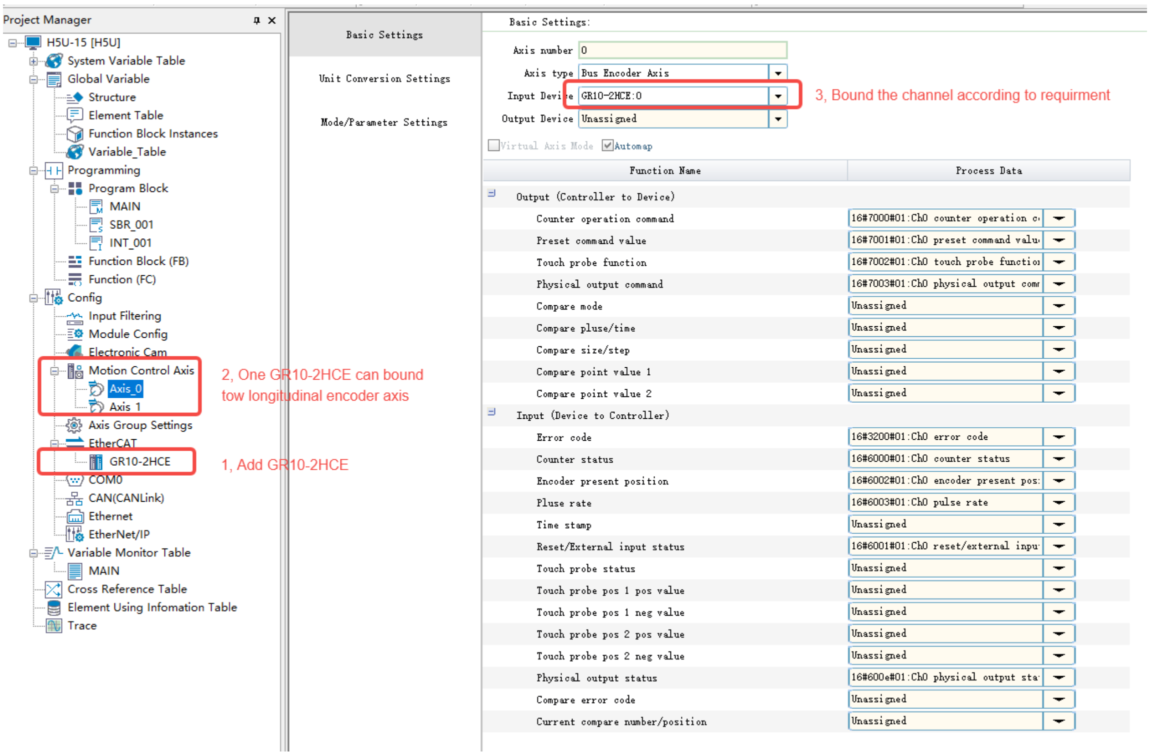
| Variable | Type | Function |
|---|---|---|
| sReset | _sENC_RST | Reservation for compatibility with the local encoder axis |
| sPreset | _sENC_PRESET | Reservation for compatibility with the local encoder axis |
| sProbe | _sENC_PROBE[2] | Reservation for compatibility with the local encoder axis |
| sMatch | _sENC_MATCH[2] | Reservation for compatibility with the local encoder axis |
| sPDO | _sENC_PDO | Parameter value area of PDOs |
| sConfigure | _sENC_CONFIG | Parameter value area of configuration |

# 15.4 Function Demonstration

## 15.4.1 Establishing the Configuration

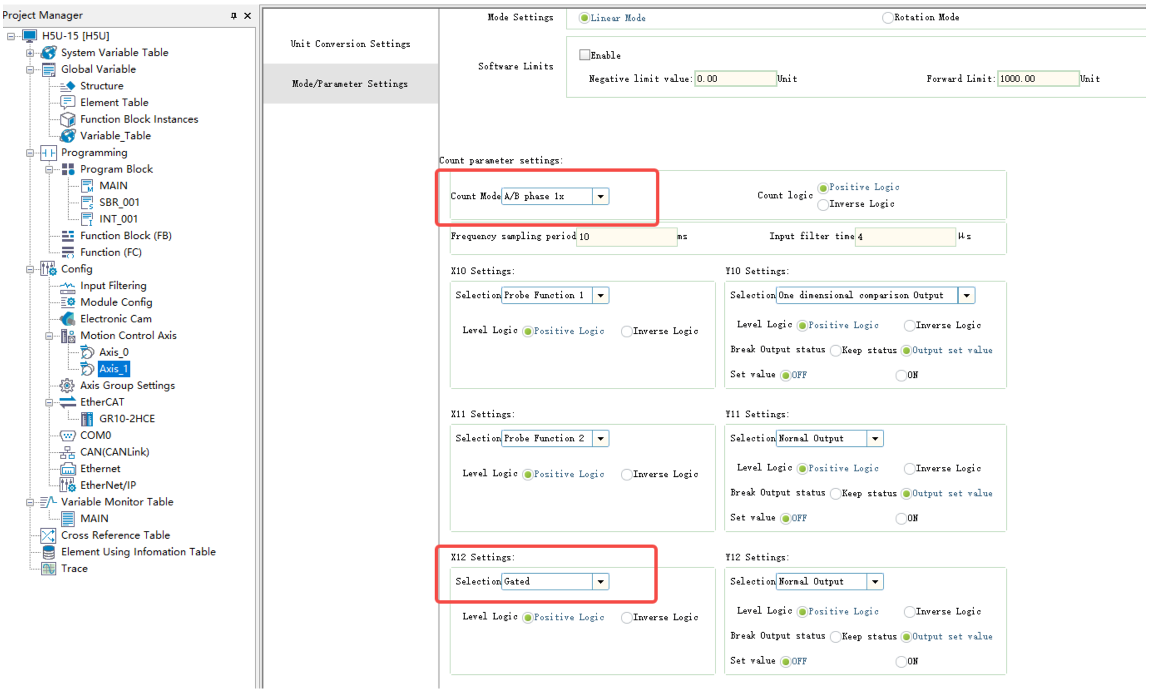
In this example, the hardware required is as follows: one H5U and one GR10-2HCE module with its channels CH0 and CH1 connected to the external phase A/B pulse of fixed frequency.

Create a project and add the GR10-2HCE module to the EtherCAT configuration. The two bus encoder axes are automatically added. Among them, Axis_0 is automatically bound to channel CH0 of the GR10-2HCE module, while Axis_1 is automatically bound to channel CH1 of the GR10-2HCE module.

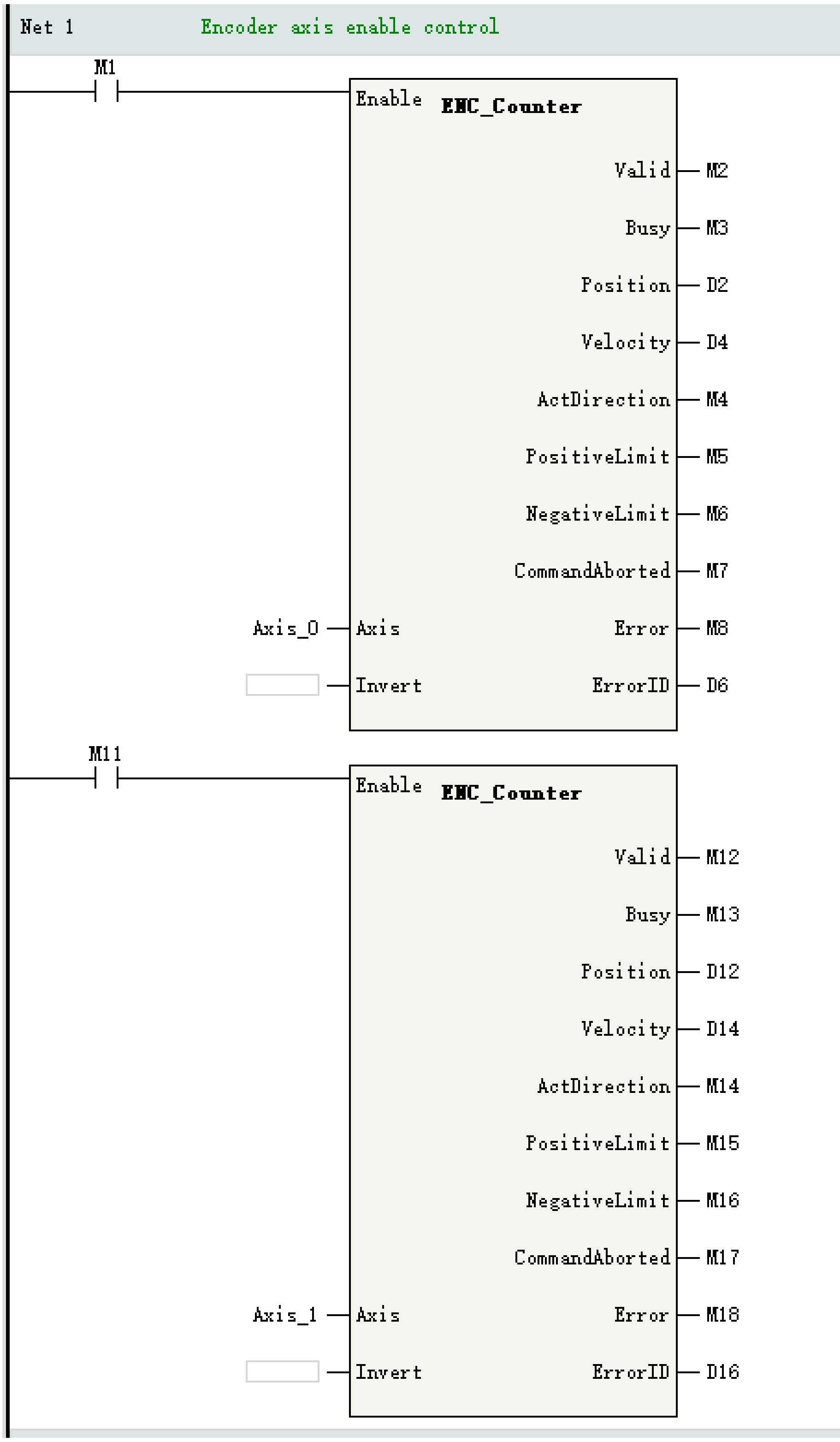


## 15.4.2 Counter Enabling

Set the "Counting mode" to "A/B phase frequency" for both Axis_0 and Axis_1, and select "Door control" in "X12 setting" for Axis_1.



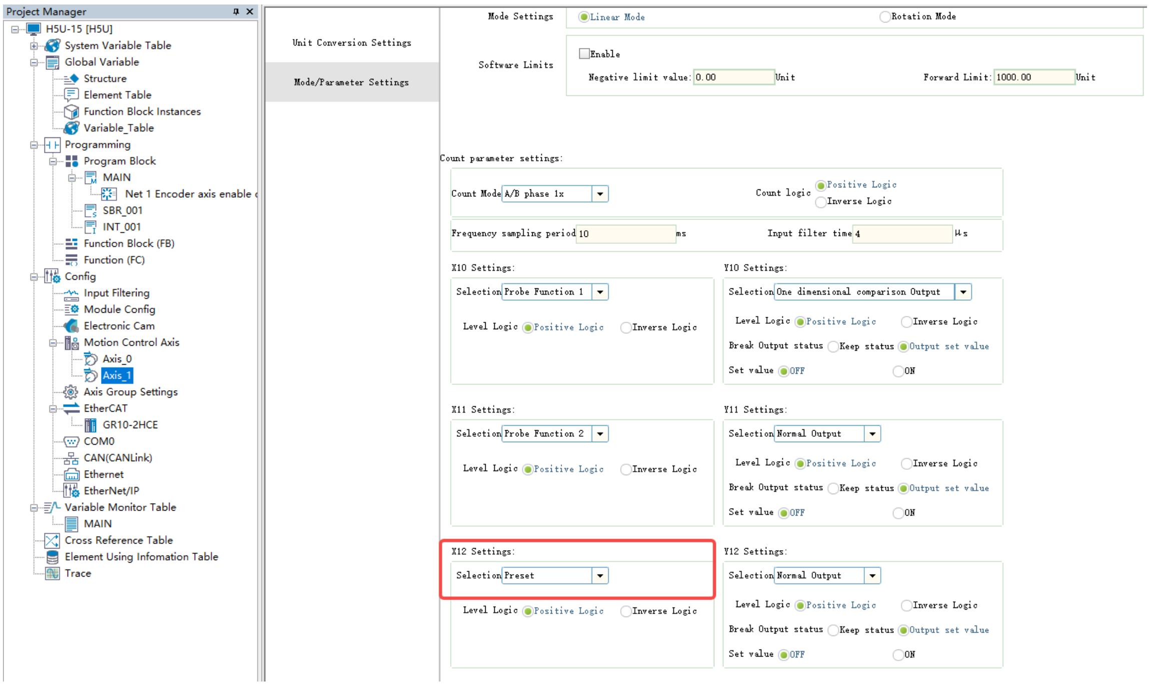

Call the instruction ENC_Counter to enable both bus encoders.

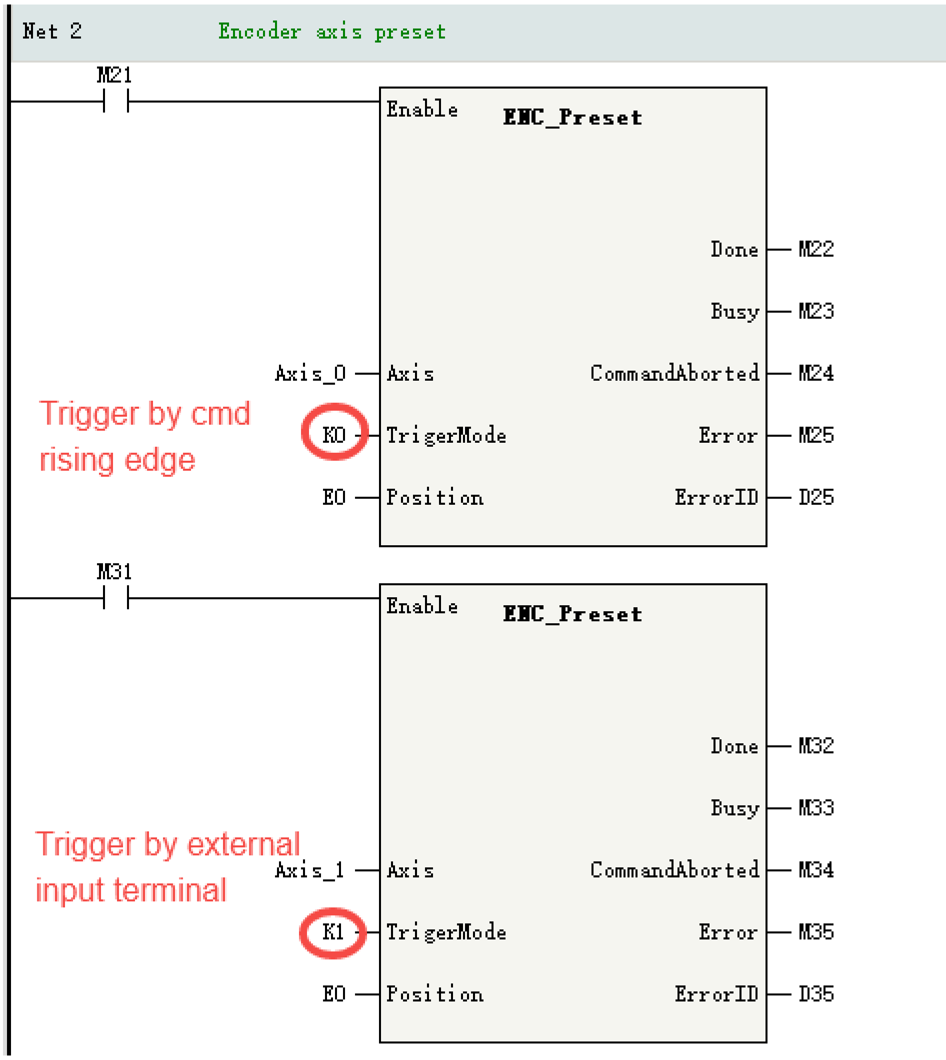



- After M1 is set to ON, M2 and M3 output is ON, D2 displays the current position, and the bus encoder axis Axis_0 starts counting.
- After M11 is set to ON, if the X12 input of the gating terminal is OFF, the M13 output of the instruction is ON, the M12 output is OFF, and D12 shows the current position, then the encoder axis Axis_1 does not count. If the X12 input of the gating terminal is ON and the M12 output of the instruction is ON, then the encoder axis Axis_1 starts counting.

### 15.4.3 Counter Presetting

Allocate X13 with the preset function and combine it with the instruction ENC_Preset to realize the function of presetting the count value for the encoder Axis_1 of the terminal.



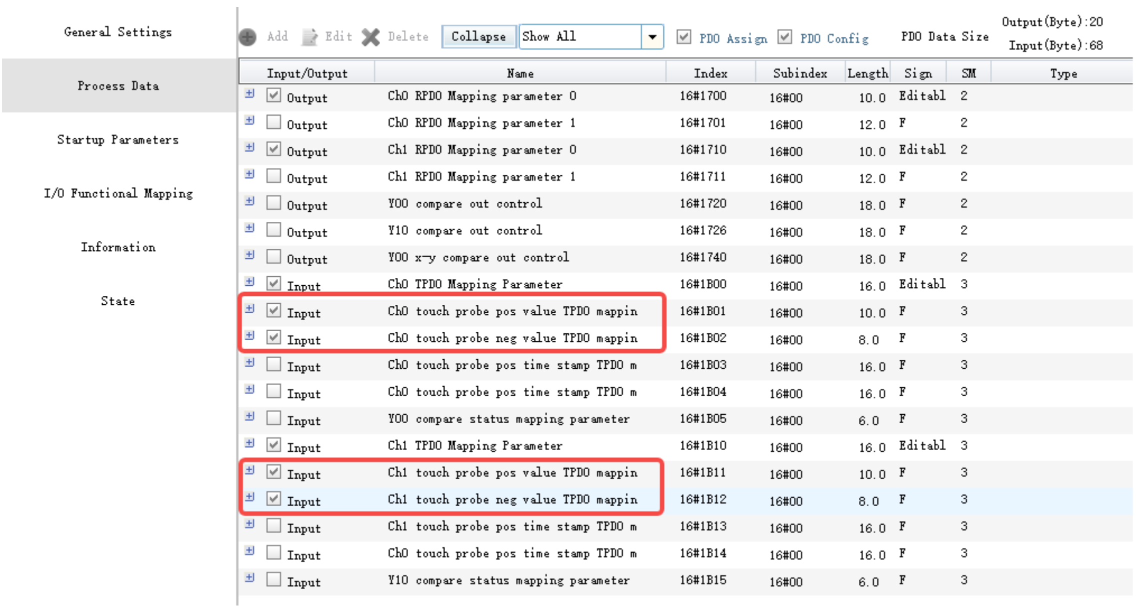



- Set M21 to ON. Then the current count value of Axis_0 will be set to 0, and M22 output will be ON after the setting is completed.
- Set M31 to ON and M33 output to ON. When the terminal X13 of the GR10-2HCE module switches its state from OFF to ON, the current count value of Axis_1 will be set to 0, and the M32 output will be ON after the setting is completed.

### 15.4.4 Probe Function

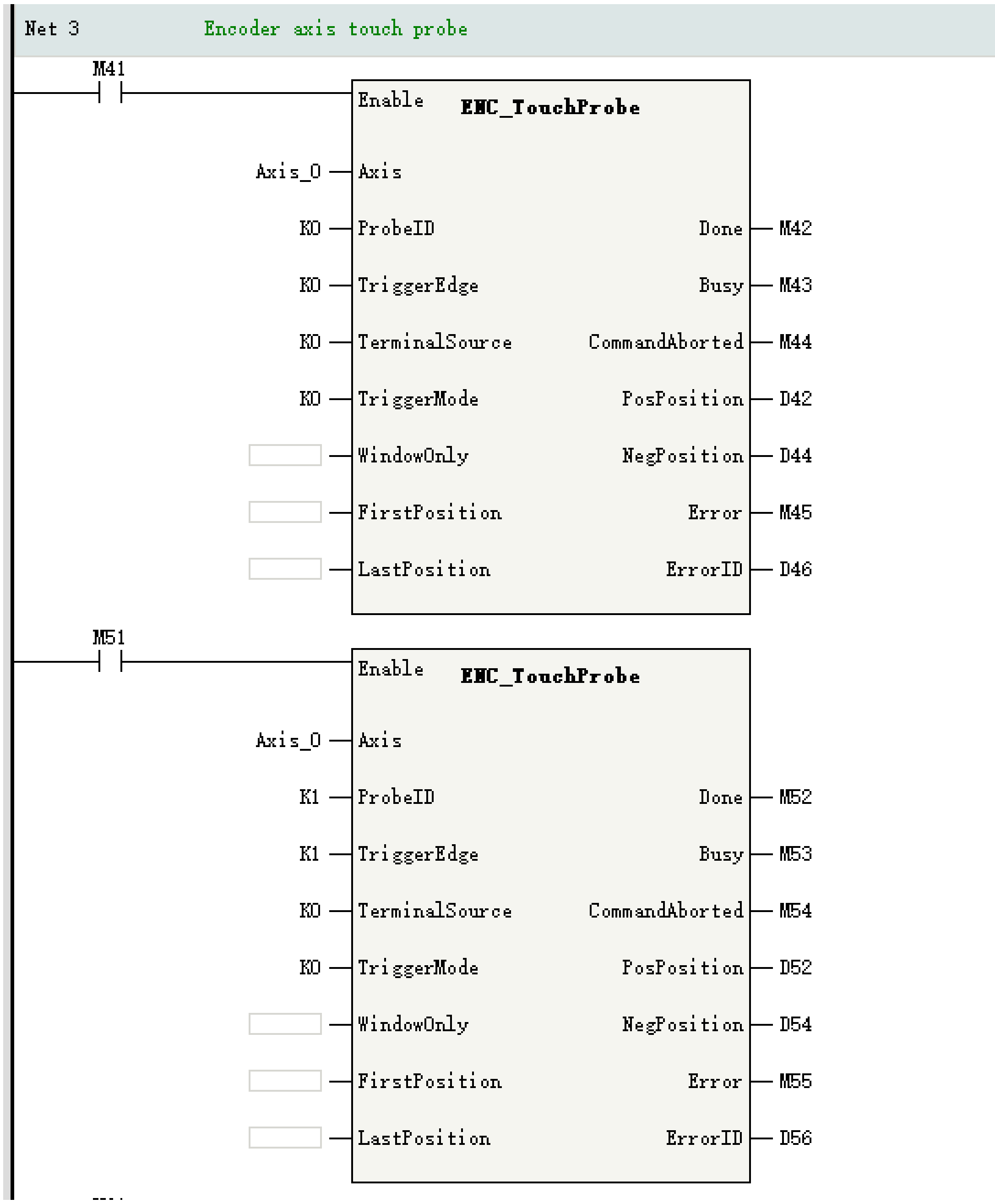
Allocate the probe function 1 and probe function 2 for X00 and X10 in the encoder axis Axis_0 and for X10 and X11 in the encoder axis Axis_1.

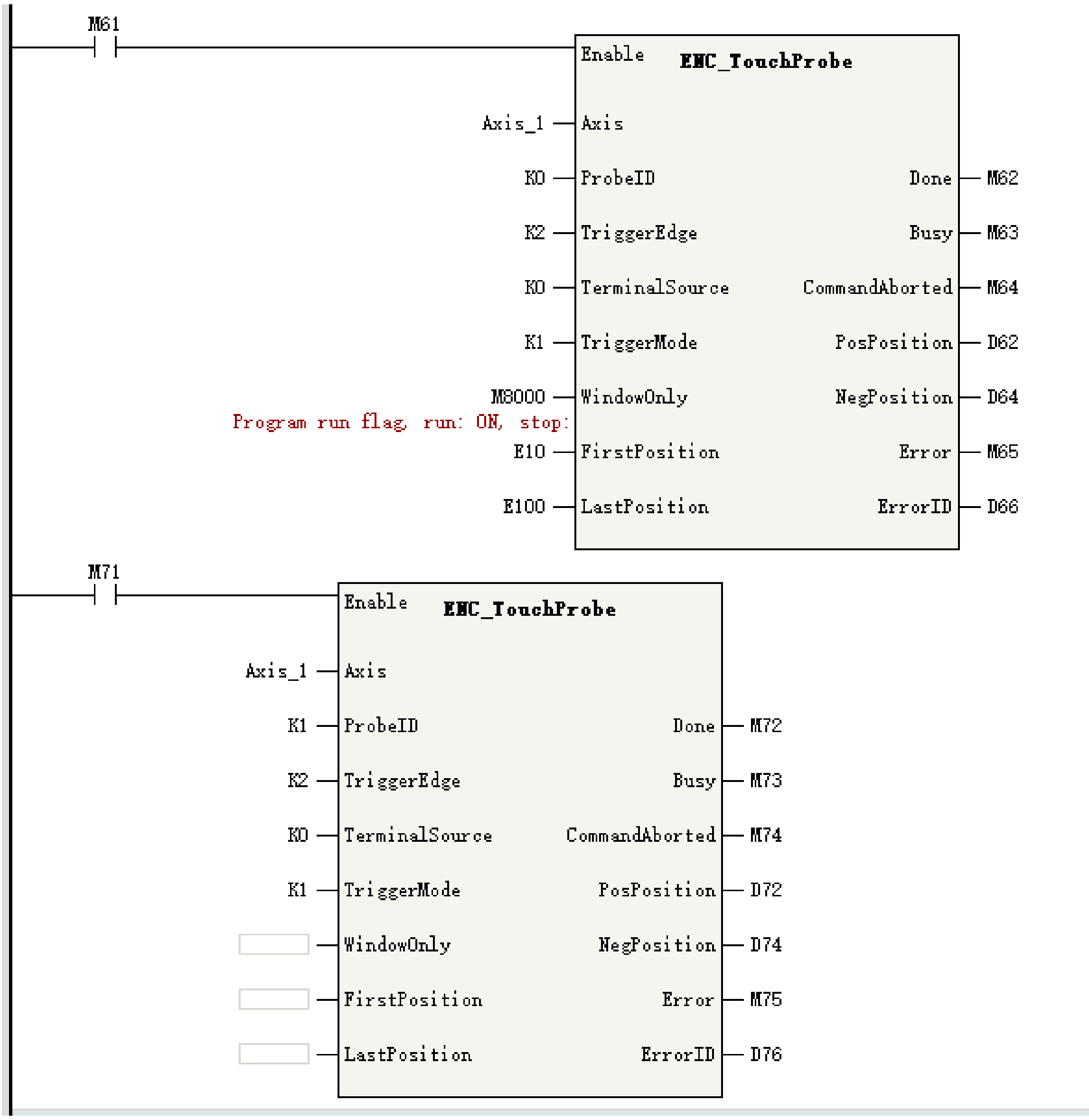

Tick the following PDO data on the interface "过程数据" of GR10-2HCE.




Call the instruction ENC_TouchProbe to control the probe function of the encoder axis. The functions of the four probes are set as follows.

| Para. | Axis_0 probe 1 | Axis_0 probe 2 | Axis_1 probe 1 | Axis_1 probe 2 |
|---|---|---|---|---|
| Probe ID | Probe 1 | Probe 2 | Probe 1 | Probe 2 |
| Trigger edge | Trigger by the rising edge only | Trigger by the falling edge only | Trigger by both rising and falling edges | Trigger by both rising and falling edges |
| Terminal | DI terminal | DI terminal | DI terminal | DI terminal |
| Trigger mode | Single trigger | Single trigger | Continuous trigger | Continuous trigger |
| Window limit | Disabled | Disabled | Enabled | Disabled |
| Start position | - | - | 10 | - |
| End position | - | - | 100 | - |

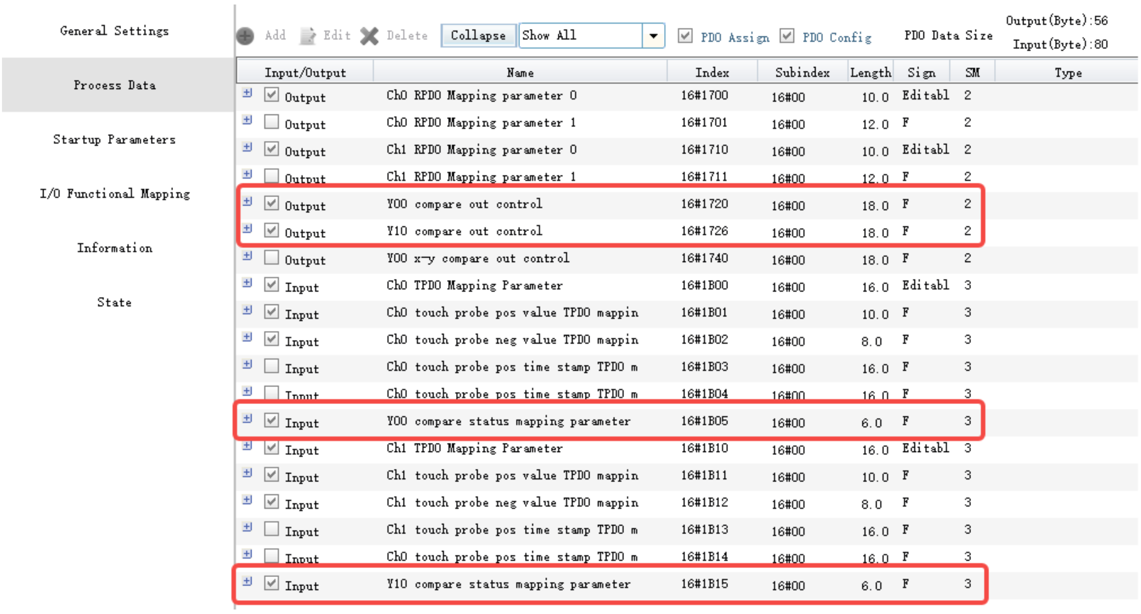

Net 3
Encoder axis touch probe
M41
EMC_TouchProbe
Enable
Axis_0
Axis
K0
ProbeID
Done
M42
K0
TriggerEdge
Busy
M43
K0
TerminalSource
CommandAborted
M44
K0
TriggerMode
PosPosition
D42
WindowOnly
NegPosition
D44
FirstPosition
Error
M45
LastPosition
ErrorID
D46
M51
EMC_TouchProbe
Enable
Axis_0
Axis
K1
ProbeID
Done
M52
K1
TriggerEdge
Busy
M53
K0
TerminalSource
CommandAborted
M54
K0
TriggerMode
PosPosition
D52
WindowOnly
NegPosition
D54
FirstPosition
Error
M55
LastPosition
ErrorID
D56




## 15.4.5 One-dimensional Comparison Output

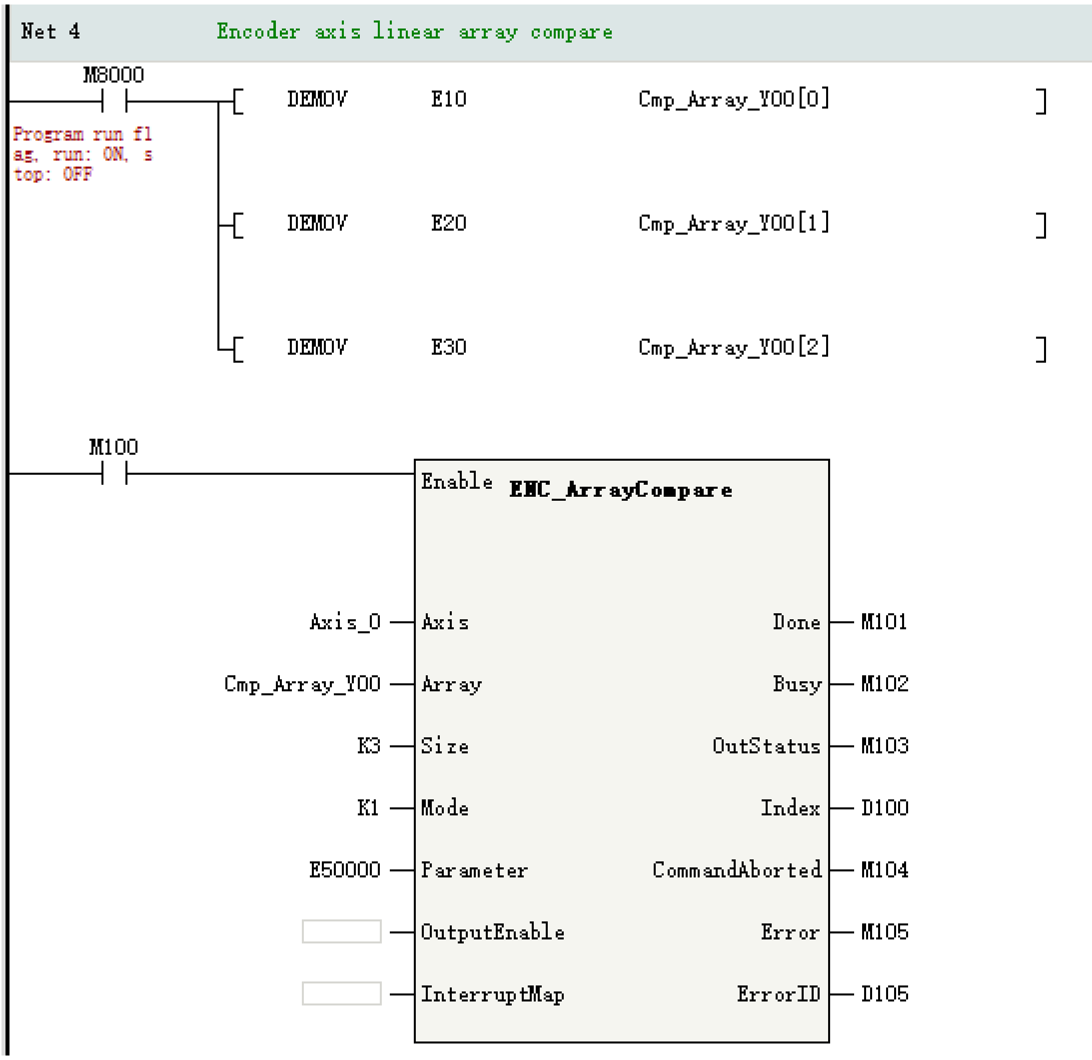
Allocate the one-dimensional comparison output function for Y00 in the encoder axis Axis_0 and Y10 in the encoder axis Axis_1.


Tick the following PDO data on the interface "Process data" of GR10-2HCE.

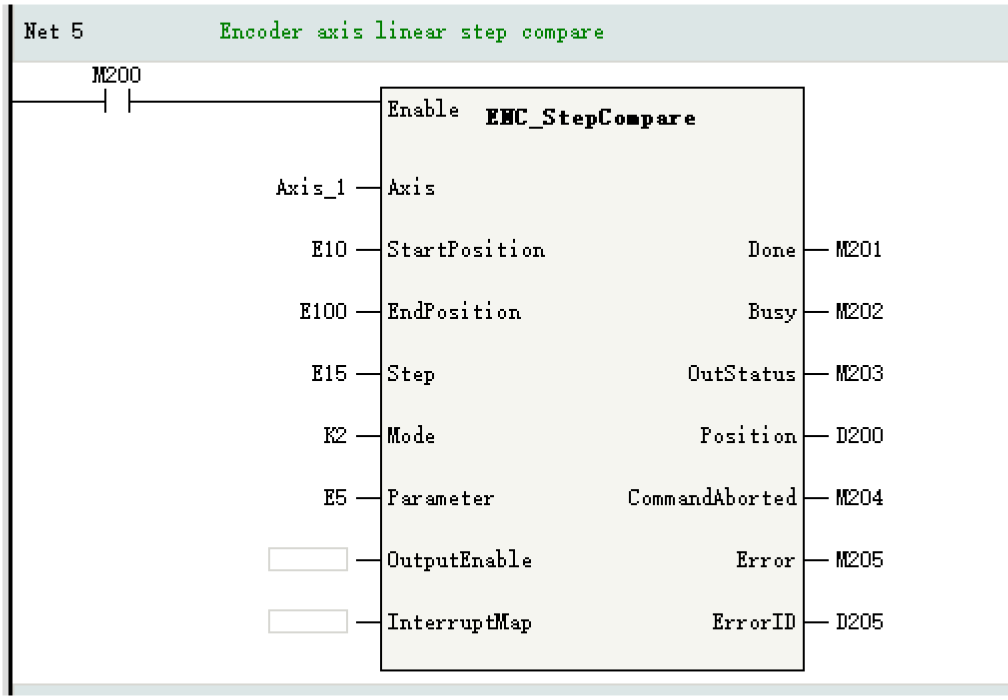



| Input/Output | Name | Index | Subindex | Length | Sign | SM | Type |
|---|---|---|---|---|---|---|---|
| Output | Ch0 RPDO Mapping parameter 0 | 16#1700 | 16#00 | 10.0 | Editabl | 2 | |
| Output | Ch0 RPDO Mapping parameter 1 | 16#1701 | 16#00 | 12.0 | F | 2 | |
| Output | Ch1 RPDO Mapping parameter 0 | 16#1710 | 16#00 | 10.0 | Editabl | 2 | |
| Output | Ch1 RPDO Mapping parameter 1 | 16#1711 | 16#00 | 12.0 | F | 2 | |
| Output | Y00 compare out control | 16#1720 | 16#00 | 18.0 | F | 2 | |
| Output | Y10 compare out control | 16#1726 | 16#00 | 18.0 | F | 2 | |
| Output | Y00 x-y compare out control | 16#1740 | 16#00 | 18.0 | F | 2 | |
| Input | Ch0 TPDO Mapping Parameter | 16#1B00 | 16#00 | 16.0 | Editabl | 3 | |
| Input | Ch0 touch probe pos value TPDO mappin | 16#1B01 | 16#00 | 10.0 | F | 3 | |
| Input | Ch0 touch probe neg value TPDO mappin | 16#1B02 | 16#00 | 8.0 | F | 3 | |
| Input | Ch0 touch probe pos time stamp TPDO m | 16#1B03 | 16#00 | 16.0 | F | 3 | |
| Input | Ch0 touch probe pos time stamp TPDO m | 16#1B04 | 16#00 | 16.0 | F | 3 | |
| Input | Y00 compare status mapping parameter | 16#1B05 | 16#00 | 6.0 | F | 3 | |
| Input | Ch1 TPDO Mapping Parameter | 16#1B10 | 16#00 | 16.0 | Editabl | 3 | |
| Input | Ch1 touch probe pos value TPDO mappin | 16#1B11 | 16#00 | 10.0 | F | 3 | |
| Input | Ch1 touch probe neg value TPDO mappin | 16#1B12 | 16#00 | 8.0 | F | 3 | |
| Input | Ch1 touch probe pos time stamp TPDO m | 16#1B13 | 16#00 | 16.0 | F | 3 | |
| Input | Ch0 touch probe pos time stamp TPDO m | 16#1B14 | 16#00 | 16.0 | F | 3 | |
| Input | Y10 compare status mapping parameter | 16#1B15 | 16#00 | 6.0 | F | 3 | |

Call the instruction ENC_ArrayCompare to implement the array comparison of terminal Y00, and output 50 ms at 10, 20, and 30 points, respectively.

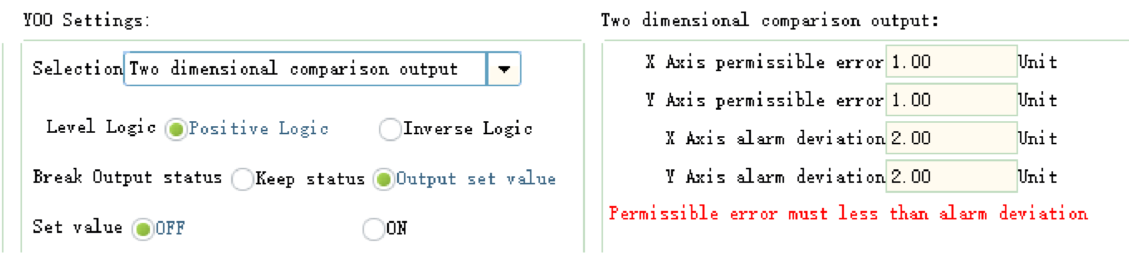



Call the instruction ENC_StepCompare to implement the step comparison of terminal Y10, with the start point at 10, end point at 100, and step size as 15. The comparison output is performed in level control mode with a level length of 5 Unit.

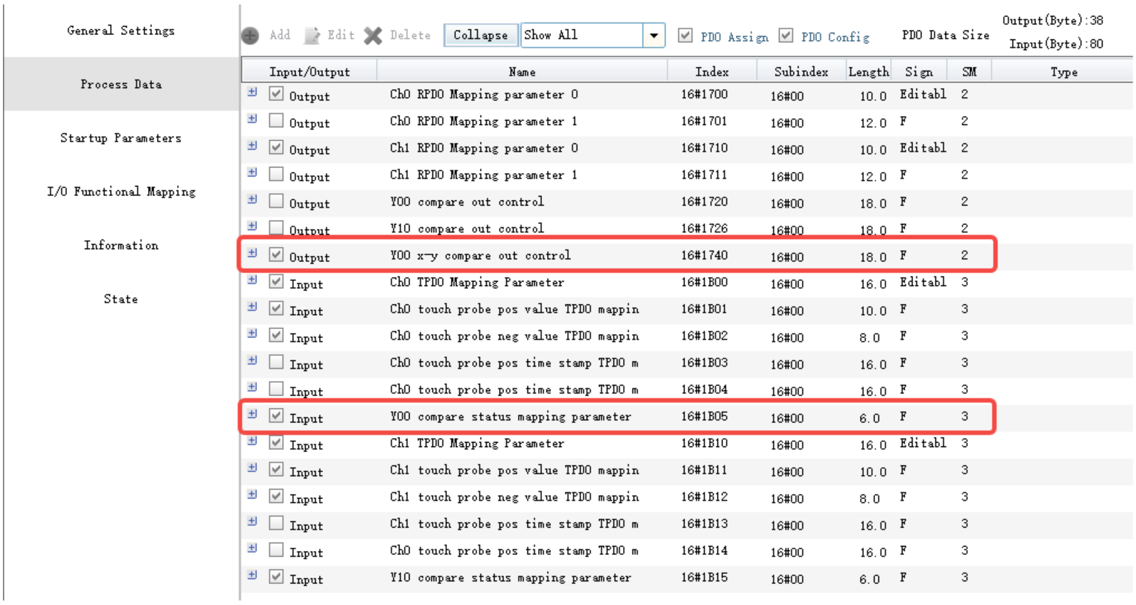



## 15.4.6 Two-dimensional Comparison Output

The GR10-2HCE module supports the two-dimensional comparison output function only at terminal Y00, so only the terminal Y00 of the encoder axis Axis_0 bound to channel CH0 can be allocated with the two-dimensional comparison output function.

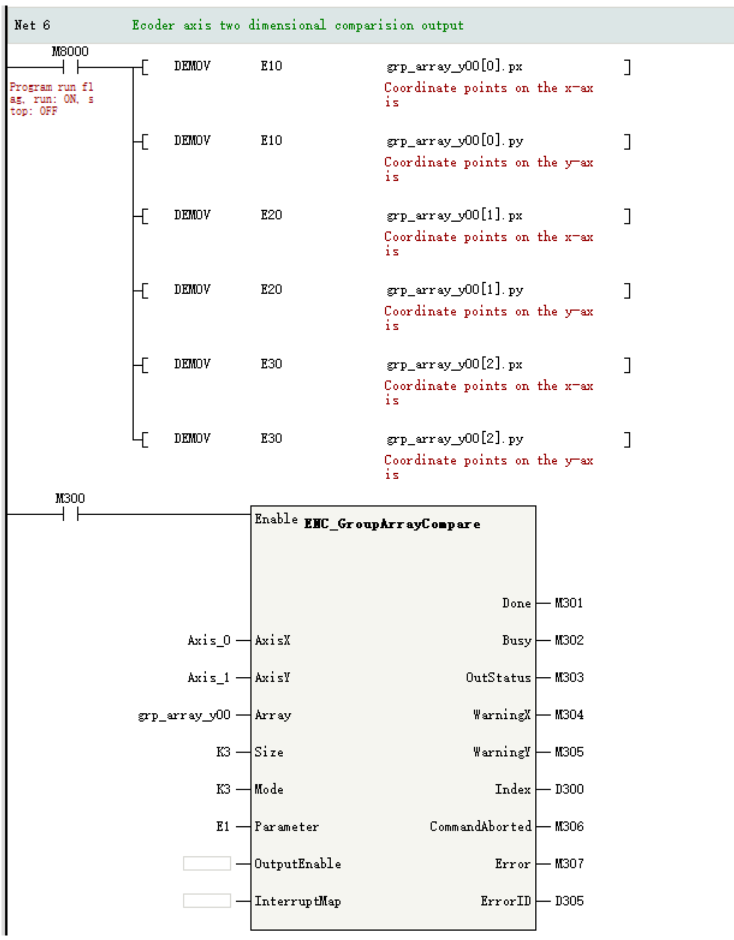



Tick the following PDO data on the interface "Process data" of GR10-2HCE.




| Input/Output | Name | Index | Subindex | Length | Sign | SM | Type |
|---|---|---|---|---|---|---|---|
| Output | Ch0 RPDO Mapping parameter 0 | 16#1700 | 16#00 | 10.0 | Editabl | 2 | |
| Output | Ch0 RPDO Mapping parameter 1 | 16#1701 | 16#00 | 12.0 | F | 2 | |
| Output | Ch1 RPDO Mapping parameter 0 | 16#1710 | 16#00 | 10.0 | Editabl | 2 | |
| Output | Ch1 RPDO Mapping parameter 1 | 16#1711 | 16#00 | 12.0 | F | 2 | |
| Output | Y00 compare out control | 16#1720 | 16#00 | 18.0 | F | 2 | |
| Output | Y10 compare out control | 16#1726 | 16#00 | 18.0 | F | 2 | |
| Output | Y00 x-y compare out control | 16#1740 | 16#00 | 18.0 | F | 2 | |
| Input | Ch0 TPDO Mapping Parameter | 16#1B00 | 16#00 | 16.0 | Editabl | 3 | |
| Input | Ch0 touch probe pos value TPDO mappin | 16#1B01 | 16#00 | 10.0 | F | 3 | |
| Input | Ch0 touch probe neg value TPDO mappin | 16#1B02 | 16#00 | 8.0 | F | 3 | |
| Input | Ch0 touch probe pos time stamp TPDO m | 16#1B03 | 16#00 | 16.0 | F | 3 | |
| Input | Ch0 touch probe pos time stamp TPDO m | 16#1B04 | 16#00 | 16.0 | F | 3 | |
| Input | Y00 compare status mapping parameter | 16#1B05 | 16#00 | 6.0 | F | 3 | |
| Input | Ch1 TPDO Mapping Parameter | 16#1B10 | 16#00 | 16.0 | Editabl | 3 | |
| Input | Ch1 touch probe pos value TPDO mappin | 16#1B11 | 16#00 | 10.0 | F | 3 | |
| Input | Ch1 touch probe neg value TPDO mappin | 16#1B12 | 16#00 | 8.0 | F | 3 | |
| Input | Ch1 touch probe pos time stamp TPDO m | 16#1B13 | 16#00 | 16.0 | F | 3 | |
| Input | Ch0 touch probe pos time stamp TPDO m | 16#1B14 | 16#00 | 16.0 | F | 3 | |
| Input | Y10 compare status mapping parameter | 16#1B15 | 16#00 | 6.0 | F | 3 | |

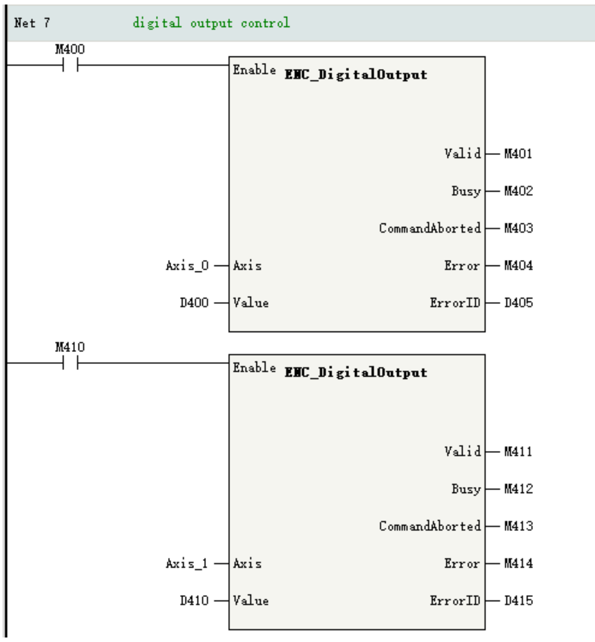
Call the instruction ENC_GroupArrayCompare to realize the comparison output function, and set three comparison points (10,10), (20,20), and (30,30). The comparison output is performed in level control mode with a high initial level.



## 15.4.7 DO Terminal Control

If the DO terminal of the GR10-2HCE module is used as a common DO terminal, call the instruction ENC_DigitalOutput in the program to control the terminal. The address mapping table of the DO terminals is as follows.

| Address | Controlled Terminal |
|---|---|
| D400.0 | Y00 |
| D400.1 | Y01 |
| D400.2 | Y02 |
| D410.0 | Y10 |
| D410.1 | Y11 |
| D410.2 | Y12 |

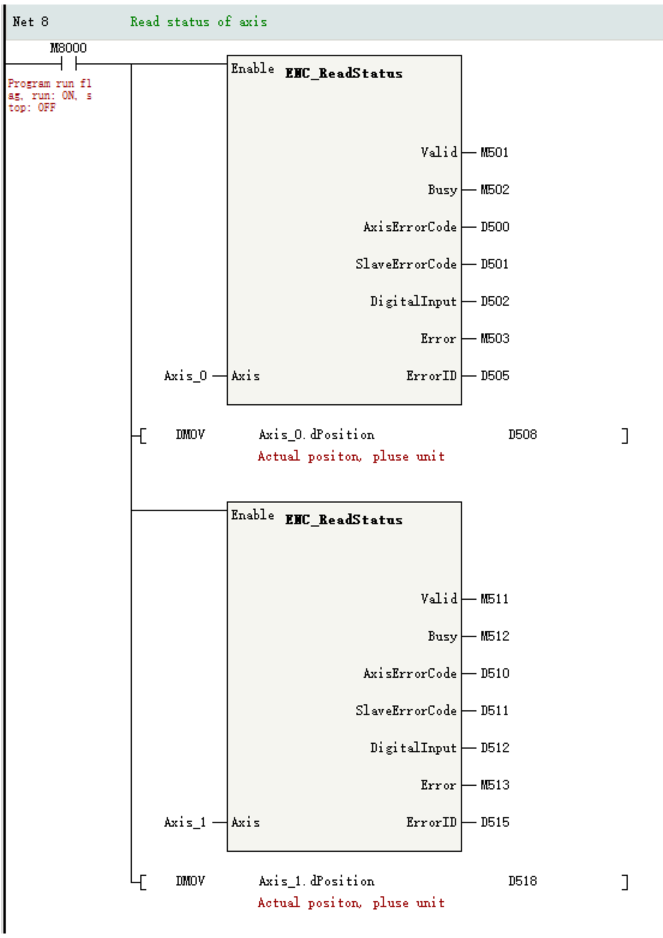



## 15.4.8 Obtaining Axis Status

Call the instruction ENC_ReadStatus to obtain the fault code of an axis and the status of the DI terminal. The address mapping table of the DI terminals is as follows.

| Address | Mapped Terminal |
|---|---|
| D502.0 | X00 |
| D502.1 | X01 |
| D502.2 | X02 |
| D502.3 | X03 |
| D512.0 | X10 |
| D512.1 | X11 |
| D512.2 | X12 |
| D512.3 | X13 |

Through the system variables, write the feedback position of the pulse unit of Axis_0 to D508 and the feedback frequency of the pulse unit of Axis_1 to D518.


Net 8
Read status of axis
M8000
Program run flag, run: ON, stop: OFF
Enable
ENC_ReadStatus
Valid — M501
Busy — M502
AxisErrorCode — D500
SlaveErrorCode — D501
DigitalInput — D502
Error — M503
Axis_0 — Axis
ErrorID — D505
[ DMOV Axis_0.dPosition D508 ]
Actual positon, pluse unit
Enable
ENC_ReadStatus
Valid — M511
Busy — M512
AxisErrorCode — D510
SlaveErrorCode — D511
DigitalInput — D512
Error — M513
Axis_1 — Axis
ErrorID — D515
[ DMOV Axis_1.dPosition D518 ]
Actual positon, pluse unit

# 16 Electronic Cam

## 16.1 Introduction to Electronic Cam

Electronic cam essentially involves the motion of the slave axis following the master axis. The motion relationship between the master axis and the slave axis can be expressed in a cam table data or electronic gear ratio approach.

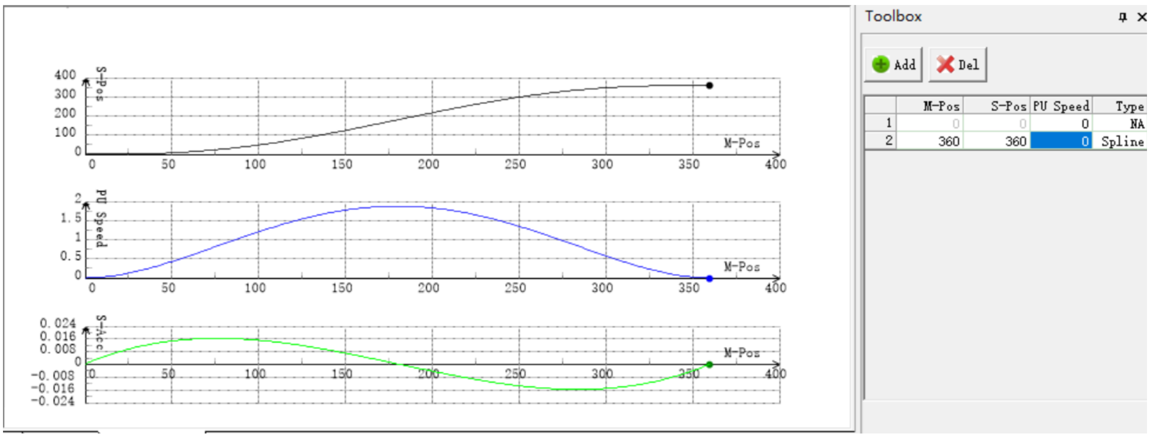
- In the cam table data approach, up to 361 key points can be created. In the electronic gear ratio approach, only one constant ratio is applied between the master axis and the slave axis.
- If electronic gear is used, just set the numerator and denominator of the electronic gear ratio and there is no need to set cam table data. If electronic cam is used, set electronic cam table data first.
- The programming software can be configured with 16 cam tables, each with up to 361 key points. Up to 8 electronic cams can be used simultaneously in the program.
- During cam execution, it is allowed to add, delete, and modify key points of a cam table, and the modified cam table takes effect in the next cam cycle.

## 16.2 Software Configuration

### 16.2.1 Overview

In "Project Manager", expand "Configure", and double-click "Electronic Cam" to open the relevant configuration page.

The cam table page contains a graphic editing area on the left and a parameter point editing area on the right.




### 16.2.2 Cam Node Settings

You can set cam nodes in the parameter point editing area.

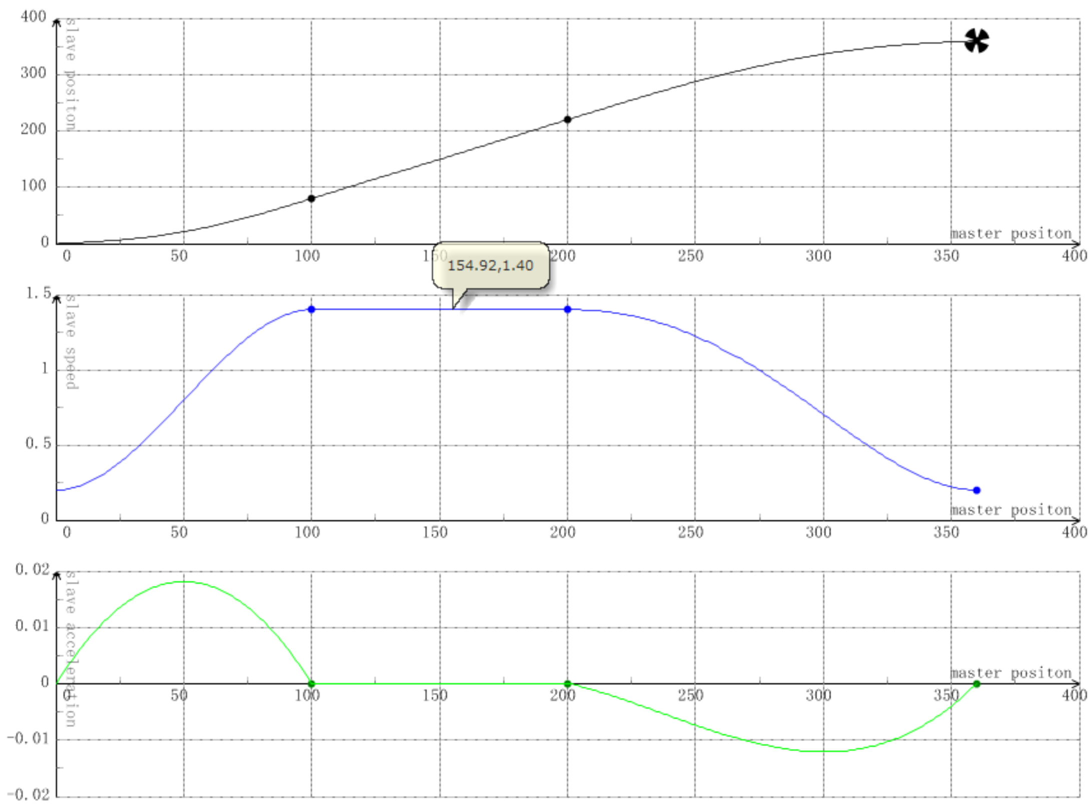
Click "Add" to add a cam node data row and edit the relevant data. To delete a node, select the corresponding node data row and click "Del".

Table 16–1 Definitions of cam node parameters

| Para. | Function |
|---|---|
| M-Pos | Master axis phase<br>Sets the phase of the master axis (relative mode) |
| S-Pos | Slave axis displacement<br>Sets the offset of the slave axis (relative mode) |
| PU-Speed | Connection speed<br>Automatically generated when the curve type is set to straight line, or manually set when the curve type is set to quintic curve |
| Type | Sets the curve type<br>Line: Straight line<br>Spline: Quintic curve |

## 16.2.3 Cam Curve Settings

In the graphic editing area, you can set cam curves, including position, speed ratio, and acceleration ratio curves.




### Cam curve description

1. Cam key points on the position curve can be moved up or down and left or right. The speed ratio curve can only be moved up or down. The acceleration ratio curve does not allow modification.
2. The last point can only be dragged up and down. To change the value of the last point leftwards or rightwards, manually modify the data in the toolbar on the right.

3. Hover the mouse cursor over a point in the coordinate system, and the specific coordinate information will be displayed.
4. Right-click to insert or delete a key point.
5. Click a line segment between two key points in any coordinate system, and the line segments between the two key points in all the three coordinate systems will become bolded.

### 16.2.4 Import and Export

You can export or import each individual cam table.
Select the electronic cam you want to export or import and right-click it to export/import the electronic cam to/from a CSV file.

### 16.2.5 Uploading Cam Tables

All the cam tables saved in a board can be uploaded by using the upload feature.

### 16.2.6 Calling System Variables and Instructions

When a cam table is created, the software backend assigns a system variable to represent the cam table. The status of the cam table can be monitored in the PLC program and can be used as a parameter for instructions such as MC_CamIn. In addition, values of key points in the cam table can be modified and updated using the MC_GenerateCamTable instruction.

## 16.3 System Variables

### 16.3.1 Cam Nodes

Each key point can be represented by a cam node variable, with the data type being _sMC_CAM_NODE. Member variables of this structure are shown in the following table.

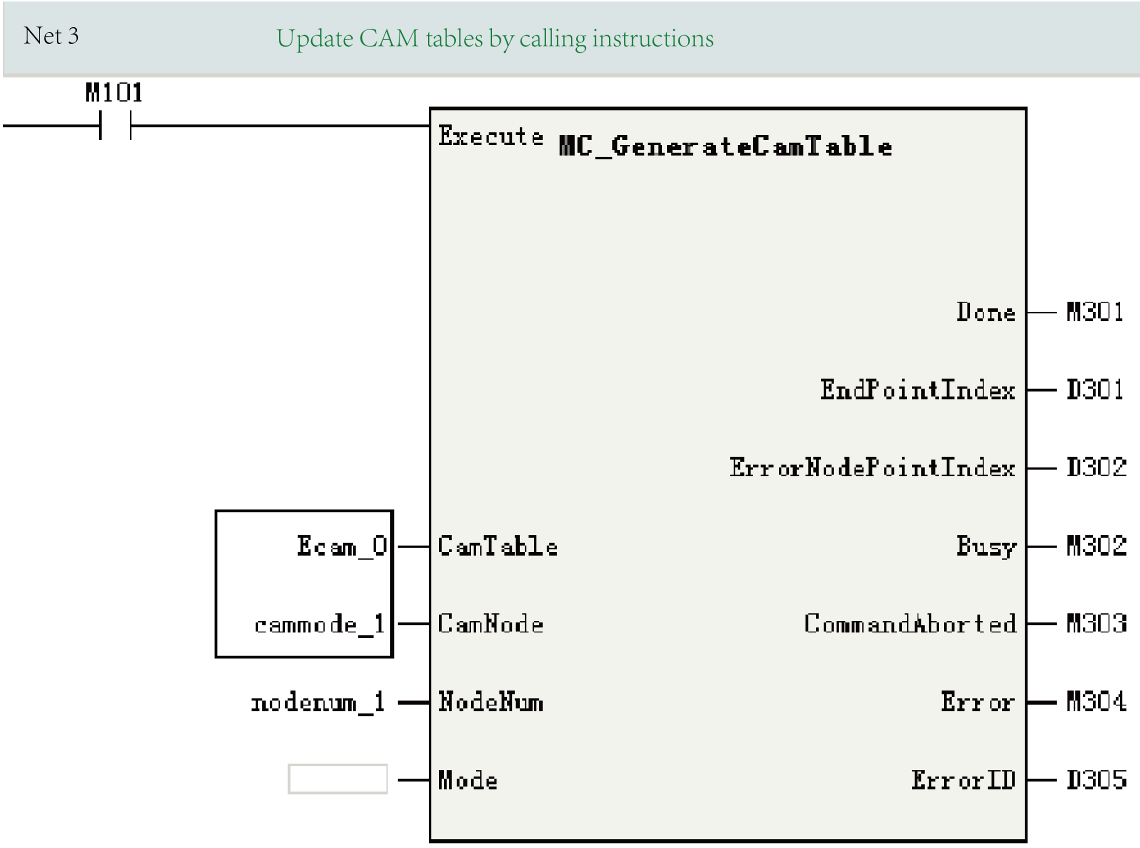
Table 16–2 _sMC_CAM_NODE structure

| Variable Name | Data Type | Function Description |
|---|---|---|
| fPhase | REAL | Master axis phase |
| fDistance | REAL | Slave axis displacement |
| fVel | REAL | Connection speed |
| fAcc | REAL | Connection acceleration rate (reserved) |
| iCuve | INT | Curve type<br>0: Reserved<br>1: Straight line<br>2: Quintic curve |

Each cam node structure is used as a member variable of a cam table structure to store key point data of the cam table. See *“16.3.2 Cam Tables” on page 517*for details.

In the program, you can also customize cam node arrays for updating cam tables.

The MC_GenerateCamTable instruction can be used to overwrite the existing cam node array in Ecam_1 with a newly-defined camnode_1 cam node array.




## 16.3.2 Cam Tables

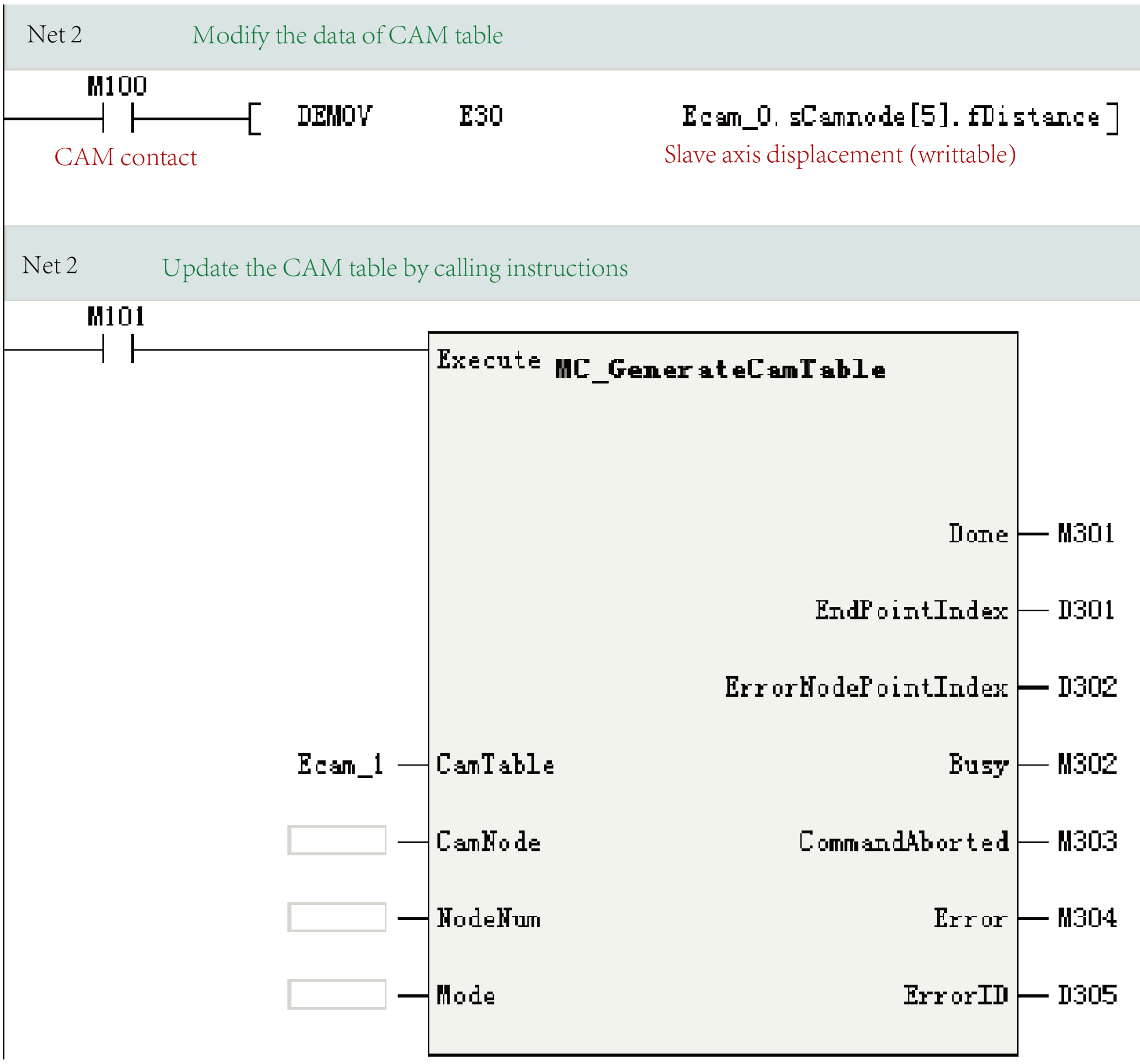
Cam tables can only be created and configured in the software tool and cannot be created in the program. However, coordinates of cam key points can be modified in the program to facilitate modification of process parameters.

Table 16–3 _sMC_CAMTABLE

| Variable Name | Data Type | Read/Write Property | Function Description |
|---|---|---|---|
| iCamID | INT | RO | ID number |
| bSaveState | BOOL | RO | Saving a cam table<br>ON: Saving<br>OFF: Idle |
| bCheckState | BOOL | RO | Checking a cam table<br>ON: Checking<br>OFF: Idle |
| bNew | BOOL | RO | Updating a cam table<br>ON: Updating<br>OFF: Idle |

| Variable Name | Data Type | Read/Write Property | Function Description |
| --- | --- | --- | --- |
| iErrorCode | INT | RO | Error code corresponding to the cam check/save failure |
| iSetNodeNum | INT | RW | Total number of set key points |
| iActNodeNum | INT | RW | Total number of actual key points<br>Updated after the first run and after each execution of the MC_GenerateCamTable instruction |
| fMaxPhase | REAL | RO | Cam cycle |
| sCamnode | _sMC_CAM_NODE [361] | RW | Cam key point array<br>Needs the MC_GenerateCamTable instruction for updating after modification in the program<br>The master axis phases must be arranged in ascending order, otherwise an error will occur. |

Cam table variables are automatically generated for cam tables created in the software tool.




## 16.3.3 Cam Contact Nodes

The system variable for the cam contact node is _sMC_CAMIN.

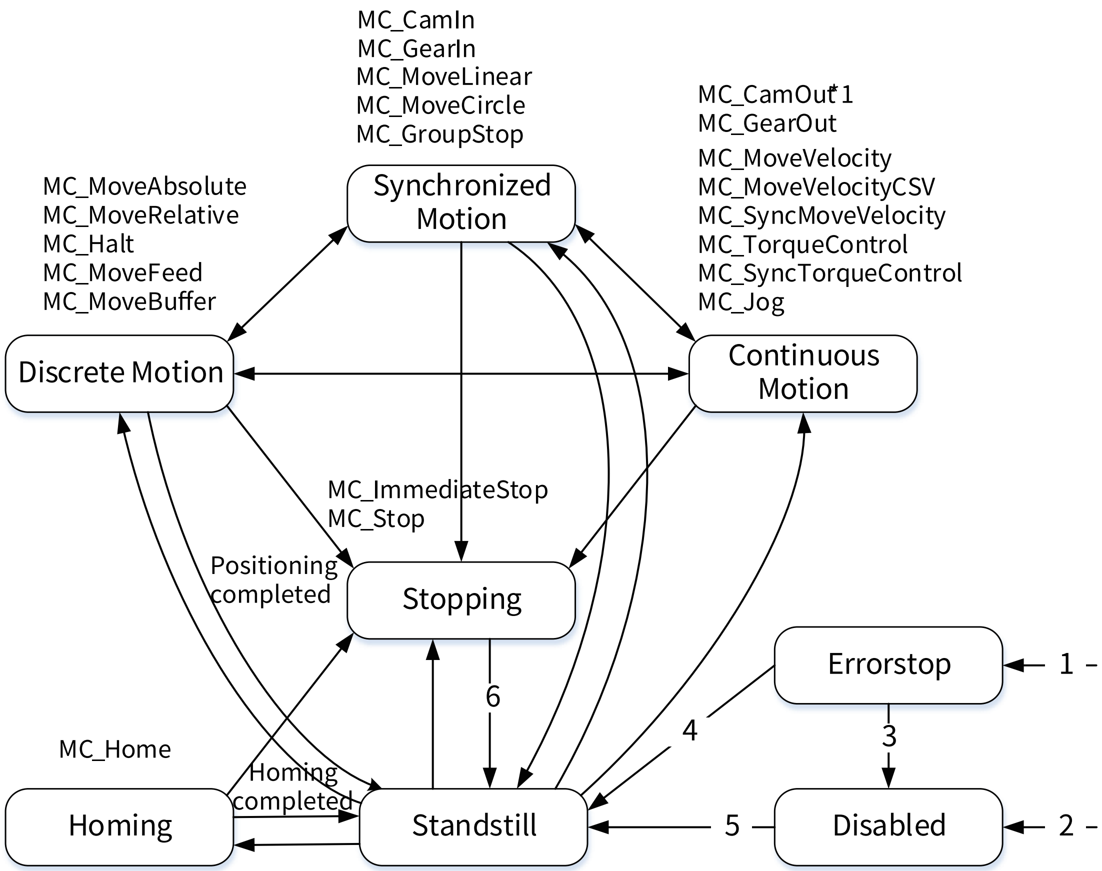
Table 16–4 _sMC_CAMIN data structure

| Variable Name | Data Type | Read/Write Property | Function Description |
|---|---|---|---|
| iCamInID | INT | RO | Cam combination ID |
| iCAMTableID | INT | RO | The cam table being executed |
| iMasterID | INT | RO | Master axis ID |
| iSlaveID | INT | RO | Slave axis ID |
| iState | INT | RO | Reserved and not defined |
| iCamCnt | INT | RO | Number of cam cycles already executed |
| iNodeCnt | INT | RO | Key points waiting for execution |
| fMasterStartpos | REAL | RO | Start position of the master axis |
| fSlaveStartPos | REAL | RO | Start position of the slave axis |
| fphase | REAL | RO | Current phase of the master axis |
| fDistance | REAL | RO | Current displacement of the slave axis |
| fPhaseShift | REAL | RO | Super-imposed amount of phase shift |
| fPhaseVelocity | REAL | RO | Super-imposed velocity of phase shift |
| fPhaseAcc | REAL | RO | Super-imposed acceleration of phase shift |

This variable can only be defined as an output variable of the MC_CamIn instruction in the program.

## 16.4 State Machines

State machines of the electronic cam are shown in the following figure.



***Note***

Calling the MC_CamOut instruction can start the Continuous Motion state only when OutMode of the instruction is 0.

Table 16–5 State definitions

| Status | Function Description |
|---|---|
| Disabled | Disabled |
| ErrorStop | Stopped due to a fault |
| Standstill | Enabled |
| Homing | Homing |
| Stopping | Stopped |
| Discrete Motion | Discrete motion |
| Continuous Motion | Continuous motion |
| Synchronized Motion | Synchronized motion |

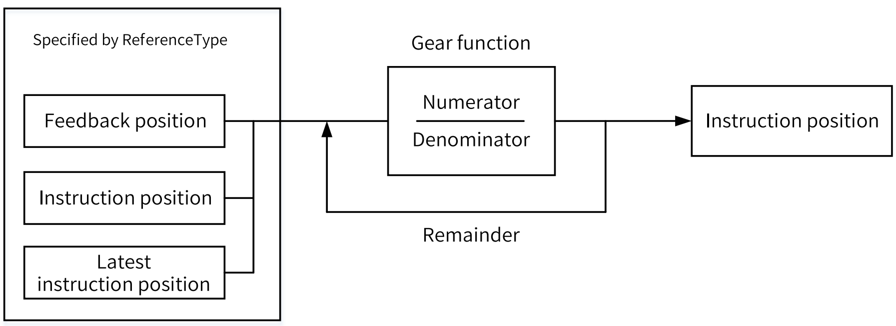
Table 16–6 State transition conditions

| Transition | Transition Conditions |
|---|---|
| 1 | The fault detection logic of the axis detects a fault. In this case, the system immediately transits to this state. |
| 2 | The axis is free of faults and MC_Power.Enable=OFF |
| 3 | MC_Reset is called to reset the axis fault and MC_Power.Status=FASLE. |
| 4 | MC_Reset is called to reset the axis fault and MC_Power.Status=ON. |
| 5 | MC_Power.Enable=ON and MC_Power.Status=ON. |
| 6 | MC_Stop(MC_ImmediateStop).Done=ON and MC_Stop(MC_ImmediateStop).Execute=OFF. |

# 16.5 Electronic Cam Operations

## 16.5.1 Gear Operation

### Basic block diagram




### Function description

Gear operation is applicable to the following types of master and slave axes.

- Master axis: bus servo axis, local pulse axis, local encoder axis, and bus encoder axis

- Slave axis: bus servo axis and local pulse axis

Use the MC_GearIn (starting gear operation) instruction to start gear operation. Use the MC_GearOut (ending gear operation) instruction or the MC_Stop (forced stop) instruction to end synchronized gear operation.

After gear operation starts, the slave axis accelerates or decelerates, with the target speed being the speed of master axis multiplied by the gear ratio.

Time before the slave axis reaches the target speed is called the Catching phase. Time after the slave axis reaches the target speed is called the InGear phase.

Gear operation is executed by setting the gear ratio between the master and slave axes.

When the gear ratio is positive, the slave axis moves in the same direction as the master axis. When the gear ratio is negative, the slave axis moves in the opposite direction to the master axis.

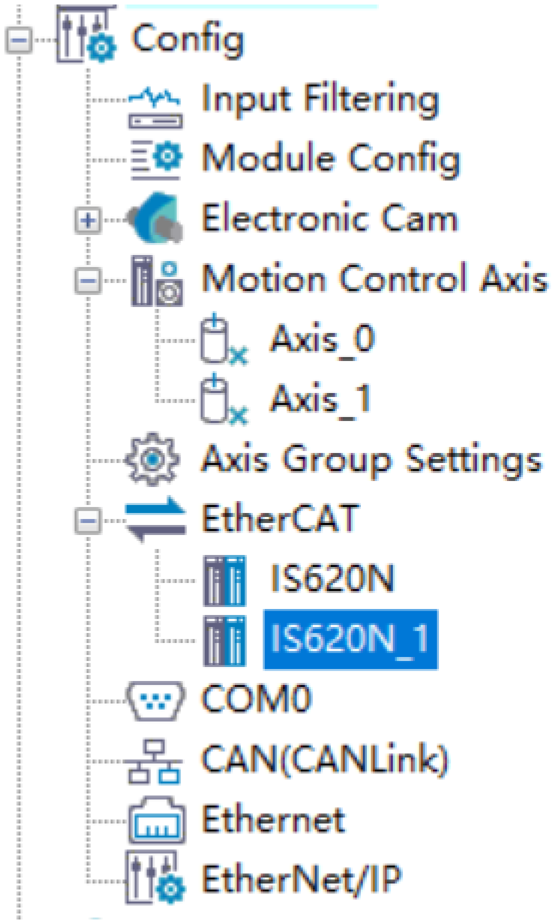
For detailed functions, see the MC_GearIn instruction in the "Electronic Cam Instructions" section of the instructions guide.

## Example

Job: Create two bus servo axes and make the second axis follow the first axis at a gear ratio of 1:1 for gear operation.

Procedure:

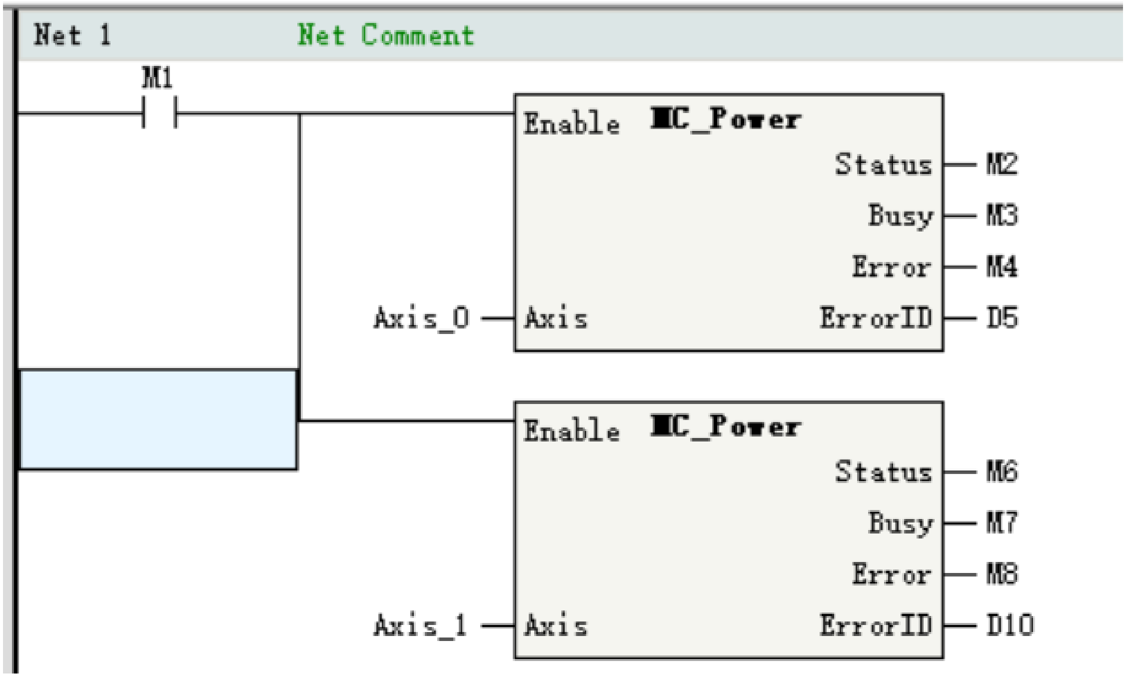
1. Create a project. Create two bus servo axes, one as a master axis and the other as a slave axis.



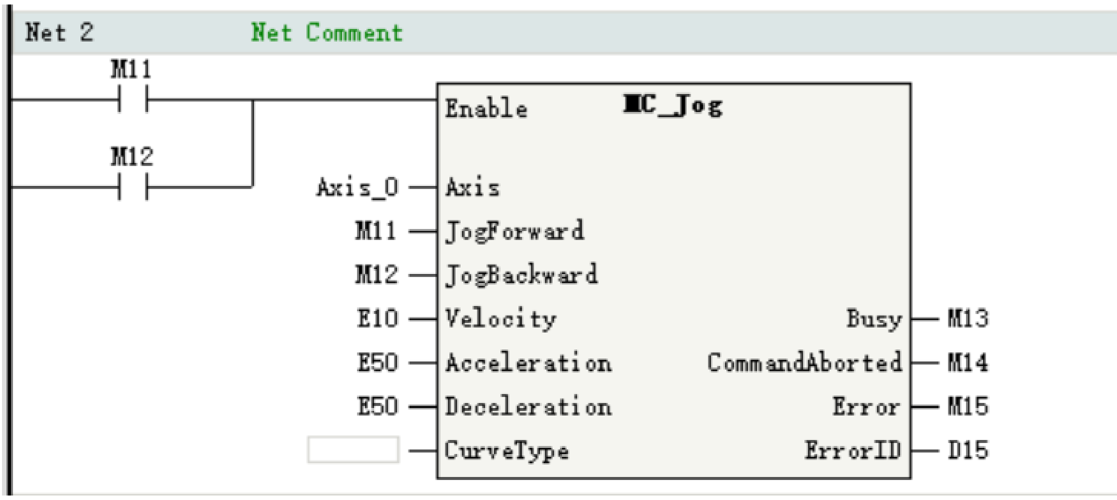
Set Axis_0 of the two bus servo axes as the master axis and Axis_1 as the slave axis.

Bind IS620N of the two servo drives to Axis_0 and IS620_1 to Axis_1.

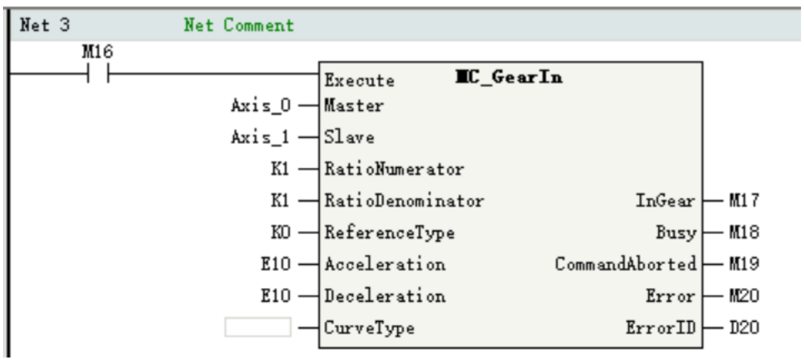
2. Call the MC_Power instruction to control the enabling of the master and slave axes.



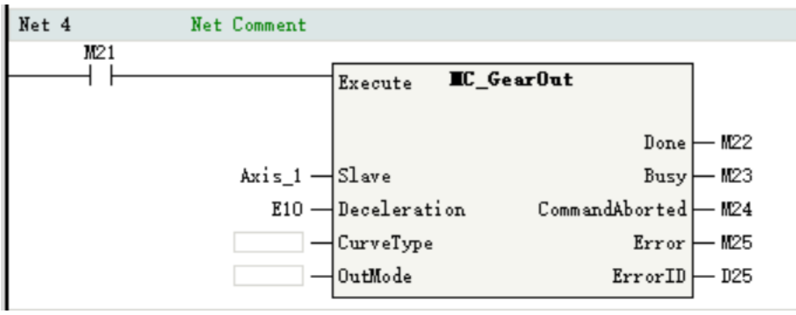

3. Call the MC_Jog instruction to control the forward and reverse motion of the master axis.




4. Call the MC_GearIn instruction to execute gear operation, with the gear ratio set to 1:1.



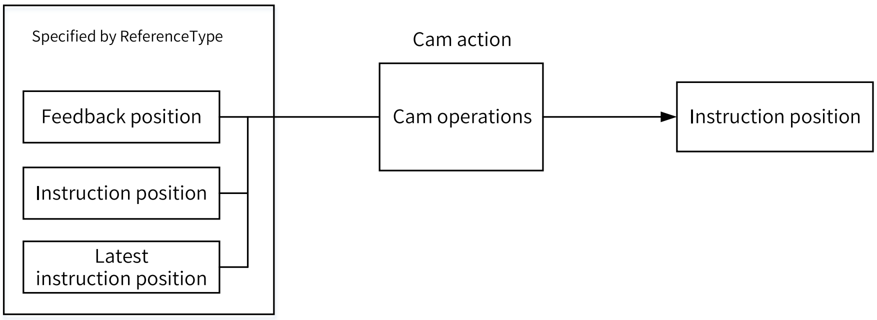
5. Call the MC_GearOut instruction to end gear operation.




## 16.5.2 Cam Operation

Cam operation refers to the motion of the slave axis in sync with the position of the master axis according to a cam table.

### Basic block diagram



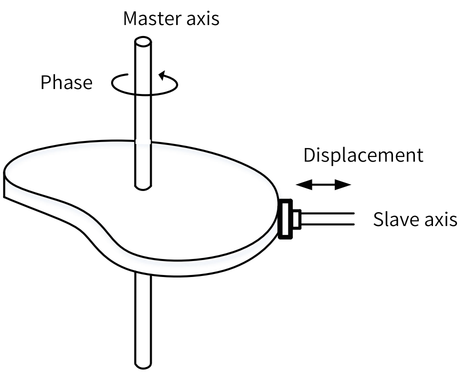

### Function description

Cam operation is applicable to the following types of master and slave axes.

- Master axis: bus servo axis, local pulse axis, local encoder axis, and remote encoder axis
- Slave axis: motion control axis

Use the MC_CamIn (starting cam operation) instruction to start cam operation or change cam tables. Use the MC_CamOut (ending cam operation) instruction or the MC_Stop (forced stop) instruction to end cam operation.

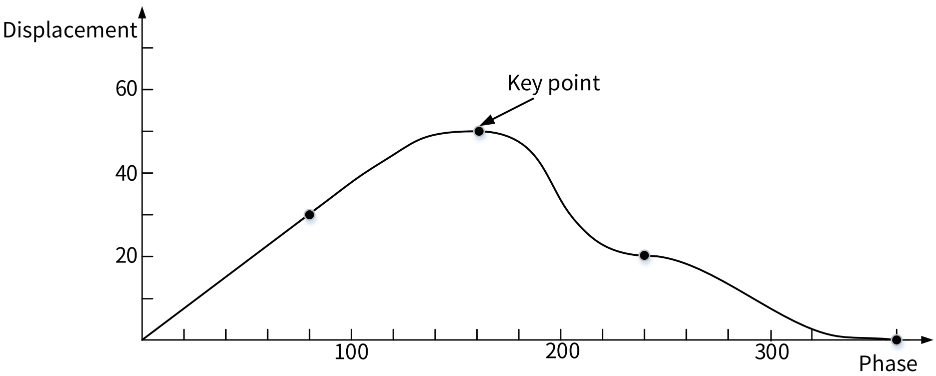
In a typical cam structure shown in the following figure, the master axis rotates periodically and the slave axis moves back and forth along a direction under the control of the master axis.



The electronic cam simulates such a structure, selecting one axis (bus servo axis, local pulse axis, local encoder axis, or remote encoder axis) as the master axis and another axis (bus servo axis or local pulse axis) as the slave axis. The master axis and the slave axis move in a synchronized way according to a set cam curve.

## Cam curves

A cam curve is a 2D coordinate system, where the horizontal axis represents the phase of the master axis and the vertical axis represents the displacement of the slave axis. Set some key points in the coordinate system, and connect every two key points with a set curve (such as a straight line or a quintic curve) to form a cam curve.




Cam table

| | Phase | Displacement |
|---|---|---|
| Start point | 0 | 0 |
| | 80 | 30 |
| | 160 | 50 |
| | 240 | 20 |
| End point | 360 | 0 |

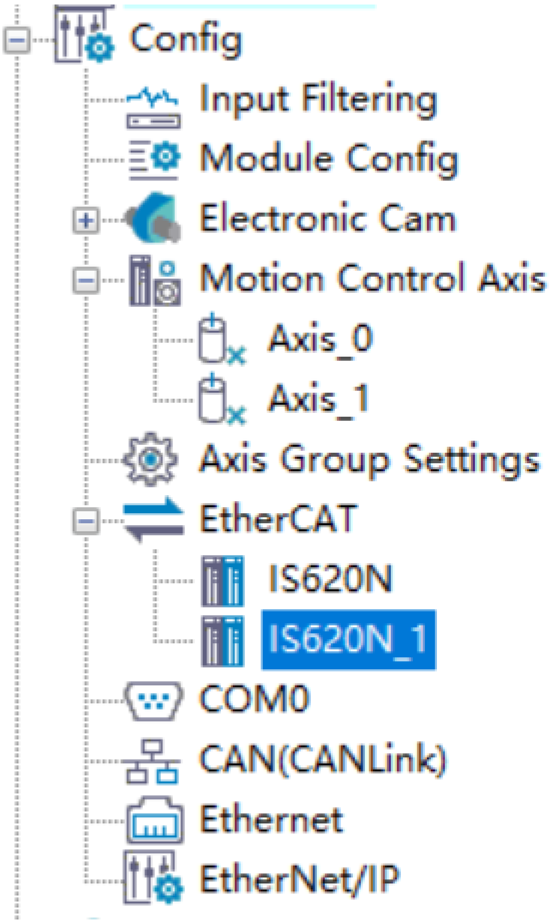
For detailed functions, see the MC_CamIn and MC_CamOut instructions in the "Electronic Cam Instructions" section of the instructions guide.

## Example

Job: Create two servo axes. Set Axis_0 as the cam master axis, and Axis_1 as the cam slave axis that follows Axis_0 to execute cam operation.

Procedure:

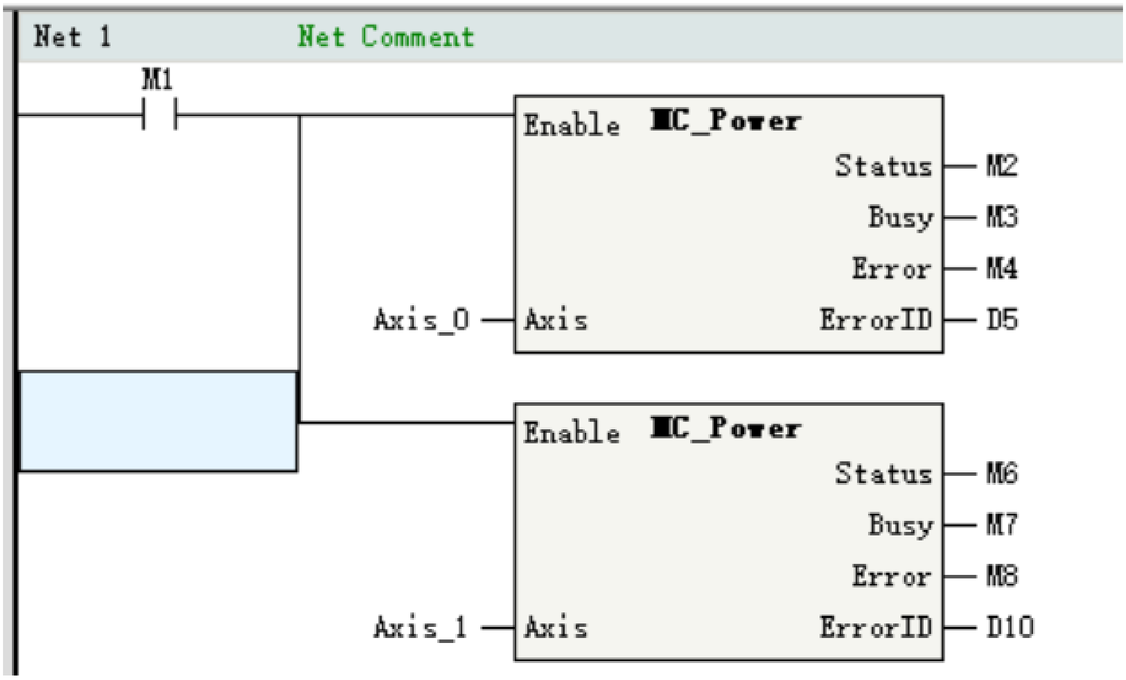
1. Create a project. Create two bus servo axes, one as a master axis and the other as a slave axis.



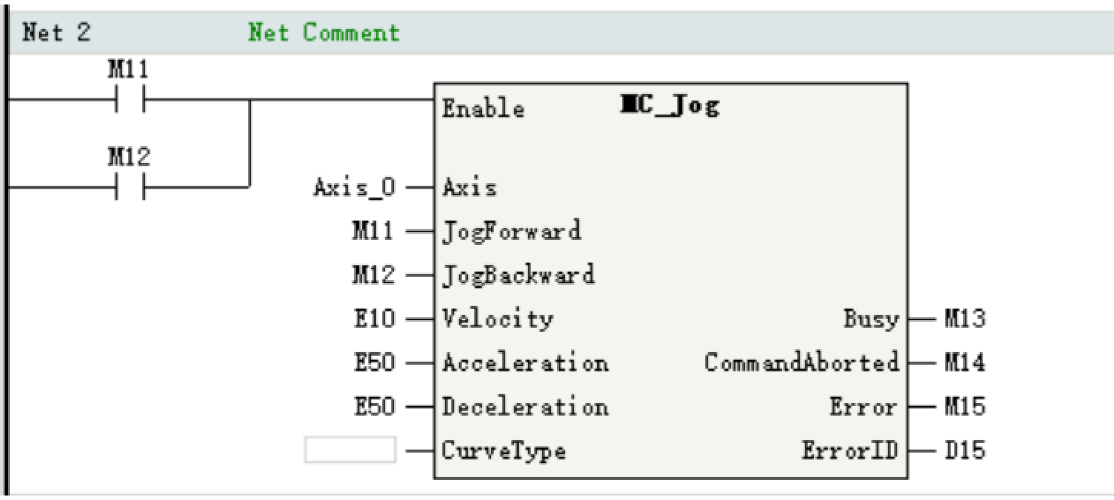

Set Axis_0 of the two bus servo axes as the master axis and Axis_1 as the slave axis.

Bind IS620N of the two servo drives to Axis_0 and IS620_1 to Axis_1.

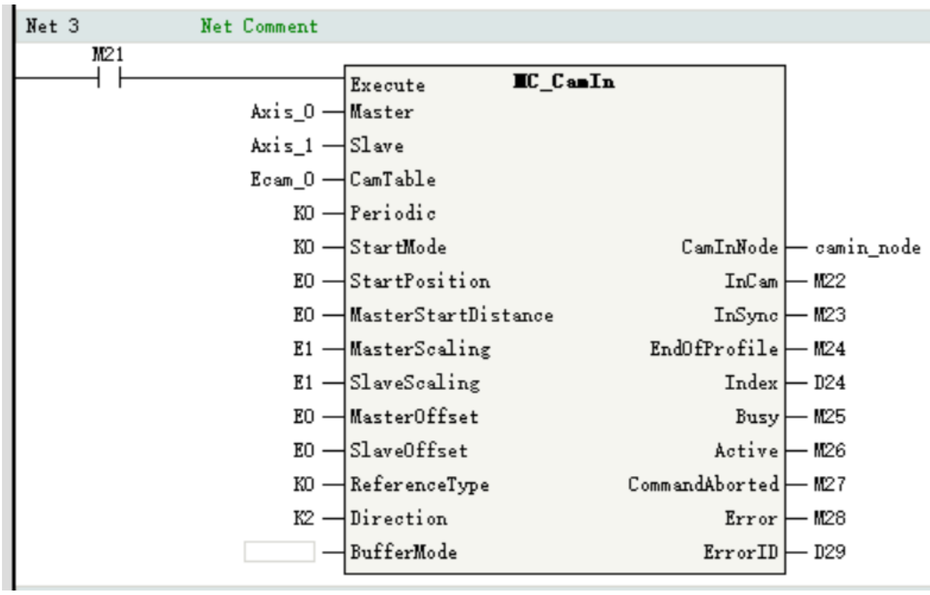
2. Create a cam table.
3. Call the MC_Power instruction to control the enabling of the master and slave axes.



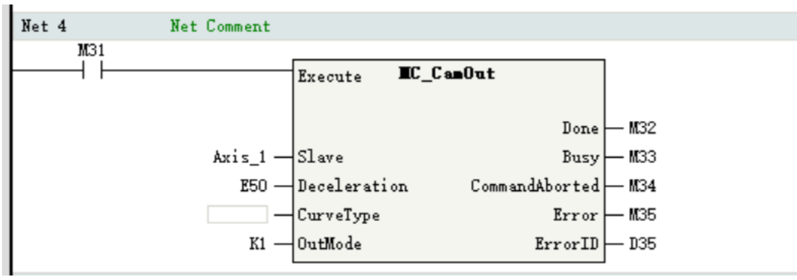
4. Call the MC_Jog instruction to control the forward and reverse motion of the master axis.




5. Call the MC_CamIn instruction to execute cam operation.




6. Call the MC_CamOut instruction to end cam operation.




## 16.5.3 Cam Tables

### 16.5.3.1 Introduction to Cam Tables

In the cam function module, a pair of data comprised of the master axis phase and the slave axis displacement is defined as cam data, and combination of cam data is defined as a cam table.

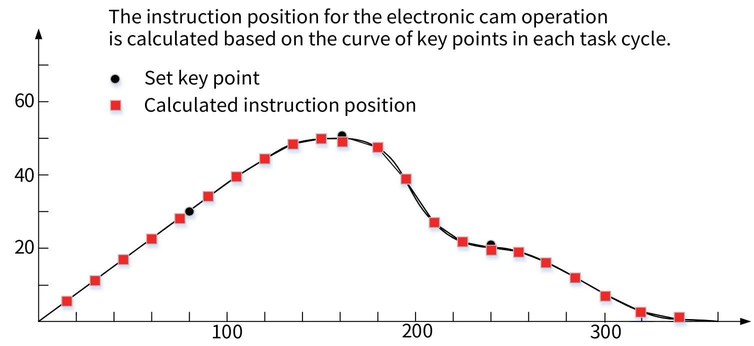
Phase and displacement values of cam data in a cam table are relative quantities expressed in relation to the start point "0.0".

In cam operation, the slave axis displacement is calculated based on the master axis phase and the set curve type, to control the operation of the slave axis.

After a cam table is created with the cam editor in AutoShop, cam data in the cam table can be modified in the user program.

Cam table

| | Phase | Displacement |
|---|---|---|
| Start point | 0 | 0 |
| | 80 | 30 |
| | 160 | 50 |
| | 240 | 20 |
| End point | 360 | 0 |




## 16.5.3.2 Cam Table Specifications

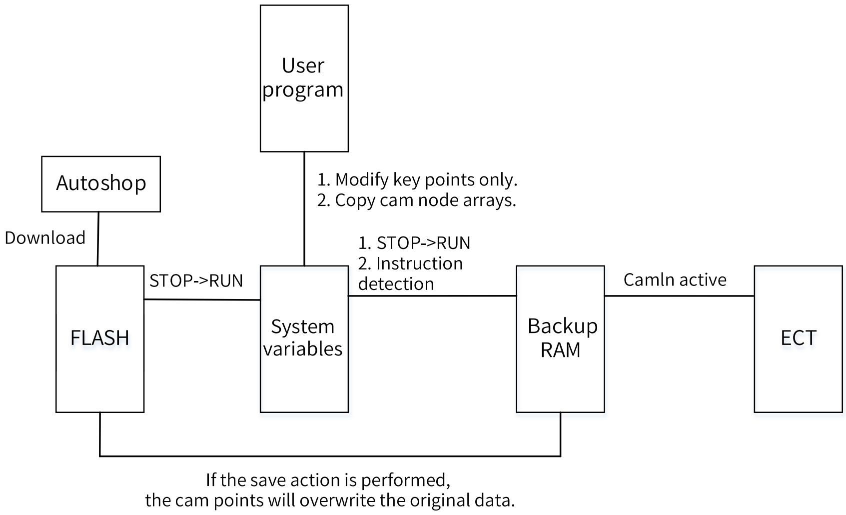
Observe the following specifications when creating cam tables.

Table 16–7 Cam table specifications

| Item | Description |
|---|---|
| Total number of cam key points supported by each cam table | 361 |
| Total number of cam tables supported | 16 |
| Number of cam tables that can be executed simultaneously in the PLC | 8 |
| Rules for switching cam tables during cam operation | Switch cam tables using the MC_CamIn instruction, and the newly selected cam table takes effect in the next cam cycle. |
| Reading and writing cam data | View the status and key point data of each cam table by using the global variable named after the cam table.<br>You can modify key point data in a cam table directly and make the modification take effect by using the MC_GenerateCamTable instruction. The cam will act according to the modified cam table in the next cam cycle. |
| Saving cam tables | Modified cam tables can be saved to the non-volatile memory of the PLC using the MC_SaveCamTable instruction. |

## 16.5.3.3 Cam Table Data Flow

The data execution flow of cam tables is shown in the following figure.

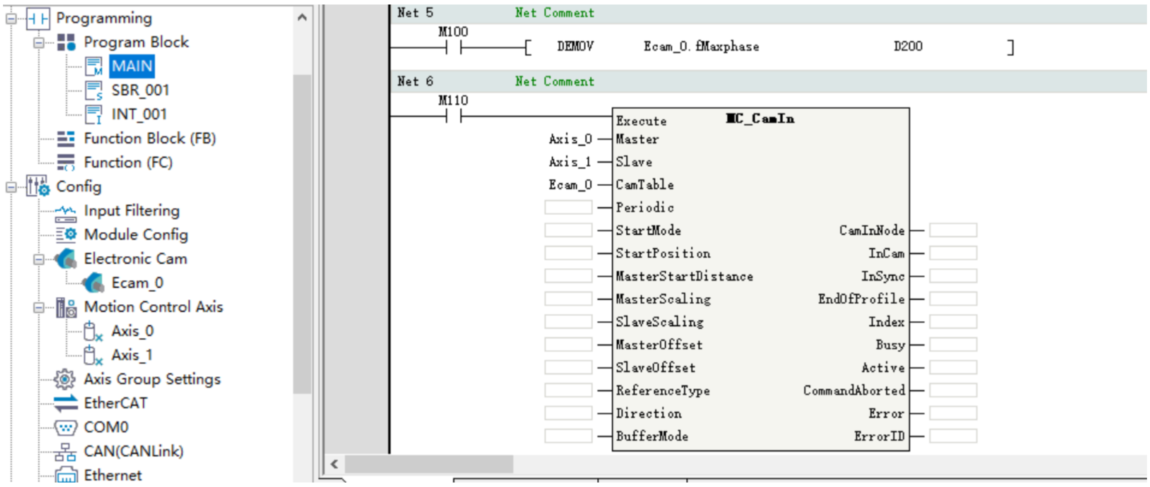



## Data flow description

1. In the background, download a cam curve to the non-volatile memory.
2. In the background, upload a cam table file from the non-volatile memory.
3. When the cam table in the non-volatile memory switches from STOP to RUN after download, the cam table is loaded to the cam table system variable and initialized to the backup area.
4. The cam table in the user area is updated to the EtherCAT memory when the execution of MC_CamIn starts or after one cam motion cycle is completed. Then, EtherCAT works according to the updated cam nodes.
5. With the user program, you can modify a cam key point in the system variable or copy a new cam node array to an existing cam table, and then copy the modified cam table to the backup RAM by using the MC_GenerateCamTable instruction.
6. After modifying or creating cam key points in the user program, call the MC_GenerateCamTable instruction to check the rationality of the cam table.
7. Call the MC_SaveCamTable instruction to write the cam table in the backup area into the non-volatile memory.

### 16.5.3.4 Creating Cam Tables

Cam table variables can only be created in the background. Every time a cam table is added, a cam table variable is created by default. The name of the cam table variable is the name of the cam table in the configuration. You can obtain the status of the cam table by using the variable and use the status as an input parameter for cam instructions.




### 16.5.3.5 Switching Cam Tables

During cam execution, you can switch to a different cam table by triggering the MC_CamIn instruction. After triggering, the cam table becomes buffered, and the buffered cam table takes effect in the next cam cycle.
Only one cam table can be buffered. If multiple MC_CamIn instructions are triggered in succession, the cam table triggered earlier will be overwritten by the cam table triggered later.

Here is an example of triggering two instructions.

- Trigger M110 first. After the instruction detects that the cam parameter is set correctly, M111 (Busy) output becomes active, Axis_1 starts to move according to the cam curve set by the Ecam_0 cam table, and M112 (Active) output becomes active. If M120 is triggered before one cam cycle is completed, the Ecam_1 cam table becomes buffered and M121 (Busy) output becomes active.
- After Axis_1 completes the first cam cycle, the first cam instruction is aborted and M113 (CommandAborted) output becomes active. In this case, Axis_1 starts to move according to the cam curve set by the Ecam_1 cam table and M122 (Active) output becomes active.

### 16.5.3.6 Modifying Cam Table Data

Cam data can be modified through the following three methods.

1. Modify values in the cam node array of the cam table through the PLC program, and then execute the MC_GenerateCamTable instruction. The modification takes effect in the next cam cycle.

Cam node array A

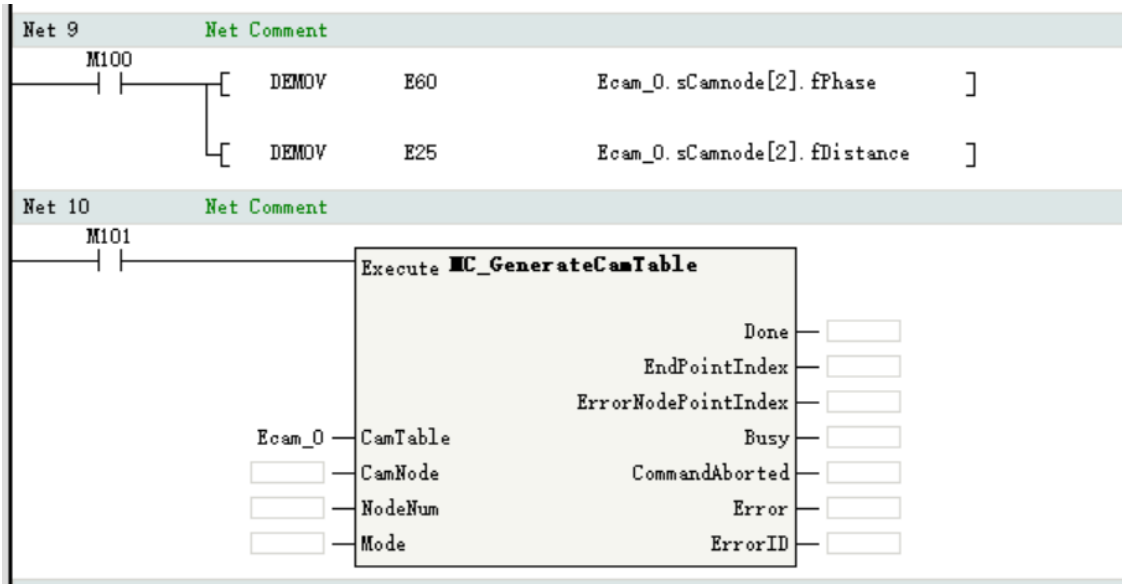
| | Phase | Displacement |
|---|---|---|
| Start point | 0 | 0 |
| | 40 | 30 |
| | 80 | 50 |
| | 120 | 20 |
| End point | 160 | 0 |
| | 0 | 0 |
| | 0 | 0 |

Modify key points only.

Cam node array A

| | Phase | Displacement |
|---|---|---|
| Start point | 0 | 0 |
| | 40 | 30 |
| | 60 | 25 |
| | 120 | 20 |
| End point | 160 | 0 |
| | 0 | 0 |
| | 0 | 0 |

Here is a program example:




2. Modify the number of key points in the cam table, and then execute the MC_GenerateCamTable instruction. The modification takes effect in the next cam cycle.

Cam node array A

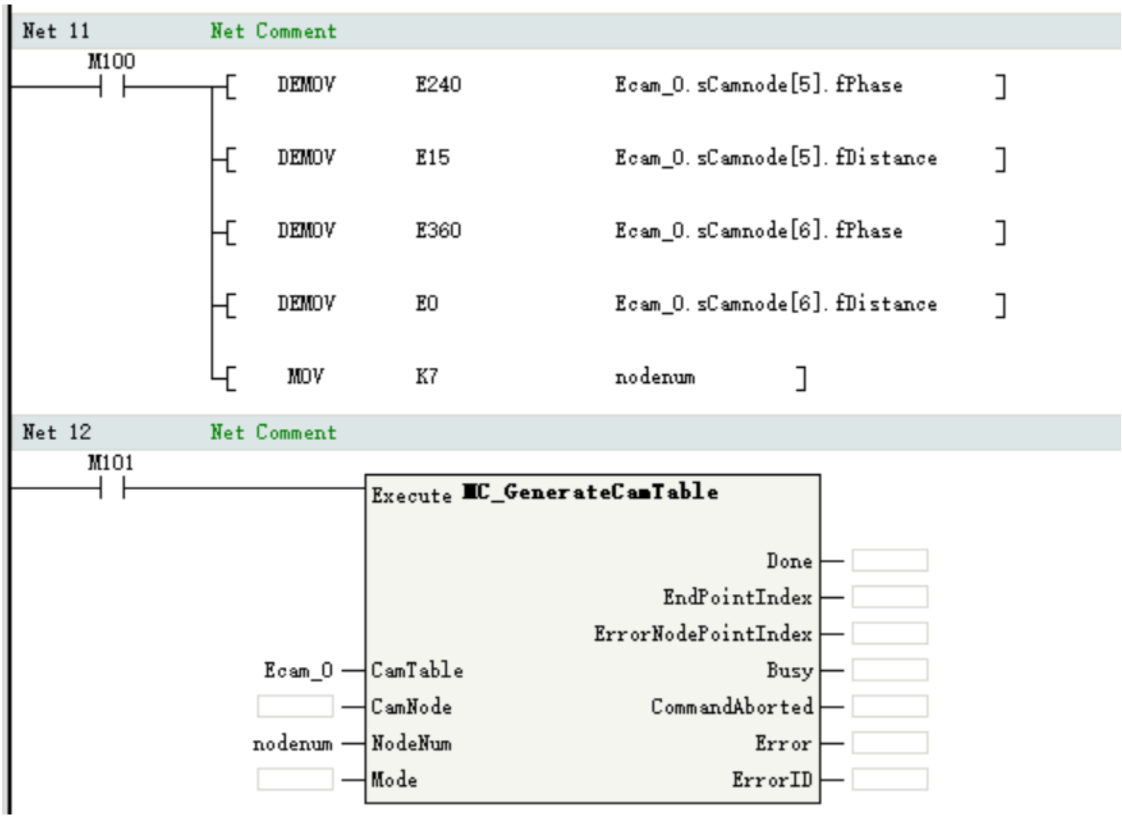
| | Phase | Displacement |
|---|---|---|
| Start point | 0 | 0 |
| | 40 | 30 |
| | 80 | 50 |
| | 120 | 20 |
| End point | 160 | 0 |
| | 0 | 0 |
| | 0 | 0 |

Add key points.

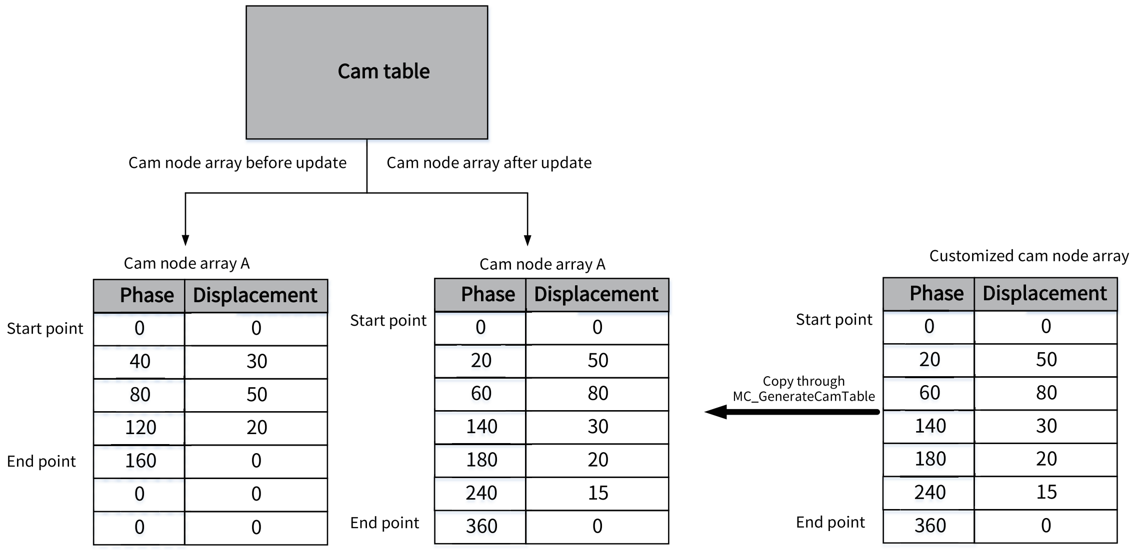
Cam node array A

| | Phase | Displacement |
|---|---|---|
| Start point | 0 | 0 |
| | 40 | 30 |
| | 80 | 50 |
| | 120 | 20 |
| | 160 | 0 |
| | 240 | 15 |
| End point | 360 | 0 |

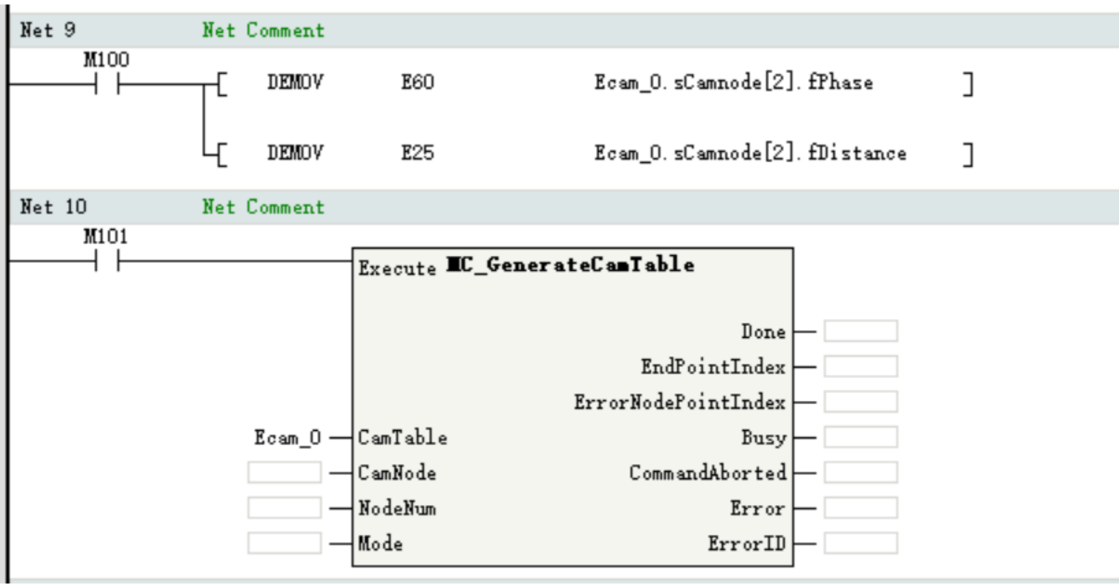
Here is a program example:




3. Create a completely new cam node array through the PLC program, and then copy the values in the cam node array to the cam table by using the MC_GenerateCamTable instruction. The modified cam table takes effect in the next cam cycle.

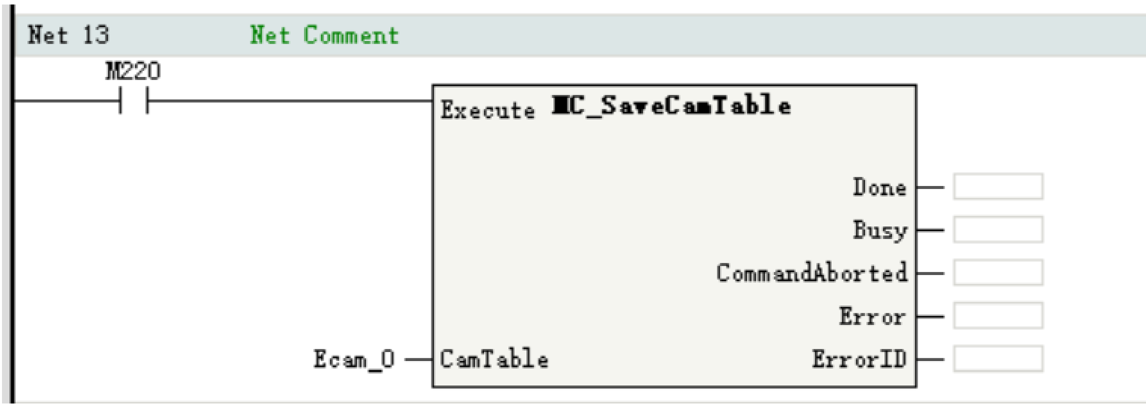



Here is a program example:




### 16.5.3.7 Saving Cam Tables

Modified cam tables can be written to the non-volatile storage space by using the MC_SaveCamTable instruction.

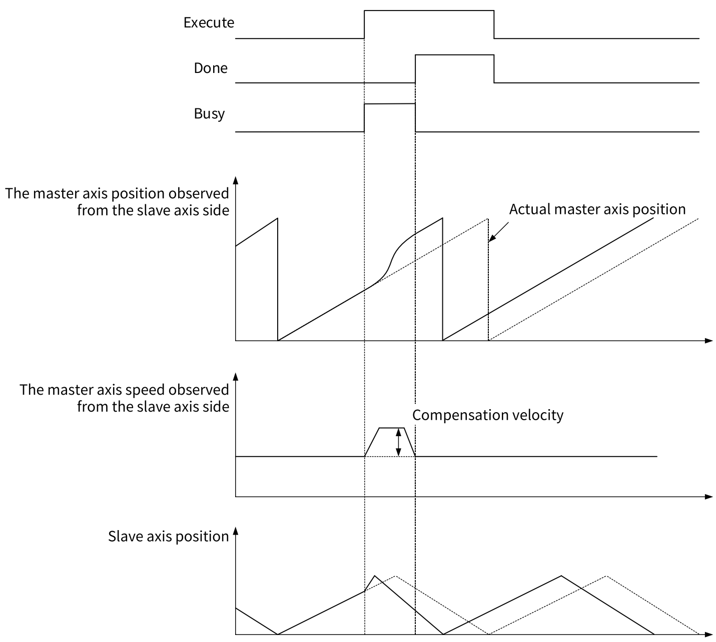



## 16.5.4 Master Axis Phase Compensation

This function allows the master axis phase to be shifted (observed from the slave axis) for instructions in operation.

Starting the MC_Phasing (master axis phase shift) instruction can compensate the phase for the synchronized control instruction.

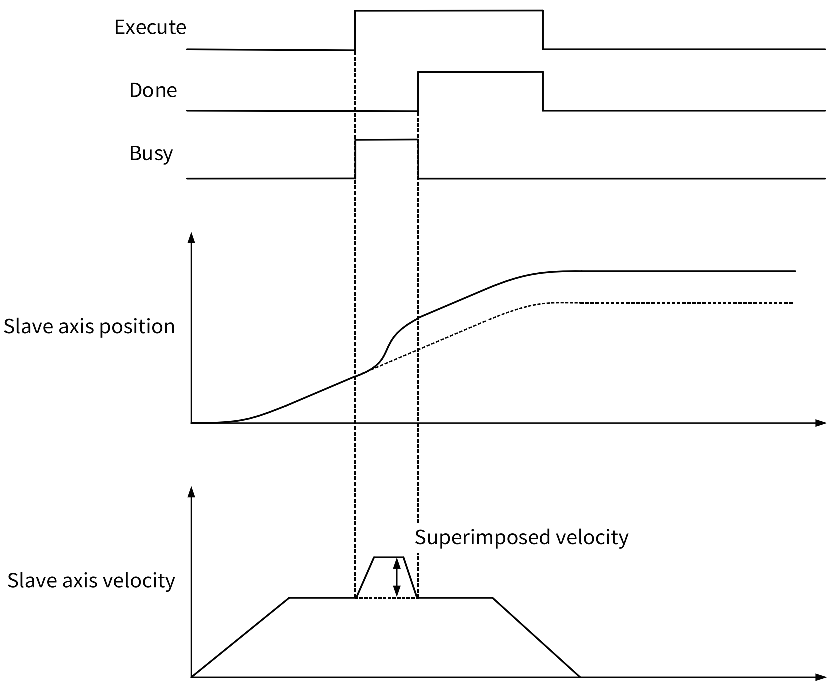
The MC_Phasing (master axis phase shift) instruction can specify parameters such as phase compensation, target speed, acceleration rate, and deceleration rate.




## 16.5.5 Motion Superimposition

Call the MC_MoveSuperImposed instruction to implement motion superimposition on the motion control axis.

The MC_MoveSuperImposed (motion superimposition) instruction can specify parameters such as position compensation, target speed, acceleration rate, and deceleration rate.



## 16.5.6 Methods of Handling Single-Axis Configuration Parameters in Cam or Gear

Methods of handling single-axis configuration parameters in cam or gear are shown in the following table.

Table 16–8 Methods of handling single-axis configuration parameters

| Para. | Method of Handling |
|---|---|
| Gear ratio setting | The master and slave axes of the cam and gear support gear ratio modification. Set gear ratios in the "Unit conversion setting" interfaces of the cam and gear, respectively. |
| Encoder mode selection | The master and slave axes of the cam and gear support drive encoder mode setting. The encoder can be set to incremental or absolute mode. Set this parameter in the "Mode/ Parameter setting" interfaces of the cam and gear, respectively. |
| Circular/linear mode setting | The master and slave axes of the cam and gear support linear and circular modes. Set this parameter in the "Mode/Parameter setting" interfaces of the cam and gear, respectively. |
| Limit handling | In linear mode, the slave axes of the cam and gear support software limit but do not support limit-based deceleration. The slave axes stop immediately after encountering the limit.<br>In both linear and circular modes, the slave axes of the cam and gear support hard limit, and stop immediately after encountering the limit. |
| Deceleration rate at axis fault | When an abnormal instruction parameter causes a fault on a slave axis, the slave axis decelerates according to the deceleration rate specified by the axis fault deceleration parameter and then enters the ErrorStop state. |
| Following error | The slave axes of the cam and gear support following error during operation. |
| Speed limit | Instructions related to the cam and gear are not restricted by the maximum speed parameter in the configuration. |
| Acceleration rate limit | The deceleration rate of the MC_CamOut instruction is restricted by the maximum acceleration parameter in the slave axis configuration. The instruction reports an error and the axis enters the ErrorStop state when the deceleration rate exceeds the limit.<br>The acceleration rate and deceleration rate of the MC_GearIn instruction are restricted by the maximum acceleration parameter in the slave axis configuration. The instruction reports an error and the axis enters the ErrorStop state when the acceleration rate or deceleration rate exceeds the limit.<br>The deceleration rate of the MC_GearOut instruction is restricted by the maximum deceleration parameter in the slave axis configuration. The instruction reports an error and the axis enters the ErrorStop state when the deceleration rate exceeds the limit. |
| Torque limit | The torque limit value is written into the servo drive as a startup parameter and is controlled by the servo drive. |

# 17 Offline Commissioning

## 17.1 Overview

Caution

Offline commissioning is available in AutoShop V4.2.0.0 and later versions.

Offline commissioning allows users to commission the logic, motion control, and communication functions of the program.

Offline commissioning covers the motion control axis, module configuration, communication, and online modification functions. It comes with a status display interface that facilitates real-time monitoring of the status of the PLC and module I/O channels. In addition, offline commissioning can be used with the online simulation function of the IT7000 series HMI to achieve simulation commissioning, making commissioning more convenient.

The following table lists the functions supported or not supported in the offline commissioning mode.

| Supported or Not | Function | Description |
|---|---|---|
| Supported | Program | Supports main program, subprogram, and FB/FC. |
| | | Supports the "timed interrupt" subprogram. |
| | | Supports online modification. |
| | Motion control | Supports local pulse axis and EtherCAT bus servo axis. |
| | | Supports local encoder axis; uses simulation of internal clock signal. |
| | Communication | Supports serial communication configuration; uses the COM9 port of computers; supports Modbus master/slave protocol; supports free serial protocol. |
| | | Supports Ethernet Modbus-TCP protocol; supports Ethernet TCP/UDP communication. |
| | | Supports online simulation with HMI. Communication is established through specified ports. A communication variable table is generated in the background and imported to the HMI. Monitoring objects include all components and customized variables. |
| | Directive | Supports all instructions, except the HOUR, DHOUR/TWR, TRD instructions. |
| | Extension | Supports extension module I/O, local DIDO, and function virtualization. |
| | Other functions | Supports RTC clock; uses the clock built in Windows; does not support PLC time setting. |
| | | Keeps consistent with PLC. |
| Not supported | Basic | Does not support time setting. |
| | | Does not support "Set/Modify Login PLC Password" or "Delete Login PLC Password". |
| | | Cannot enter or exit offline commissioning during compile, download, or firmware upgrade process. |
| | Program | Does not support hard interruption, edge interruption, or comparison interruption. |
| | Motion control | Does not support bus encoder axis. |
| | Communication | Does not support CANlink or CANopen. |
| | | Does not support EtherCAT communication or instructions. |

***Note***

- Offline commissioning of the operating system may result in some difference between the timer and the actual PLC, involving the timed-interrupt subprogram and internal clock signal.
- In offline commissioning, the CPU and memory usage displayed is the CPU and memory usage of the PC.
- Functions that are not supported cannot be used normally, but they do not affect offline commissioning and therefore need no special treatment.

## 17.2 Starting Offline Commissioning

**Prerequisite:** The project to be commissioned offline is created or opened.

1. In the toolbar, click  to start the offline debugger. Run the PLC program that has been created or opened.
   The interface is comprised of the following parts.

| No. | Description |
| --- | --- |
| ① | PLC status |
| ② | Status of I/O channels of the PLC. Green indicates active I/O, whereas gray indicates inactive I/O. |
| ③ | Status of extension modules. Status of digital extension modules are consistent with the PLC, whereas the section of analog extension modules shows the values in the current mapped registers. |

## *Note*

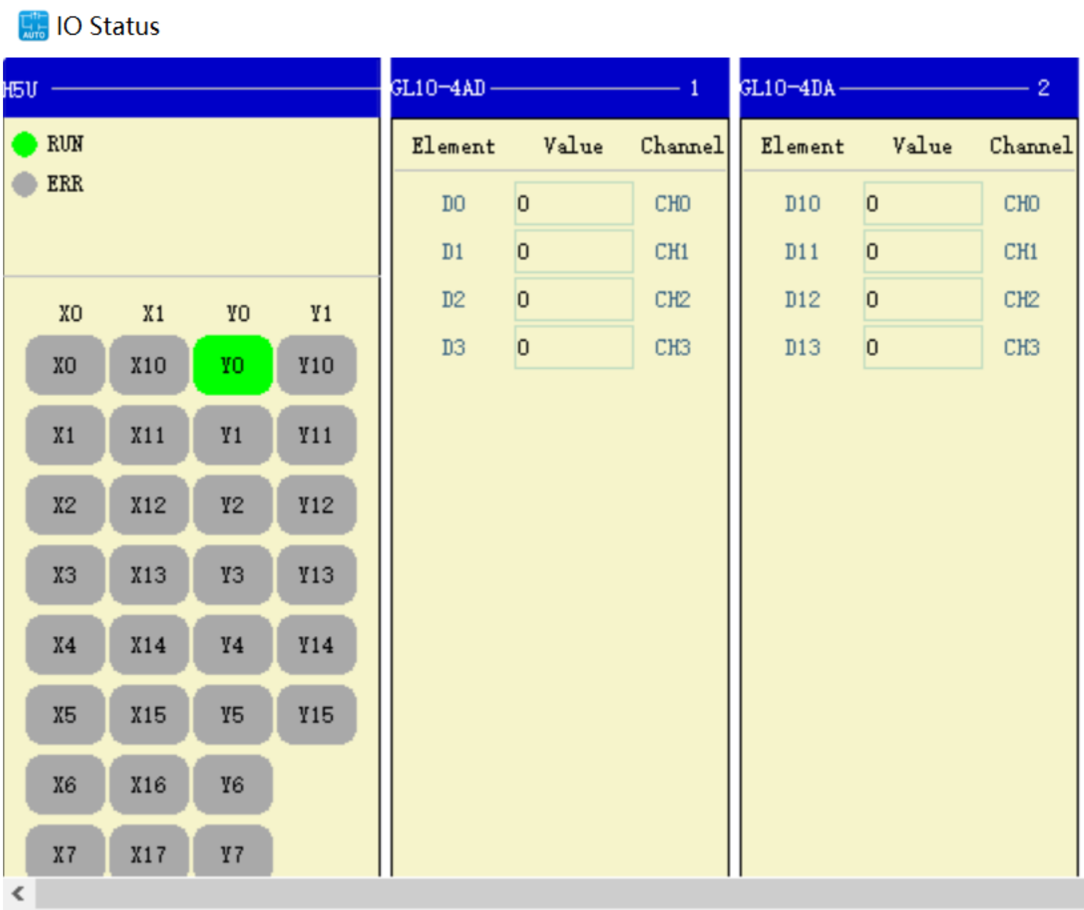
After starting offline commissioning, you can perform the following operations:

- Monitor the status of the program online, including the inputs and outputs of the PLC.
- Modify or download the PLC program.
- Modify the program online.

2. Commission digital and analog terminals.

- Commission digital terminals: For any I/O point that is not controlled by the program, directly click the I/O point to switch its ON/OFF state.
  I/O points controlled by the program run according to the logic of the program.


- Commission analog terminals: Click a value input field to enter an analog value.
  After the value is input, the parameter is written to the corresponding mapping element. Similar to digital terminals, mapping elements controlled by the program run according to the logic of the program.




***Note***

Actual sensors cannot be connected during offline commissioning. Therefore, analog input values must be typed manually for offline commissioning of analog terminals.

## 17.3 Motion Control Axes in Offline Commissioning

### Local pulse axis and bus servo axis

- In offline commissioning, local pulse axis and bus servo axis can be used without special modifications in the program.
- All functions, including probes and hardware limits, related to external input cannot be used in offline commissioning.
- Using the homing instruction does not need special settings. When the homing instruction is used, homing mode No. 35 is activated (that is, the current position is taken as the home).

### Local encoder axis and bus encoder axis

- To use local encoder axis in offline commissioning, select the single-phase counting mode and select internal clock signal (1 ms or 1 μs) as the signal source. If other modes are used, the local encoder axis cannot start counting.
- In offline commissioning, only HC_Counter and HC_Preset instructions are supported for local encoder axis.

- Bus encoder axis is not supported in offline commissioning.

# 17.4 Simulation Commissioning with InoTouchPad

## 17.4.1 Overview

The H5U or Easy series PLC can work with the IT7000 series HMI to achieve simulation commissioning without physical objects through the commissioning function of AutoShop and InoTouchPad software.

The PLC and HMI communicate with each other through TCP monitoring protocol, supporting customized variables and read and write operations on soft elements.

## 17.4.2 PLC Configuration

The PLC and HMI employ internal communication for simulation commissioning. Therefore, there is no need to configure the PLC's IP address. Users only need to export the PLC's variables to the HMI monitoring variable table to complete the PLC configuration.

1. After compiling the user program, open the variable table, right-click any area of the variable table, and select "Export HMI Monitoring Variable Table (H)" in the shortcut menu.
2. Select the path to save the file to be exported, enter the file name, and click "Save" to complete the export.

## 17.4.3 HMI Configuration

To use simulation commissioning, add a PLC connection on the HMI and import the variable table. For H5U, specific operation steps are as follows.

1. Create an HMI connection.

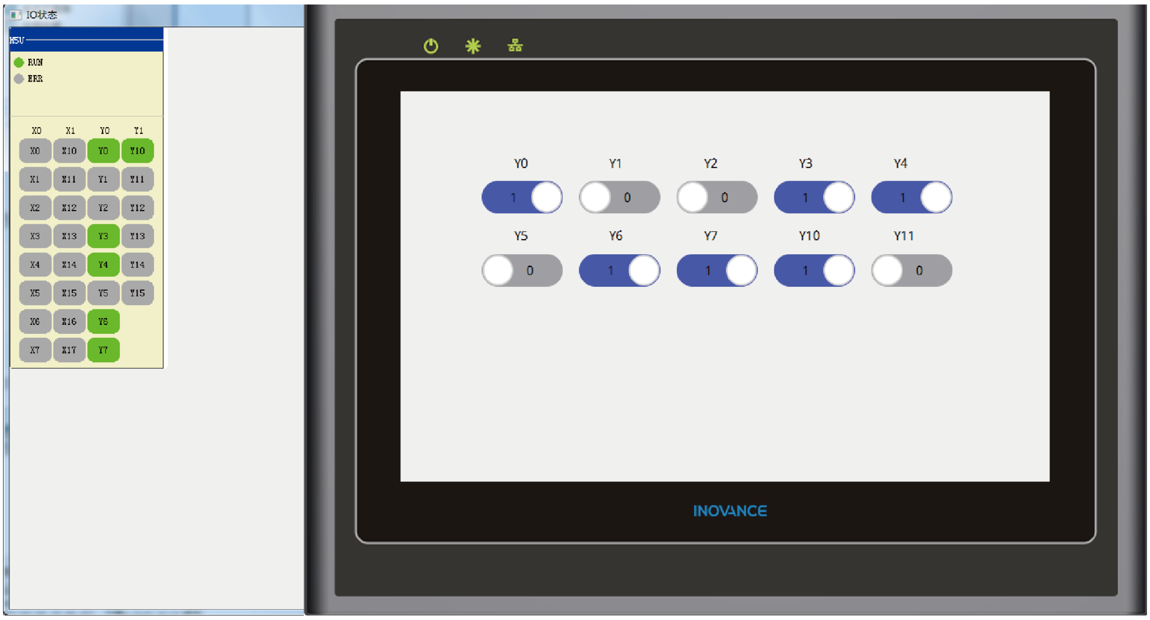
   a. Double-click "Connection" to open the connection tab.
   b. Click + to add a connection.
   c. In the "Communication protocol" column, select "H5U TCP monitoring protocol".
   d. In the "IP Address" field, enter "127.0.0.1".

2. Import the HMI monitoring variable table.

   a. Double-click "Add variable group" to add a variable group.
   b. Right-click the newly created variable group and select "Import".
   c. In the opened dialog box, select the HMI monitoring variable table exported from the PLC and click "Open".
   d. In the "Select device" field, select the HMI connection created in step 1.
   After the import is completed, variables are automatically generated in the variable group.

## 17.4.4 Starting Commissioning

After editing the program and importing the variable table for HMI and PLC, you can start the offline commissioning function of AutoShop and the online simulation function of InoTouchPad for commissioning.



# 18 Memory Management

## 18.1 Overview

Memory management includes customized variable and soft element variable memory management. Variable memory data at a specific moment can be obtained and used as the basis for commissioning and analysis. Variable memory data at a specific moment can also be saved as recipe data for commissioning parameters of different processes or recipe parameters of multiple steps of one process. Specifically, variable memory data can be used in the following scenarios:

- When the program encounters an exception, obtain the current variable memory data for problem analysis.
- Obtain multiple sets of variable memory data parameters at a specific moment and save them as recipe parameter files for use by other machines.
- Monitor the values of all the data in the current variable table in real time.
- Synchronize the current variable memory data parameters to the initial values.
- Save data of different recipe parameters when commissioning different processes of one program.
- Save different sets of recipe parameters when commissioning different steps of one process.

## 18.2 Memory Management of Customized Variable Tables

### 18.2.1 Expanding and Collapsing Complex Type Variables

Complex type variables contained in the customized variable table are arrays and structures. The system supports expanding and collapsing sub-members of arrays and structures. For sub-members, only the initial value, comment, and data columns are editable, while values in other columns are not editable.

| Variable... | Data Type | Initial Value | Power Down Hold | Comment | Element Addr. | Length | CurValue | Value1 |
|---|---|---|---|---|---|---|---|---|
| Axis1 | BOOL | OFF | Non Retained | | | nBitLen:1 | | |
| Axis_30 | REAL[5] | ... | Non Retained | | | nBitLen:0 | | |
| Axis_30[0] | REAL | 0.000000 | | | | | | |
| Axis_30[1] | REAL | 0.000000 | | | | | | |
| Axis_30[2] | REAL | 0.000000 | | | | | | |
| Axis_30[3] | REAL | 0.000000 | | | | | | |
| Axis_30[4] | REAL | 0.000000 | | | | | | |
| Reset_Flag | BOOL | OFF | Non Retained | | | nBitLen:1 | | |
| | | | | | | | | |

### 18.2.2 Monitoring Variables

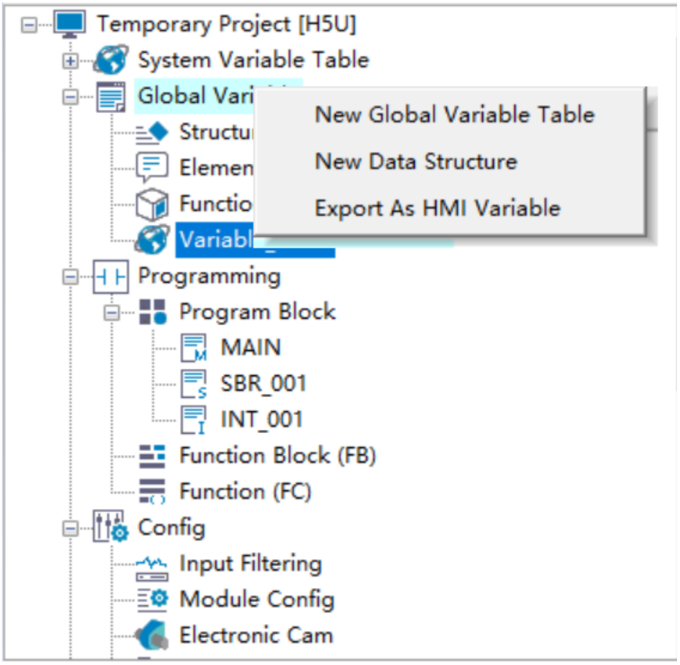
The variable table supports monitoring. Click the "Download and monitoring" button in the user project, and the system will monitor all variables displayed on the current variable table page without the need to add variables to the monitoring table separately.

| Variable... | Data Type | Initial Value | Power Down Hold | Comment | Element Addr. | Length | CurValue | Val |
|---|---|---|---|---|---|---|---|---|
| Axis1 | BOOL | OFF | Non Retained | | | nBitLen:1 | OFF | OFF |
| Axis_30 | REAL[5] | ... | Non Retained | | | nBitLen:160 | | |
| Axis_30[0] | REAL | 0. 000000 | | | | | 0. 000000 | 0. 000 |
| Axis_30[1] | REAL | 0. 000000 | | | | | 0. 000000 | 0. 000 |
| Axis_30[2] | REAL | 0. 000000 | | | | | 0. 000000 | 0. 000 |
| Axis_30[3] | REAL | 0. 000000 | | | | | 0. 000000 | 0. 000 |
| Axis_30[4] | REAL | 0. 000000 | | | | | 0. 000000 | 0. 000 |
| Reset_Flag | BOOL | OFF | Non Retained | | | nBitLen:1 | OFF | OFF |

## 18.2.3 Reading and Writing Memory Data

In the running state, for a single variable table, select the specified array or structure, right-click it, and select "Write Memory" to write non-null data to the PLC. In the monitoring state, right-click and select "Read Memory" to read the current variable memory data from the PLC to the selected data column of the variable table.

In the running state, you can upload or download newly-added variable values through one click. Specifically, right-click "Global Variable", and select "Upload project variable value" to batch read the current variable memory data from the PLC to the selected data columns of the variable table; or select "Download project variable value" to batch write non-null data in the variable table to the PLC.




### Note

- Select the "Auto stop for writing" option, and the PLC will automatically stop before memory data is written.
- If the "Auto stop for writing" option is not selected, memory data may not be written in the same scan cycle.

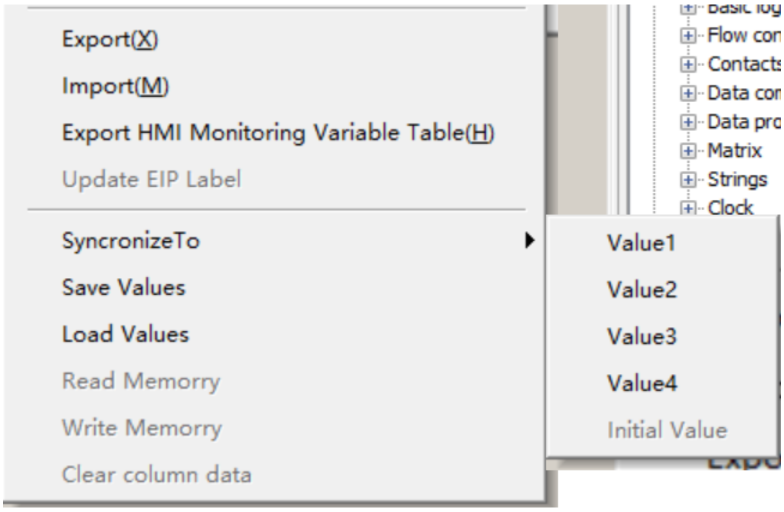
In the stop state, only retentive variables can be written.

## 18.2.4 Synchronizing and Clearing Data

Data values, current values, and initial values can be synchronized with each other.

### Synchronizing data

For example, to synchronize initial values to current values, select the target initial value item (or select multiple initial value items), right-click and select "Synchronize To" > "Value".




***Note***

Current values cannot be synchronized to initial values.

### Clearing data

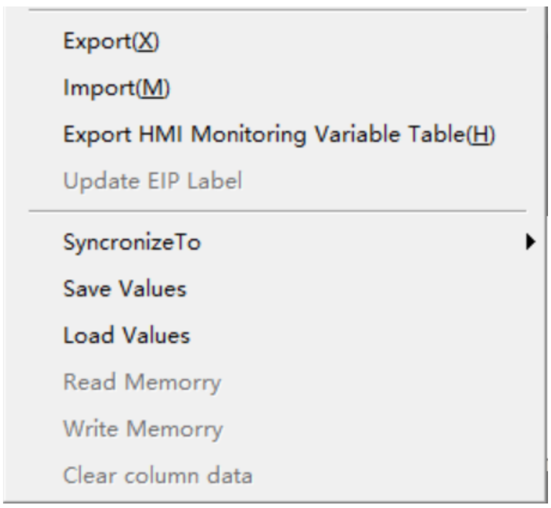
Select "Clear Column Data" to delete the currently selected data value. This operation can only be performed on data values.

For example, to clear the Data3 column, select "Data3", right-click it, and select "Clear Column Data".

## 18.2.5 Saving and Loading Data

You can select "Save Values" in the shortcut menu to save specified data values in a CSV file. Then, open the CSV file using EXCEL to edit the data values.

You can also select "Load Values" in the shortcut menu to import the edited CSV recipe file to the PLC.



### 18.2.6 Editing Initial Values and Comments of Variables

You can directly expand the variable table to edit initial values and comments of member data, or define them in the customized variable box in the program. These two methods are equivalent to each other.

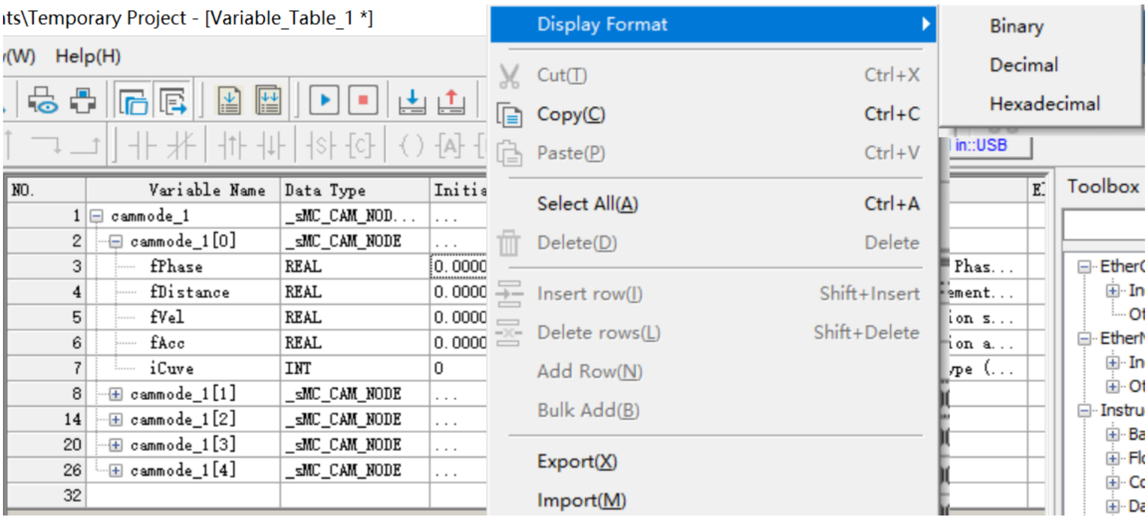
| Variable Name | Data Type | Initial Value | Power Down Hold | Network Pubilc | Comment |
|---|---|---|---|---|---|
| ⊟ cammode_1 | _sMC_CAM_... | ... | Non Retained | Private | |
| ⊟ cammode_1[0] | _sMC_CAM_NODE | ... | | | |
| fPhase | REAL | 0.000000 | | | Spindle Phas... |
| fDistance | REAL | 0.000000 | | | Displacement... |
| fVel | REAL | 0.000000 | | | Connection s... |
| fAcc | REAL | 0.000000 | | | Connection a... |
| iCuve | INT | 0 | | | Curve type (... |

**Note**

English characters and special characters such as commas (,), brackets ([]), and parentheses (()) in comments of variable member data are automatically filtered out.

### 18.2.7 Switching and Displaying Number Systems

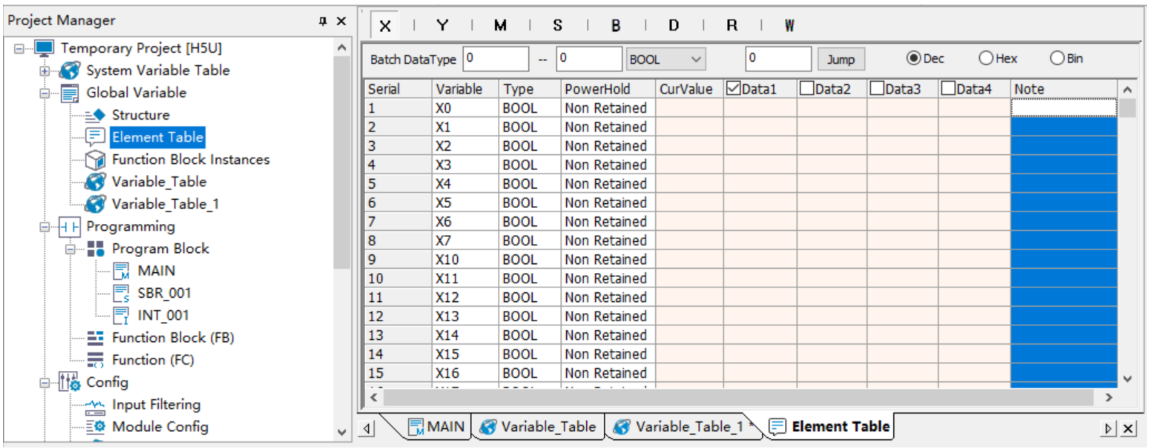
Customized variable tables allow switchover between decimal, binary, and hexadecimal displays.




## 18.3 Memory Management of Soft Elements

### 18.3.1 Operation Interface

The element table provides the comment and memory management functions, as shown in the following figure.



① Soft element switchover area. Switch to different soft elements to manage their memories and comments.

② This area is used to batch modify the data type of selected soft elements on the current page. To select soft elements, enter the start and end numbers of the elements in the two edit boxes.

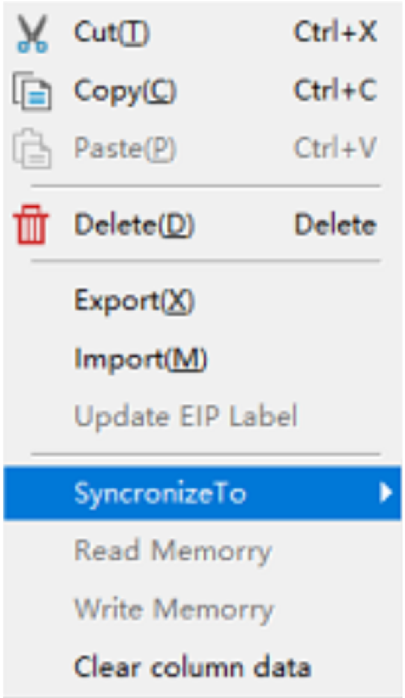
③ Click the drop-down box to select the data type to be changed to. For example, switch to the D elements, enter 50 and 100 to select the D50 to D100 elements, and then click the drop-down box to select REAL. The data type of D50, D52, D54...D100 is changed to REAL. (Note: REAL and DINT each are composed of 32 bits, occupying two soft elements.)

④ This area can redirect you to a specific element. For example, switch to the D elements, enter 1000 in this box, and then click "Jump" or press Enter. The page automatically redirects to the D1000 element. (Note: For the X and Y elements, only octal numbers of up to five digits can be entered in an input box. If the entered number exceeds the total number of elements, the page redirects to the end.)

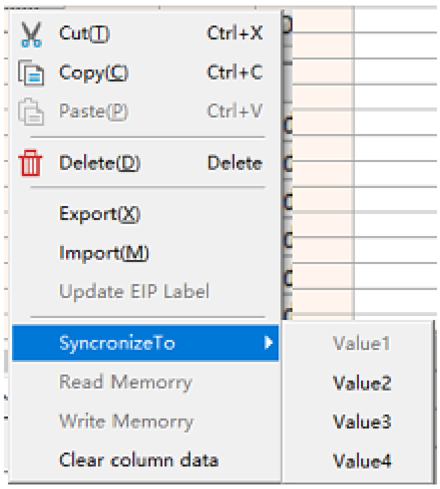
⑤ This area is used to change the display format of the data value and current value columns. For example, clicking the "Hex" option will switch all data to hexadecimal display.

## 18.3.2 Data Operation

The shortcut menu of soft elements provides multiple function options, as shown in the following figure.




- The Cut, Copy, Paste, and Delete options are available for the value columns and the comment column.
- The Edit option is available for only six columns, including the data type column, value columns, and comment column.
  The value columns can be edited in any mode, while other columns cannot be edited in the monitoring mode. All these columns can be edited in the online modification mode.
- Import and Export: Only rows with modified data can be exported. If there is any data error in a row during import, the system reports the error in the information output window and skips the row. When the number of error rows exceeds 100, the import stops.
- Synchronize To: synchronizes all data in a selected column to a value column selected using the menu. For example, right-click a cell in the "Value1" column and choose "Synchronize To" > "Value2" to overwrite the Value2 column with the data in the Value1 column.



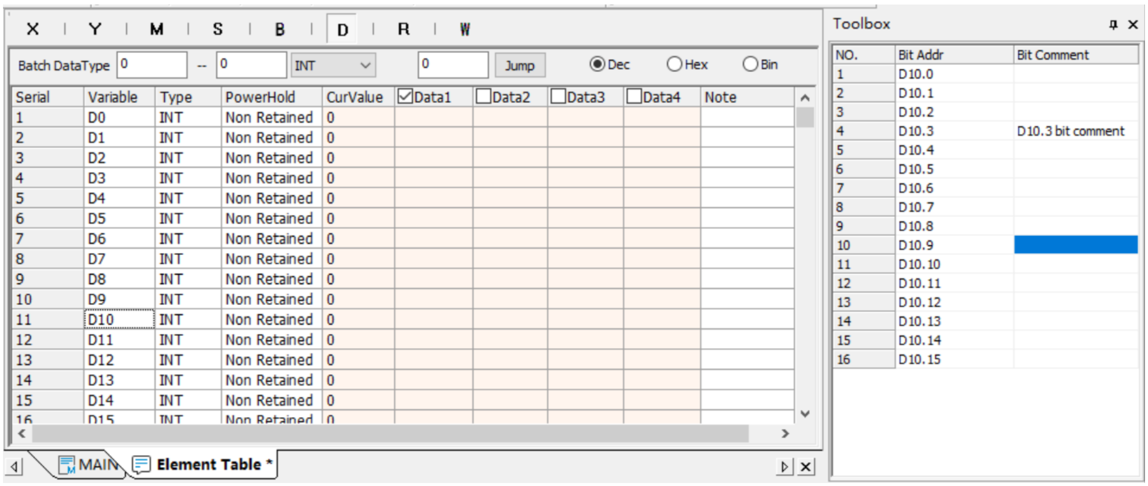

- Read Memory and Write Memory: Reading or writing soft element memories is allowed only in the online modification mode or monitoring mode. On the interface of a single element, tick the header of a value column, right-click and select "Read Memory" or "Write Memory" to read or write to the specific column you ticked. To read or write data values to the entire soft element table in batch, right-click "Global Variable", and select "Upload project variable value" to batch read the current variable memory data from the PLC to the selected data columns of the variable table; or select "Download project variable value" to batch write non-null data in the variable table to the PLC.

- Clear Column Data: clears all data in a column.

### 18.3.3 Bit Comments

Select word elements (D, R, or W) in the element table and then select a row. Bit comments of the row are displayed in the toolbox area. You can edit the bit comments in the toolbox area.

For example, select D10, edit the comment of D10.3, and save the modification. As a result, the bit comment is displayed in the ladder diagram.




### 18.3.4 Rules of Editing Data Types

1. For bit elements (X, Y, M, S, and B), the data type can only be set to BOOL, and the values are either ON or OFF.
2. For word elements, the data type can be set to INT, DINT, or REAL. An INT element is composed of 16 bits, whereas a DINT or REAL element is composed of 32 bits.
3. A 32-bit word element occupies two element rows. Therefore, when a word element is set as the REAL or DINT type, values in the row next to the word element are automatically cleared and data type of that row cannot be edited. In addition, the data column of the row preceding the word element cannot be edited. In memory reading, the row next to a REAL or DINT element are skipped.

## 18.4 Function Demonstration

Save different sets of recipe parameters when commissioning different steps of one process.

1. Create a standard project, define variables and structures and write the program for the project, and then download the project to the PLC.
2. Enter project monitoring.

3. Open the variable table and tick "Value1". At a specific moment, right-click and select "Read Memory" to read the variable memory as the recipe parameters for the step of the specific moment. As a result, the variable memory values obtained at the specific moment are displayed in the "Value1" column. In batch reading of memory values, the memory values read through right-click at a specific moment will be read to the entire selected value column of the variable table, whether open or not, and will be used as the recipe parameters for that step.
4. Similarly, tick "Value2". At another moment, right-click and select "Read Memory" to obtain recipe parameters for another step and have them displayed in the "Value2" column. Batch reading of memory values is similar to the previous operation. Values obtained through batch reading are used as the recipe parameters for another step.
5. Save the recipe. Before saving the recipe, you can edit some of the obtained values (or export and edit them in an EXCEL file and then load the file). After editing, right-click and select "Save" to save the recipe data of different steps in a CSV file in the disk for backup.
6. Edit recipe values. Open the saved recipe CSV file in Excel and fine-tune the variable parameters.

| 2 | FullName | DataType | Vaule1 | value2 | value3 | value4 |
|---|---|---|---|---|---|---|
| 3 | gh_bAuto | BOOL | ON | ON | | |
| 4 | gh_bStart | BOOL | OFF | OFF | | |
| 5 | gh_bCycleStop | BOOL | OFF | OFF | | |
| 6 | gh_bEstop | BOOL | OFF | OFF | | |
| 7 | gh_bReset | BOOL | OFF | OFF | | |
| 8 | gh_bMachineJog | BOOL | OFF | OFF | | |
| 9 | gh_bMachineOnce | BOOL | OFF | OFF | | |
| 10 | gh_bProductNum_ReReset | BOOL | OFF | OFF | | |
| 11 | gh_bProductNum_NoReRes | BOOL | OFF | OFF | | |
| 12 | gh_bMaterialOffsetAdd | BOOL | OFF | OFF | | |
| 13 | gh_bMaterialOffsetSub | BOOL | OFF | OFF | | |
| 14 | gh_bColorMarkOffsetAdd | BOOL | OFF | OFF | | |
| 15 | gh_bColorMarkOffsetSub | BOOL | OFF | OFF | | |
| 16 | gh_bKnifePower | BOOL | OFF | OFF | | |
| 17 | gh_bFilmPower | BOOL | OFF | OFF | | |

7. Load the recipe. After saving the data modified in step 6, right-click in the variable table and click "Load Values". As a result, the modified configuration parameters are displayed in the "Value1" and "Value2" columns.
8. Write the recipe values. Tick "Value2", right-click and select "Write Memory" to write the recipe parameters for the corresponding step into the memory.

# 19 Fault Diagnosis

## 19.1 Diagnosis Through the Panel

### 19.1.1 Indicators

States and meanings of the panel indicators of the H5U series are shown in the following table.

| Indicator | Meaning |
|---|---|
| RUN | Current system status (running or stopped)<br>ON: Running; OFF: Stopped |
| ERR | System fault |
| BAT | Battery alarm |
| BF | EtherCAT bus fault |
| CRUN | CAN running |
| CERR | CAN error |

States and meanings of the panel indicators of the Easy series are shown in the following table.

| Port Type | Interface Mark | Definition | Indicator Color | Description |
|---|---|---|---|---|
| I/O indicator | IN/OUT | I/O status | Yellow-green | • Steady ON: Input or output active<br>• OFF: Input or output inactive |
| Status indicator | PWR | Power supply | Yellow-green | • Steady ON: Power supply normal<br>• OFF: Power supply abnormal |
| | RUN | Normal running | Yellow-green | • Steady ON: User program running<br>• OFF: User program stopped |
| | ERR | Running error | Red | • OFF: No major error<br>• Flashing: Major error |
| | ETH1 | EtherNET1 Link | Yellow-green | • Steady ON: Connected<br>• Flashing: Communication in progress<br>• OFF: Disconnected |
| | ETH2 | EtherNET2 Link | Yellow-green | • Steady ON: Connected<br>• Flashing: Communication in progress<br>• OFF: Disconnected |

### 19.1.2 MFK Key

#### 19.1.2.1 Overview

The MFK key works with the LED display to support multi-function menu operations. Long-press the MFK key, and the LED display will toggle between different function menus at an interval of 2 seconds, as shown in the following figure.


When the function menu you want to enter is displayed on the LED display, release the MFK key and then short-press the MFK key to enter the function menu. Note: Short-press is a brief press for less than 2 seconds.

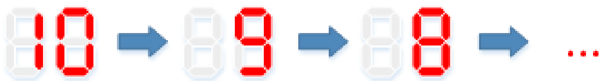
If you enter a menu that cannot be executed, the LED display shows an error.

| Display Code | Name | Description |
|---|---|---|
|  | E1 | The PLC is in a non-secure state (running or downloading) and operation is prohibited. |
|  | E2 | No SD card or programming file is detected. |
|  | E3 | Multiple programming files are detected in the SD card. |
|  | E4 | Programming file data is abnormal or the device model is not compatible. |
|  | E5 | Password verification error |

### 19.1.2.2 Restoring the Factory Default IP Address

The factory default IP address of the CPU module is 192.168.1.88. If you forget the IP address after modifying it, leading to a failure in networking and communication with another PC, you can enter the "IP" menu and reset the IP address of the CPU module to the factory default.

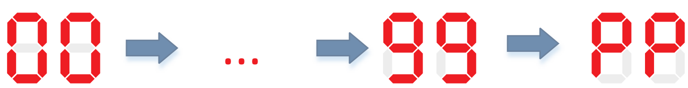

Enter the "IP" menu, and the LED display will start counting down from 10 to 0.




Before the countdown reaches 0, a short-press on the MFK key can cancel the reset. When the countdown ends, the IP is reset and the factory default IP address will be used.

### 19.1.2.3 Writing User Programs Through SD Cards

Save the SD card programming file compiled using AutoShop into the "PLCProgram" directory of the SD card. Then, mount the SD card to the PLC main module. Enter the "Sd" menu to start writing the user program in the SD card into the PLC host. The LED display shows the programming progress (00 to 99). When the programming is completed, the LED display shows "PP".




### 19.1.2.4 LED Display of the CPU Module

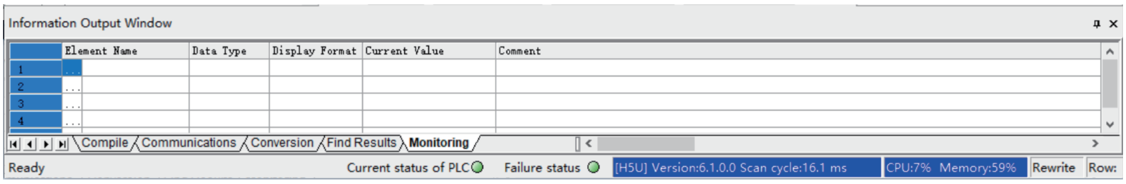
When a system fault occurs, the LED display of the CPU shows the fault code, with "Er" and the code of the fault displayed alternately. For example, when the fault code is Er1501, the LED display is as follows:


For detailed definitions of fault codes, see *“19.3 Fault Codes” on page 552*

# 19.2 Diagnosis Through Software

## 19.2.1 Obtaining Basic PLC Information

1. You can click  in the toolbar to enter the monitoring mode. In the monitoring mode, the basic information of the PLC is displayed in the lower right corner of the interface. The basic information includes:




(1) PLC status indicator and fault indicator

(2) Current firmware version and program scan cycle

(3) CPU and memory utilization rates

Table 19–1 Indicator states and meanings

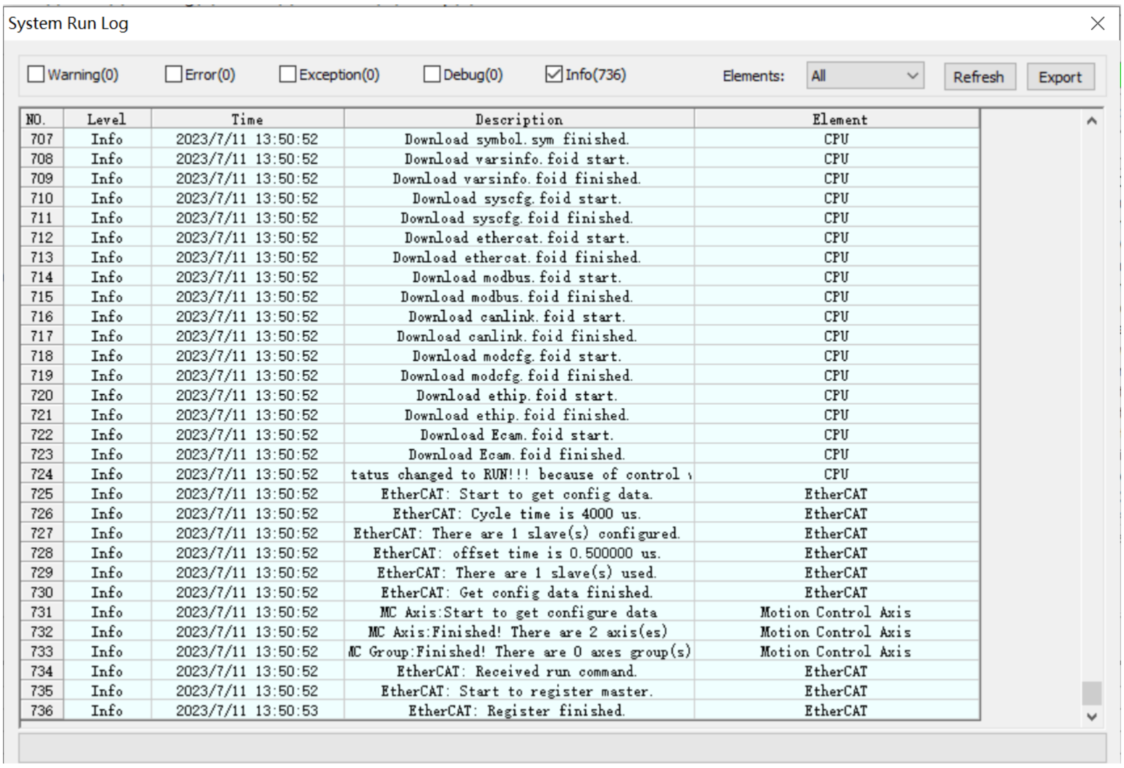
| Current PLC status | | Status | |
|---|---|---|---|
| Green | Running | Green | No fault |
| Red | Stopped | Yellow | Minor error |
| - | - | Red | Major error |

2. Double-click the fault indicator to enter the fault diagnosis page and obtain detailed fault information.

## 19.2.2 Viewing Operation Logs

Operation logs include fault logs and system logs. To view operation logs, follow these steps:

1. In the toolbar, click "Debug" and then choose "System Run Log View".
2. The system operation log page is displayed.




| NO. | Level | Time | Description | Element |
|---|---|---|---|---|
| 707 | Info | 2023/7/11 13:50:52 | Download symbol.sym finished. | CPU |
| 708 | Info | 2023/7/11 13:50:52 | Download varsinfo.foid start. | CPU |
| 709 | Info | 2023/7/11 13:50:52 | Download varsinfo.foid finished. | CPU |
| 710 | Info | 2023/7/11 13:50:52 | Download syscfg.foid start. | CPU |
| 711 | Info | 2023/7/11 13:50:52 | Download syscfg.foid finished. | CPU |
| 712 | Info | 2023/7/11 13:50:52 | Download ethercat.foid start. | CPU |
| 713 | Info | 2023/7/11 13:50:52 | Download ethercat.foid finished. | CPU |
| 714 | Info | 2023/7/11 13:50:52 | Download modbus.foid start. | CPU |
| 715 | Info | 2023/7/11 13:50:52 | Download modbus.foid finished. | CPU |
| 716 | Info | 2023/7/11 13:50:52 | Download canlink.foid start. | CPU |
| 717 | Info | 2023/7/11 13:50:52 | Download canlink.foid finished. | CPU |
| 718 | Info | 2023/7/11 13:50:52 | Download modcfg.foid start. | CPU |
| 719 | Info | 2023/7/11 13:50:52 | Download modcfg.foid finished. | CPU |
| 720 | Info | 2023/7/11 13:50:52 | Download ethip.foid start. | CPU |
| 721 | Info | 2023/7/11 13:50:52 | Download ethip.foid finished. | CPU |
| 722 | Info | 2023/7/11 13:50:52 | Download Ecam.foid start. | CPU |
| 723 | Info | 2023/7/11 13:50:52 | Download Ecam.foid finished. | CPU |
| 724 | Info | 2023/7/11 13:50:52 | tatus changed to RUN!!! because of control | CPU |
| 725 | Info | 2023/7/11 13:50:52 | EtherCAT: Start to get config data. | EtherCAT |
| 726 | Info | 2023/7/11 13:50:52 | EtherCAT: Cycle time is 4000 us. | EtherCAT |
| 727 | Info | 2023/7/11 13:50:52 | EtherCAT: There are 1 slave(s) configured. | EtherCAT |
| 728 | Info | 2023/7/11 13:50:52 | EtherCAT: offset time is 0.500000 us. | EtherCAT |
| 729 | Info | 2023/7/11 13:50:52 | EtherCAT: There are 1 slave(s) used. | EtherCAT |
| 730 | Info | 2023/7/11 13:50:52 | EtherCAT: Get config data finished. | EtherCAT |
| 731 | Info | 2023/7/11 13:50:52 | MC Axis:Start to get configure data | Motion Control Axis |
| 732 | Info | 2023/7/11 13:50:52 | MC Axis:Finished! There are 2 axis(es) | Motion Control Axis |
| 733 | Info | 2023/7/11 13:50:52 | MC Group:Finished! There are 0 axes group(s) | Motion Control Axis |
| 734 | Info | 2023/7/11 13:50:52 | EtherCAT: Received run command. | EtherCAT |
| 735 | Info | 2023/7/11 13:50:52 | EtherCAT: Start to register master. | EtherCAT |
| 736 | Info | 2023/7/11 13:50:53 | EtherCAT: Register finished. | EtherCAT |

- (1) Select which categories of information to display.
- (2) Select which elements to display, refresh the operation logs, or export the operation logs.

## 19.3 Fault Codes

The software tool prompts various categories of fault codes when faults occur in user programming. The following table lists the fault codes and corresponding solutions.

Table 19–2 Fault codes

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| **Program** | | | |
| 1500 | User program watchdog timed out | The user program execution time is too long and has exceeded the set program watchdog time. | Increase the watchdog time as appropriate, or check whether there is a program block with unexpectedly long execution time in the user program. |
| 1501 | Undefined instruction | The instruction is not supported. | Upgrade the PLC firmware to the version that supports the instruction. |
| 1502 | Incomplete user program, length error | The user program is incomplete, and the length is incorrect. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1503 | Program authorization protection identifier error. Check whether the identifier matches. | The program authorization protection identifier is incorrect. Check whether the authorization protection identifier of the device is set correctly. | Contact the equipment provider. |
| 1504 | User program empty | The user program is empty. There is no valid program. | Re-download the user program. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 1505 | Block POU identifier error | The block POU identifier is incorrect. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1510 | Subprogram identifier error | The subprogram identifier is incorrect. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1511 | Subprogram type error | The subprogram type is incorrect. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1512 | Subprogram serial number error or out of range | The subprogram serial number is incorrect or out of range. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1513 | Incorrect, duplicate, or conflicting subprogram address | The subprogram address is incorrect, duplicated, or conflicting. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1514 | Interrupt subprogram serial number error or out of range | The interrupt subprogram serial number is incorrect or out of range. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1515 | Incorrect, duplicate, or conflicting interrupt subprogram address | The interrupt subprogram address is incorrect, duplicated, or conflicting. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1516 | Interrupt subprogram edge error (not rising edge or falling edge) | The interrupt subprogram edge is incorrect (not rising edge or falling edge). | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1517 | Interrupt timing duration range error in the interrupt subprogram timer | The interrupt timing duration range of the interrupt subprogram timer is incorrect. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1520 | OBprog program identifier error | The OBprog program identifier is incorrect. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1521 | OBprog program type error | The OBprog program type is incorrect. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1522 | OBprog program serial number error or out of range | The OBprog program serial number is incorrect or out of range. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1523 | Incorrect, duplicate, or conflicting OBprog program address | The OBprog program address is incorrect, duplicated, or conflicting. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1524 | OBprog program variable quantity error | The variable quantity of the OBprog program is incorrect. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1525 | OBprog program variable length error | The variable length of the OBprog program is incorrect. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1526 | OBprog program header data error | The header data of the OBprog program is incorrect. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 1530 | CJ-LBL instruction LBL serial number error or out of range | The LBL serial number of the CJ-LBL instruction is incorrect or out of range. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 1531 | Incorrect, duplicate, or conflicting LBL address of CJ-LBL instruction | The LBL address of the CJ-LBL instruction is incorrect, duplicated, or conflicting. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 5001 | Exception in user program execution or instruction return value error, some instructions not executed | Execution of the user program is abnormal or the return value of the instruction is incorrect, and some instructions are not executed, causing program execution to end abnormally. | Check the logic of the user program for any exception in execution process or execution logic. |
| 5010 | CALL instruction subprogram serial number error or out of range | The subprogram serial number of the CALL instruction is incorrect or out of range. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 5011 | CALL instruction subprogram non-existent or not initialized | The subprogram of the CALL instruction does not exist or is not initialized. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 5012 | CALL instruction subprogram nesting levels out of range or less than or equal to 0 | The number of subprogram nesting levels of the CALL instruction is out of range. | Modify the program logic to reduce the subprogram nesting levels. |
| 5013 | Relationship error returned by the subprogram of the CALL instruction | The subprogram of the CALL instruction returns a relationship error. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 5014 | Mismatch between subprogram call and subprogram return | Subprogram execution is abnormal. The subprogram call and subprogram return do not match. | Check whether the subprogram call and return are disordered due to the abnormal end of the user program. |
| 5015 | Interrupt subprogram undefined | The interrupt subprogram is undefined or does not exist. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 5016 | Interrupt queue full and interrupt lost in the interrupt subprogram timer | The interrupt queue of the interrupt subprogram timer is full and the interrupt is lost. | Modify the interrupt subprogram properties or logic, and reduce the number of interrupts as appropriate. |
| 5020 | FBFC program serial number error or out of range | The FBFC program serial number is incorrect or out of range. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 5021 | FBFC program non-existent or not initialized | The FBFC program does not exist or is not initialized. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 5022 | FBFC program variable non-existent or not initialized | The variable of the FBFC program does not exist or is not initialized. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 5023 | FBFC program nesting levels out of range or less than or equal to 0 | The number of FBFC program nesting levels is out of range. | Modify the program logic to reduce the FBFC program nesting levels. |
| 5024 | Relationship error returned by FBFC program | The FBFC program returns a relationship error. | Check whether the FBFC special instruction is used in the wrong position, or recompile and download the user program. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 5025 | Mismatch between OBprog program call and program return | OBprog program execution is abnormal. The program call and program return do not match. | Check whether the program call and return are disordered due to the abnormal end of the user program. |
| 5030 | CJ-LBL instruction LBL serial number error or out of range | The LBL serial number of the CJ-LBL instruction is incorrect or out of range. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 5031 | CJ-LBL instruction LBL non-existent or not initialized | The LBL of the CJ-LBL instruction does not exist or is not initialized. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 5032 | FOR-NEXT instruction nesting levels out of range or less than or equal to 0 | The number of nesting levels of the FOR-NEXT instruction is out of range. | Modify the program logic to reduce the FOR-NEXT instruction nesting levels. |
| 5033 | FOR-NEXT instruction loops out of range or less than or equal to 0 | The number of FOR-NEXT instruction loops is out of range or less than or equal to 0. | Modify the program logic to change the number of FOR-NEXT instruction loops. |
| 5034 | FOR-NEXT instruction loops equal to 0 | The number of FOR-NEXT instruction loops is 0. | Modify the program logic to change the number of FOR-NEXT instruction loops. |
| 5035 | FOR and NEXT not paired | The FOR and NEXT instructions are not paired. | Check whether the disorder is caused by abnormal stop of the user program. |
| 5080 | Array subscript access out of bounds | The array access subscript is greater than the maximum array subscript value, and the subscript value in use has been changed to the maximum array subscript value. | Double-click the fault code to go to the corresponding program position to modify the subscript value. |
| 5081 | Division-by-zero protection, divisor 0 replaced by 1 | The division-by-zero protection is triggered and the divisor 0 is replaced by 1 automatically. | Double-click the fault code to go to the corresponding program position to modify the divisor. |
| 5082 | Long-time no response from program loop | The program loop has no response for a long time. | Double-click the fault code to go to the corresponding program position to modify the loop statement. |
| 5083 | Array subscript access out of bounds | The array access subscript is less than 0, and the subscript value in use has been changed to 0. | Double-click the fault code to go to the corresponding program position to modify the subscript value. |
| 5084 | Invalid data | The floating-point data is invalid. | Check whether the input values of functions such as LN, LOG, SQRT are legal. |
| 5101 | Instruction parameter variable address error, or variable non-existent | The address of the parameter variable of the instruction is incorrect, or the variable does not exist. | Check whether the address of the parameter variable of the instruction is normal and whether the variable exists. |
| 5102 | Instruction parameter variable size error, or variable non-existent or out of range | The size of the parameter variable of the instruction is incorrect. The variable does not exist or is out of range. | Check whether the data length of the parameter variable of the instruction is out of range. |
| 5104 | Instruction parameter sequence error or relationship error | The instruction parameter sequence or relationship is incorrect. | Check whether the parameter sequence or relationship of the instruction is correct. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 5105 | String data error or length error in string instruction | The character string data or length of the string instruction is incorrect. | Check whether the character string data of the string instruction is illegal. |
| 5110 | Pointer serial number error or out of range | The serial number of the Pointer is incorrect or out of range. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| 5111 | Pointer not initialized or not pointing to a valid data variable | The Pointer is not initialized or does not point to a valid data variable. | Check whether the Pointer is initialized and whether it points to a valid variable address. |
| 5112 | Variable pointed to by the Pointer non-existent or out of range | The variable pointed to by the Pointer does not exist or is out of range. | Check the variable address pointed to by the Pointer or initialize the Pointer again. |
| 5113 | Pointer offset out of range | The offset of the Pointer is out of range. | Check whether the offset of the Pointer is too large. If yes, reduce the offset. |
| 5114 | Variable pointed to by the Pointer execution result non-existent or out of range | The variable pointed to by the execution result of the Pointer does not exist or is out of range. | Check whether the variable address pointed to by the execution result of the Pointer exists and whether it is out of range. |
| 5120 | Counter instruction instantiation failed | Failed to instantiate the counter instruction. | Recompile and download the user program. |
| 5121 | Counter instruction comparand error or out of range | The comparand of the counter instruction is incorrect or out of range. | Check whether the comparand of the counter instruction is incorrect or out of range. |
| 5130 | Timer instruction instantiation failed | Failed to instantiate the timer instruction. | Recompile and download the user program. |
| 5131 | Timer instruction comparand error or out of range | The comparand of the timer instruction is incorrect or out of range. | Check whether the comparand of the timer instruction is incorrect or out of range. |
| 5140 | Number of SFC STL parallel branch/parallel recombination/selective branch/selective recombination lines out of range | The number of SFC STL parallel branch/parallel recombination/selective branch/selective recombination lines is out of range. | Ensure that the number of SFC STL parallel branch/ parallel recombination/selective branch/selective recombination lines is within the specified range. |
| 5150 | Function block instruction instantiation failed | Failed to instantiate the function block instruction. | Recompile and download the user program. |
| 5160 | Array subscript variable code error or non-existent | The subscript variable code of the array is incorrect or does not exist. | Recompile and download the user program. |
| 5161 | Array subscript variable data error or out of range | The subscript variable of the array is incorrect or out of range. | Modify the value of the subscript variable so that the array falls within the allowable range. |
| 5600 | SerialSR instruction instantiation failed | Failed to instantiate the SerialSR instruction. | Recompile and download the user program. |
| 5601 | SerialSR instruction port ID out of range | The port ID of the SerialSR instruction is out of range. | Modify the port ID of the SerialSR instruction. |
| 5602 | SerialSR instruction protocol error | The protocol of the SerialSR instruction is incorrect. | Set the free protocol for the serial port by using the software tool. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 5603 | SerialSR instruction port conflict | Multiple instructions call the SerialSR instruction at the same time, and the instruction that fails to preempt the port reports an error. | Modify the instruction scheduling timing to implement time division multiplexing. |
| 5604 | SerialSR instruction TX data length out of range or less than 0 | The TX data length of the SerialSR instruction is out of range or less than 0. | Check whether the TX data length of the SerialSR instruction is out of range or less than 0. |
| 5605 | SerialSR instruction TX data buffer error | Failed to obtain the TX data buffer of the SerialSR instruction. | Enable this instruction again. |
| 5606 | SerialSR instruction RX data length out of range or less than 0 | The RX data length of the SerialSR instruction is out of range or less than 0. | Check whether the RX data length of the SerialSR instruction is out of range or less than 0. |
| 5607 | SerialSR instruction RX data buffer error | Failed to obtain the RX data buffer of the SerialSR instruction. | Enable this instruction again. |
| 6580 | Invalid axis ID in the CANopen axis instruction | The axis ID specified in the CANopen axis instruction is invalid. | Modify the axis ID. |
| 6701 | Invalid memory address: element or variable non-existent | The memory address is invalid. The element or variable to access does not exist. | Modify the instruction parameter to use a valid element or variable. |
| 6705 | Invalid memory size: memory non-existent or out of range | The memory size is invalid. The number of elements or variables to access is too large or out of range. | Modify the instruction parameter to adjust the number of elements or variables. |
| 6706 | Improper data or data out of range | The instruction parameter is improper or out of the allowable range. | Refer to the instructions guide to modify the instruction parameter value. |
| 6711 | Invalid variable address: variable non-existent | The variable address is invalid. The element or variable to access does not exist. | Modify the instruction parameter to use a valid element or variable. |
| 6712 | Invalid variable size: variable out of range | The variable size is invalid. The number of elements or variables to access is too large or out of range. | Modify the instruction parameter to adjust the number of elements or variables. |
| 6713 | Invalid variable encoding | The variable encoding is invalid. | Recompile and download the user program, or recompile and download the user program after replacing the software tool. |
| **CPU** | | | |
| 1011 | FPGA initialization failed | FPGA initialization failed. | The device hardware is faulty. Replace the device and return the faulty device to the factory for repair. |
| 1012 | Interrupt initialization failed | Interrupt initialization failed. | The device hardware is faulty. Replace the device and return the faulty device to the factory for repair. |
| 1013 | Timer interrupt initialization failed | Failed to initialize the timer interrupt of the user program. | Restart the device and try again, or replace the device and return the faulty device to the factory for repair. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 5200 | Error in data retention upon power failure | An error occurs to data retention upon power failure. | Check whether the function of data retention upon power failure works properly. |
| 5238 | 2038 problem imminence warning | The device will not work normally after 11:14:07 on January 19, 2038 (UTC+8). | Change the device time. |
| 5250 | Low RTC battery voltage | The battery voltage of the RTC clock is low. If the device is powered off at this time, the system time will be restored to the initial value. | Replace the battery of the RTC clock while keeping the device powered on. |
| 5900 | Network down: Ethernet IP address conflict | When the device connects to the network or starts running after stop, or when its IP address is modified, it detects whether its IP address is used by other devices in the current network. If yes, the device automatically shuts down the network to avoid conflict. | Change the device IP address. |
| **Local I/O** | | | |
| 5300 | Initialization failed | Initialization failed. | The device hardware is faulty. Replace the device and return the faulty device to the factory for repair. |
| 5301 | Invalid DI filter parameter configuration | The DI filter parameter configuration data is invalid. | Modify the DI filter parameter configuration data. |
| **Extension Module** | | | |
| 5400 | Failed to initialize extension module interface hardware | The hardware of the extension module interface is faulty, which causes the initialization to fail. | The device hardware is faulty. Replace the device and return the faulty device to the factory for repair. |
| 5401 | Failed to parse extension module configuration data | The configuration data of the extension module cannot be parsed correctly because its format does not meet requirements. | Clear the compilation information using AutoShop and recompile and download the program. If the problem persists, delete the module configurations and add modules and configurations again one by one. |
| 5402 | Failed to initialize extension module interface slot | The slot of the extension module interface is faulty, which causes the initialization to fail. | 1. Check whether the extension module interface slot is short-circuited. If yes, eliminate the short circuit.<br>2. Check whether the installed module hardware works properly. If not, replace the module. |
| 5403 | Extension module not installed | The extension module is configured but not installed. | Install the extension module as required, or modify the configuration of the extension module. |
| 5404 | Module installed inconsistent with module configured | The module installed in the slot must be inconsistent with the configured module; otherwise, it cannot work properly. | Install the extension module as required and modify module configuration accordingly to ensure consistency. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 5405 | Extension module interface hardware exception | The extension module interface is abnormal. | 1. Check whether the extension module interface slot is short-circuited. If yes, eliminate the short circuit.<br>2. Check whether the installed module hardware works properly. If not, replace the module. |
| 5406 | Extension module interface software error | The extension module interface software is abnormal. | 1. Upgrade the PLC firmware.<br>2. If the problem persists after the firmware upgrade, replace the device and return the faulty device to the factory for repair. |
| 5411 | Module in the slot not powered | The module requires external power supply to function properly, but the external power supply is not on. | Connect the external power supply correctly according to the module specifications. |
| 5412 | Slot module hardware fault | The module has an internal fault and cannot work properly. | Replace the module and return the faulty module to the factory for repair. |
| 5413 | Slot module over-temperature | The module detected a high internal temperature that may lead to malfunction. | 1. Do not install the module in an environment that does not meet the relevant temperature requirements.<br>2. Replace the module and return the faulty module to the factory for repair. |
| 5419 | Slot module channel input or output overflow | For the input channel, the input signal has exceeded the upper sampling threshold. Sampling cannot be performed properly, and there is a possibility that the input port may be burned. For the output channel, the output value of the corresponding channel has exceeded the set upper threshold, and signals cannot be output properly. | Input channel: Check the actual input signal value.<br>If the signal input to this channel has exceeded the set sampling range under normal working conditions, modify the sampling range as appropriate.<br>If the signal is abnormal, check the output device or instrument of the signal.<br>Output channel: Check the set output value and ensure that the set output is within the set range. If the set range cannot meet requirements, modify it as appropriate. |
| 5420 | Slot module channel input or output underflow | For the input channel, the input signal has fallen below the lower sampling threshold, and sampling cannot be performed properly. For the output channel, the output value of the corresponding channel has fallen below the set lower threshold, and signals cannot be output properly. | Input channel: Check the actual input signal value.<br>If the signal input to this channel has exceeded the set sampling range under normal working conditions, modify the sampling range as appropriate.<br>If the signal is abnormal, check the output device or instrument of the signal.<br>Output channel: Check the set output value and ensure that the set output is within the set range. If the set range cannot meet requirements, modify it as appropriate. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 5421 | Slot module channel input upper limit exceeded or current output disconnected | For the input channel, the input signal has exceeded the upper sampling threshold. At this time, the signal can be sampled normally but the accuracy cannot be guaranteed. For the current output channel, the output port is not connected to the load or the impedance of the connected load is too large, so that the current cannot be output normally. | Input channel: Check the actual input signal value.<br>If the signal input to this channel has exceeded the set sampling range under normal working conditions, modify the sampling range as appropriate.<br>If the signal is abnormal, check the output device or instrument of the signal.<br>Current output channel: Ensure that the load of the output port is connected properly and reliably, and that the load impedance is within the range specified in the module specifications. |
| 5422 | Slot module channel input lower limit exceeded or voltage output short-circuited | For the input channel, the input signal has fallen below the lower sampling threshold. At this time, the signal can be sampled normally but the accuracy cannot be guaranteed. For the voltage output channel, the output port is possibly short-circuited or the impedance of the connected load is too small, so that the voltage cannot be output normally. | Input channel: Check the actual input signal value. If the signal input to this channel has exceeded the set sampling range under normal working conditions, modify the sampling range as appropriate. If the signal is abnormal, check the output device or instrument of the signal. Voltage output channel: Ensure that the load of the output port is connected properly and reliably, and that the load impedance is within the range specified in the module specifications. |
| 5423 | Slot module channel input disconnected or output hardware faulty | For the input channel, no input signal is connected to the input port or the input signal is too weak and cannot be detected or sampled. For the output channel, the channel hardware is faulty and may have burned out. | Input channel: Ensure that the signal of the input port is normal and valid and is connected properly and reliably. Output channel: Replace the module and return the faulty module to the factory for repair. |
| | | **Local Encoder Axis** | |
| 6300 | Input device not assigned or assigned input device invalid | The local encoder axis must be assigned with a high-speed counter, and each high-speed counter can only be assigned to one axis, otherwise the axis cannot work properly. | Assign a high-speed counter that has not been assigned yet in "Input Device" on the "Basic Settings" page of the axis. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 6301 | Axis unit conversion configuration invalid | After a high-speed counter is assigned to an axis, its count value (pulse unit) is converted into the equivalent in user unit (Unit) according to the unit conversion setting parameter. If the number of pulses per revolution of the encoder, the displacement of the encoder per revolution, or the gear ratio of the transmission device is set incorrectly, the axis cannot work properly. | Check the settings on the "Unit Conversion Settings" page of the axis and correct the parameter values. |
| 6302 | Axis software limit or revolution cycle configuration invalid | In linear mode, the negative limit must be less than 0, and the positive limit must be greater than 0. In rotary mode, the revolution cycle must be greater than 0. Since the high-speed counter is a 32-bit counter, the negative limit, positive limit, and revolution cycle must be 32-bit integers in the range of [–2147483648, +2147483647] after being converted into pulse units. | Linear mode: Modify the positive and negative limits to ensure that the negative limit is less than 0, the positive limit is greater than 0, and they are 32-bit integers in the range of [–2147483648, +2147483647] after being converted into pulse units. Rotary mode: Modify the revolution cycle to ensure that it is greater than 0 and is a 32-bit integer in the range of [–2147483648, +2147483647] after being converted into pulse units. |
| 6303 | Axis counting mode or signal source configuration invalid | The high-speed counter supports the following counting modes and signal sources: A/B phase frequency multiplication by 1: X0-A phase, X1-B phase, X2-A phase, X3-B phase A/B phase frequency multiplication by 2: X0-A phase, X1-B phase, X2-A phase, X3-B phase A/B phase frequency multiplication by 4: X0-A phase, X1-B phase, X2-A phase, X3-B phase CW/CCW: X0-CW, X1-CCW, X2-CW, X3-CCW Pulse +direction: X0-pulse, X1-direction, X2-pulse, X3-direction | Select a supported counting mode and signal source. |
| 6304 | Axis preset function: input terminal invalid | The preset function supports the input terminals X0, X1, X2, X3, X4, X5, X6, and X7. | Select an input terminal supported by the preset function. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 6305 | Axis probe 1: input terminal invalid | Probe 1 supports the input terminals X0, X1, X2, X3, X4, X5, X6, and X7. | Select an input terminal supported by probe 1. |
| 6306 | Axis probe 2: input terminal invalid | Probe 2 supports the input terminals X0, X1, X2, X3, X4, X5, X6, and X7. | Select an input terminal supported by probe 2. |
| 6307 | Axis comparison output: terminal invalid | The comparative output supports the output terminals Y0, Y1, Y2, and Y3. | Select an output terminal supported by the comparison output. |
| 6308 | Axis comparison output: pulse width invalid | When the unit is ms, the time range is 0.1 ms to 6553.5 ms. When the unit is Unit, the set value must fall between 1 and 65535 after being converted into pulse units. | Modify the pulse width to ensure that it is within the allowable range. |
| **CANlink** | | | |
| 6400 | Station address conflict: Station address already exists in the network. | In CANlink communication, the addresses of all stations connected to the network must be unique. Address conflict detection is performed after a device node is powered on and initialized or the station address is modified. If the address is duplicated, a fault is reported and all CANlink bus activities of the node are stopped. | Change the station address to ensure that there are no duplicate addresses in the network. |
| 6401 | Slave offline | Failed to communicate with the slave because it is offline. | Check whether the CAN network connection works properly. Ensure that the connection is reliable without short circuit or open circuit, CANH and CANL are not reversely connected, and the terminal resistance is normal. |
| 6411 | Slave configuration exception response (1) "Undefined encoding used" | During configuration of a slave, the slave returns exception response (1) "Undefined encoding used". | Check whether the type/model of the connected device is consistent with the configuration. |
| 6412 | Slave configuration exception response (2) "Configured index exceeds the maximum value supported by the node" | During configuration of a slave, the slave returns exception response (2) "Configured index exceeds the maximum value supported by the node". | Check whether the type/model of the connected device is consistent with the configuration. |
| 6413 | Slave configuration exception response (3) "Register address non-existent or inaccessible" | During configuration of a slave, the slave returns exception response (3) "Register address non-existent or inaccessible". | Check whether the type/model of the connected device is consistent with the configuration. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 6415 | Slave configuration exception response (5) "Register data length invalid" | During configuration of a slave, the slave returns exception response (5) "Register data length invalid". | Check whether the type/model of the connected device is consistent with the configuration. |
| 6416 | Waiting for slave configuration command response timed out | During configuration of a slave, waiting for slave response timed out. | Check whether the type/model of the connected device is consistent with the configuration. |
| 6421 | Slave synchronization exception response (1) "Illegal command code" | When a synchronization command is sent to a slave, the slave returns exception response (1) "Illegal command code". | Check whether the type/model of the connected device is consistent with the configuration. |
| 6422 | Slave synchronization exception response (2) "Register address non-existent or inaccessible" | When synchronization data is sent to a slave, the slave returns exception response (2) "Register address non-existent or inaccessible". | Check whether the type/model of the connected device is consistent with the configuration. |
| 6423 | Slave synchronization exception response (3) "Value beyond allowable range" | When synchronization data is sent to a slave, the slave returns exception response (3) "Value beyond allowable range". | 1. Check whether the set value in the corresponding register address has exceeded the allowed range.<br>2. Check whether the type/model of the connected device is consistent with the configuration. |
| 6424 | Slave synchronization exception response (4) "Operation unreachable or not allowed in the current state" | When synchronization data is sent to a slave, the slave returns exception response (4) "Operation unreachable or not allowed in the current state". | Check whether the type/model of the connected device is consistent with the configuration. |
| 6425 | Slave synchronization exception response (5) "Data length invalid" | When synchronization data is sent to a slave, the slave returns exception response (5) "Data length invalid". | Check whether the type/model of the connected device is consistent with the configuration. |
| 6426 | Waiting for slave synchronization command response timed out | Waiting for slave response to a synchronization command timed out. | Check whether the type/model of the connected device is consistent with the configuration. |
| **CANopen** | | | |
| 6401 | Node offline | Failed to communicate with the node because it is offline. | Check whether the CAN network connection works properly. Ensure that the connection is reliable without short circuit or open circuit, CANH and CANL are not reversely connected, and the terminal resistance is normal. |
| **Modbus Master** | | | |
| 5500 | 8-bit data required for Modbus-RTU serial port | The Modbus-RTU serial port only supports 8-bit data. | Use 8-bit data for Modbus-RTU serial port. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 6001 | Slave returned exception response (01) "Illegal function code" | The function code received in the query is not an allowable action for the server (or slave). This may be because the function code is only applicable to new devices, and is not implementable in the unit selected. It could also indicate that the server (or slave) is in the wrong state to process a request of this type, for example, because it is unconfigured and is being asked to return register values. | Check whether the server (or slave) supports the function code. |
| 6002 | Slave returned exception response (02) "Illegal data address" | The data address received in the query is not an allowable address for the server (or slave). More specifically, the combination of reference number and transfer length is invalid. For a controller with 100 registers, a request with the offset 96 and the length 4 will succeed, but a request with the offset 96 and the length 5 will result in exception code 02. | Check whether the corresponding function code of the server (or slave) supports all the addresses accessed by this configuration. |
| 6003 | Slave returned exception response (03) "Illegal data" | A value contained in the query data field is not an allowable value for server (or slave). This indicates a fault in the structure of the remainder of a complex request, such as that the implied length is incorrect. It specifically does not mean that a data item submitted for storage in a register has a value outside the expectation of the application program, since the Modbus protocol is unaware of the significance of any particular value of any particular register. | Check whether the value is within the allowed range. |
| 6004 | Slave returned exception response (04) "Slave device fault" | An unrecoverable error occurred while the server (or slave) was attempting to perform the requested action. | Check whether slave is abnormal or faulty. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 6128 | Response station number and requested station number mismatch | After the master sends a request frame, the station number in the received response frame is inconsistent with that in the transmitted request frame. | Check whether the connected slave is a normal Modbus slave. |
| 6129 | Response function code and requested function code mismatch | After the master sends a request frame, the function code in the received response frame is inconsistent with that in the transmitted request frame. | Check whether the connected slave is a normal Modbus slave. |
| 6130 | Response data address and requested data address mismatch | After the master sends a request frame, the data address in the received response frame is inconsistent with that in the transmitted request frame. | Check whether the connected slave is a normal Modbus slave. |
| 6131 | Response data value and requested data value mismatch | After the master sends a request frame, the data value in the received response frame is inconsistent with that in the transmitted request frame. | Check whether the connected slave is a normal Modbus slave. |
| 6240 | Cache address mapping in configuration invalid | The cache address mapping in the configuration is invalid and the configuration cannot be executed correctly. | Modify the cache address mapping in the configuration to a valid variable or element address. |
| 6255 | Request timed out | After sending a request frame, if the master does not receive a response from the slave within the specified timeout period, it retries according to the set number of retries. When the retry attempts exceed the set number, the master considers the slave abnormal and reports a request timeout error. | 1. Ensure that the communication network cable is connected reliably.<br>2. Ensure that the slave station number is consistent with the configured slave station number.<br>3. Modify the timeout period to ensure that the master can receive the response frame within the timeout period.<br>4. Check whether the connected slave is a normal Modbus slave. |
| **Modbus-TCP Master** | | | |
| 6000 | Configuration disconnected | The Modbus-TCP client fails to establish a TCP connection with the server. | 1. Ensure that the communication network cable is connected reliably.<br>2. Check whether the slave IP address and port ID are consistent with the configuration.<br>3. If the client and server are connected through a network bridge, router, or gateway, make sure that the client and server gateways are set correctly. |

| Fault Code | Message | Description | Troubleshooting |
| --- | --- | --- | --- |
| 6001 | Slave returned exception response (01) "Illegal function code" | The function code received in the query is not an allowable action for the server (or slave). This may be because the function code is only applicable to new devices, and is not implementable in the unit selected. It could also indicate that the server (or slave) is in the wrong state to process a request of this type, for example, because it is unconfigured and is being asked to return register values. | Check whether the server (or slave) supports the function code. |
| 6002 | Slave returned exception response (02) "Illegal data address" | The data address received in the query is not an allowable address for the server (or slave). More specifically, the combination of reference number and transfer length is invalid. For a controller with 100 registers, a request with the offset 96 and the length 4 will succeed, but a request with the offset 96 and the length 5 will result in exception code 02. | Check whether the corresponding function code of the server (or slave) supports all the addresses accessed by this configuration. |
| 6003 | Slave returned exception response (03) "Illegal data" | A value contained in the query data field is not an allowable value for server (or slave). This indicates a fault in the structure of the remainder of a complex request, such as that the implied length is incorrect. It specifically does not mean that a data item submitted for storage in a register has a value outside the expectation of the application program, since the Modbus protocol is unaware of the significance of any particular value of any particular register. | Check whether the value is within the allowed range. |
| 6004 | Slave returned exception response (04) "Slave device fault" | An unrecoverable error occurred while the server (or slave) was attempting to perform the requested action. | Check whether slave is abnormal or faulty. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 6128 | Response station number and requested station number mismatch | After the master sends a request frame, the station number in the received response frame is inconsistent with that in the transmitted request frame. | Check whether the connected slave is a normal Modbus slave. |
| 6129 | Response function code and requested function code mismatch | After the master sends a request frame, the function code in the received response frame is inconsistent with that in the transmitted request frame. | Check whether the connected slave is a normal Modbus slave. |
| 6130 | Response data address and requested data address mismatch | After the master sends a request frame, the data address in the received response frame is inconsistent with that in the transmitted request frame. | Check whether the connected slave is a normal Modbus slave. |
| 6131 | Response data value and requested data value mismatch | After the master sends a request frame, the data value in the received response frame is inconsistent with that in the transmitted request frame. | Check whether the connected slave is a normal Modbus slave. |
| 6240 | Cache address mapping in configuration invalid | The cache address mapping in the configuration is invalid and the configuration cannot be executed correctly. | Modify the cache address mapping in the configuration to a valid variable or element address. |
| 6255 | Request timed out | After sending a request frame, if the master does not receive a response from the slave within the specified timeout period, it retries according to the set number of retries. When the retry attempts exceed the set number, the master considers the slave abnormal and reports a request timeout error. | 1. Ensure that the communication network cable is connected reliably.<br>2. Ensure that the slave station number is consistent with the configured slave station number.<br>3. Modify the timeout period to ensure that the master can receive the response frame within the timeout period.<br>4. Check whether the connected slave is a normal Modbus slave. |
| **EtherNet/IP** | | | |
| 6600 | EtherNet/IP connection instance: not connected | When the PLC is in the "Stopped" state, the connection instance is displayed as not connected. | Switch the PLC to the "Running" state. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 6602 | EtherNet/IP connection instance: connection failed, target device offline | 1. The IP of the connection instance is inconsistent with the IP of the target device.<br>2. The target device is powered off or is in the "Stopped" state.<br>3. Network device failure. | 1. Set the IP of the connection instance to the IP of the target device.<br>2. Switch the target device to the "Running" state.<br>3. Replace the switch or cable. In case of connection across network segments, configure a gateway. |
| 6603 | EtherNet/IP connection instance: connection failed, target device not responding | The target device is online, but the EtherNet/IP protocol of the target device is abnormal. | Power off and on the target device. |
| 6604 | EtherNet/IP connection instance: connection failed, target device returned an error response | The specified connection path does not exist, or the specified data size does not match. | Open the connection status page, check the connection status code and status description, and modify the connection path, data size, or other relevant parameters. |
| 6605 | EtherNet/IP connection instance: connection timeout | 1. High CPU load (reaching 90%) of the PLC or target device can cause timeout in packet message reception.<br>2. Network device failure. | 1. Increase the PLC scan cycle, increase the RPI cycle of the EtherNet/IP connection, and reduce the number of EtherNet/IP connections to reduce the CPU load.<br>Use a high-performance PLC or target device.<br>2. Replace the switch or cable. |
| 6607 | EtherNet/IP configuration data format inconsistent | The software version does not match the board version. | Select AutoShop software and PLC firmware that are compatible with each other. |
| 6631 | EtherNet/IP display label: cannot connect to the path specified in the request | 1. The IP of the parameter is inconsistent with the IP of the target device.<br>2. The target device is powered off or is in the "Stopped" state.<br>3. Network device failure. | 1. Use the target device IP as the request parameter.<br>2. Switch the target device to the "Running" state.<br>3. Network troubleshooting: Replace the switch or cable. In case of connection across network segments, configure a gateway. |
| 6632 | EtherNet/IP display label: request timed out, no response received | 1. High CPU load (reaching 90%) of the PLC or target device can cause timeout in packet message reception.<br>2. Network device failure. | 1. Reduce the CPU load or use a high-performance PLC or target device.<br>2. Replace the switch or cable. |
| 6633 | EtherNet/IP display label: request succeeded, but error response received | 1. The name of the specified label is inconsistent with that of the target label.<br>2. The element quantity of the specified label is inconsistent with that of the target label, and exceeds the limit. | 1. Set the parameter according to the name of the target label.<br>2. Set the element quantity to a value less than or equal to the element quantity of the target label. |
| 6634 | EtherNet/IP display label: request succeeded, but data type inconsistent | The data type of the specified label is inconsistent with that of the target label. | Set the parameter according to the data type of the target label. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 6635 | EtherNet/IP display label: request succeeded, but data length inconsistent | The data packet returned by the target device is abnormal. | Power off and on the target device. |
| **EtherCAT** | | | |
| 8001 | Failed to read master configuration | Failed to read the master configuration information. | Check whether the board software and software tool versions match. |
| 8002 | Failed to obtain slave configuration parameters | Failed to obtain slave configuration parameters. | Check whether the board software and software tool versions match. |
| 8003 | EtherCAT startup timed out | EtherCAT startup timed out. | 1. Check whether the network is properly connected.<br>2. Check whether the connected slave is consistent with the configuration.<br>3. Check whether the slave type matches. |
| 8004 | Failed to request the master | Failed to request the master. | Restart the PLC. |
| 8200 | Failed to write slave startup parameters to SDO | Failed to write the slave startup parameters to the SDO. | 1. Check whether there is an object dictionary that is not supported by the slave in the startup parameter list.<br>2. Check whether the value of the object dictionary is out of range. |
| 8201 | Slave lost during operation | The slave is lost during operation. | 1. Check whether the network with the slave is disconnected.<br>2. Check whether the slave is powered off. |
| 8202 | Slave state machine switched to non-OP mode | The slave state machine is switched to non-OP mode. | 1. Check whether the network with the slave is disconnected.<br>2. Check whether the slave is powered off. |
| 8203 | Slave state machine switching failed | Slave state machine switching failed. | - |
| 8204 | Slave type mismatch | The slave type is incorrect. | 1. Check whether the network cable is reversely connected.<br>2. Check whether the connected device matches the configuration. |
| 8205 | PDO address error | The PDO address is incorrect. | 1. Check whether the memory runs out.<br>2. Check whether the background and board software versions match.<br>3. Power off and restart the PLC. |
| 8206 | PDO length error | The PDO length is incorrect. | Check whether the background and board software versions match. |
| 8301 | Failed to switch to INIT state | Failed to switch to INIT state. | Check whether the slave station machine supports state transition. |
| 8302 | Failed to switch to PerOP state | Failed to switch to PerOP state. | Check whether the slave supports the CoE protocol. |
| 8304 | Failed to switch to SafeOP state | Failed to switch to SafeOP state. | Check whether the PDO communication configuration is correct. |
| 8308 | Failed to switch to OP state | Failed to switch to OP state. | 1. Check the network communication quality.<br>2. Check whether the EtherCAT task cycle is appropriate. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 8310 | FMMU unit configuration error | An FMMU unit configuration error occurs. | Check whether the slave supports the FMMU unit. |
| 8311 | Email configuration error | An email configuration error occurs. | Check whether the slave supports the SM unit. |
| 8400 | ECTA configuration error | The ECTA configuration is incorrect. | Check whether the configured extension module is consistent with the actually connected extension module. |
| 8401 | ECTA hardware error | An ECTA hardware error occurs. | 1. Check whether the connection between the ECTA and the extension module is loose.<br>2. Replace the ECTA. |
| 8402 | ECTA extension module error | An ECTA extension module error occurs. | 1. Locate the extension module with the ERR indicator on.<br>2. Read the diagnosis object dictionary of the faulty module by using ETC_ReadParameter_CoE.<br>3. Determine the fault type based on description of the diagnosis object dictionary of the extension module in the ECTA application guide and eliminate the fault. |
| **Motion Control Axis** | | | |
| 9001 | Local axis emergency stop active | The emergency stop terminal input is active, and the pulse output is stopped. | Disable the emergency stop terminal input and then call the MC_Reset instruction to reset the fault. |
| 9003 | Overspeed | The pulse output frequency exceeds 200 kHz. | Check whether the pulse frequency obtained by multiplying the target velocity by the gear ratio exceeds 200 kHz. |
| 9020 | Homing error | The negative limit is not mapped. | Map the negative limit on the configuration interface. |
| 9021 | Homing error | The positive limit is not mapped. | Map the positive limit on the configuration interface. |
| 9022 | Homing error | The home signal is not mapped. | Map the home switch on the configuration interface. |
| 9023 | Homing error | 1. The output frequency exceeds 200 kHz when the axis runs at the homing velocity.<br>2. The output frequency exceeds 200 kHz when the axis runs at the homing approach velocity. | 1. Modify the unit conversion setting to ensure that the homing velocity and homing approach velocity do not exceed 200 kHz.<br>2. Change the homing velocity to ensure that the output frequency does not exceed 200 kHz.<br>3. Change the homing approach velocity to ensure that the output frequency does not exceed 200 kHz. |
| 9024 | Homing error | Homing timed out. | 1. Check whether the limit signal and home signal can be connected normally.<br>2. Check whether the homing timeout time is too short. |
| 9025 | Homing error | The limit signal is incorrect during homing. | Check whether the limit signal that is not applicable to the current homing mode is triggered. |
| 9030 | Limiting active | The limit signal input is active during positioning. | Check whether the limit is reached during normal running. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9031 | Synchronization error | The target number of transmitted pulses and the actual number of transmitted pulses do not match. | Check whether the limit is reached during normal positioning. |
| 9101 | Axis type error or non-existent | 1. The type of the axis specified by AxisID is incorrect.<br>2. The axis specified by AxisID does not exist. | 1. Check whether the instruction supports the axis specified by AxisID.<br>2. Check whether the axis specified by AxisID exists. |
| 9102 | Axis configuration failed | 1. The axis configuration data is lost.<br>2. The axis configuration parameters are improper. | Check whether the parameters are correct. |
| 9103 | MC_Reset called when the axis is not faulty | The MC_Reset instruction is called when the axis is not faulty. | Check whether the MC_Reset instruction is called when the axis is not switched to ErrorStop state. |
| 9104 | Axis state unknown when MC_ReadStatus is called | The axis is in unknown state when the MC_ ReadStatus instruction is called. | Check whether the current state of the axis is uncontrollable by using the online monitoring function. |
| 9105 | Current position setting not allowed | The MC_SetPosition instruction is called during running or stop. | Set the current position when the axis is in StandStill, Poweroff, or ErrorStop state. |
| 9106 | Stopping upon fault | The axis is stopping upon a fault. | Execute the instruction after stop upon fault is completed, the fault is resolved, and the reset instruction is executed. |
| 9107 | Improper parameter | The parameters are improper. | Check whether the parameters on the left of the instruction are set properly. |
| 9108 | Improper PLCOpen state machine | The PLCOpen state machine is improper. | Check whether the current PLCOpen state machine satisfies the execution conditions for this instruction. If not, call the relevant instruction to switch the axis to the required state. |
| 9110 | MC_Stop called repeatedly during stop | The MC_Stop instruction is called repeatedly during stop. | Trigger only one MC_Stop instruction at a time. |
| 9111 | Instruction linked list lost | The instruction linked list is lost. | 1. Check whether the background version and board version match.<br>2. Contact the manufacturer. |
| 9112 | AxisID changed | The value of AxisID is changed while the instruction flow is active. | Do not change the axis number while the flow is active for Enable instructions such as MC_Power and MC_Jog. |
| 9113 | Reset by MC_Reset timed out | Reset by executing the MC_ Reset instruction timed out. | 1. Check whether the drive fault can be reset.<br>2. Check whether the axis fault type supports reset. |
| 9114 | Failed to write to 0x6060 | The axis fails to write to 0x6060. | 1. Check for interference in network communication.<br>2. Check whether the slave supports the object dictionary 0x6060. |
| 9115 | MC_Halt called when the axis is in Stopping state | The MC_Halt instruction is called when the axis is in Stopping state. | Do not call the MC_Halt instruction when the axis is in Stopping state. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9116 | Axis in online commissioning mode | The current axis is in online commissioning mode. | Check whether the current axis is in online commissioning mode. PLC motion control instructions are invalid in online commissioning mode. |
| 9118 | Maximum acceleration (deceleration) exceeded | The acceleration (deceleration) of the instruction exceeds the maximum acceleration. | Check whether the acceleration (deceleration) of the instruction exceeds the maximum acceleration. |
| 9119 | MC_Jog target velocity exceeded maximum jogging velocity | The target velocity of the MC_Jog instruction exceeds the maximum jogging velocity. | Check whether the target velocity of the MC_Jog instruction exceeds the maximum jogging velocity. |
| 9120 | Target velocity exceeded maximum velocity | The target velocity exceeds the maximum velocity. | Check whether the target velocity of the instruction exceeds the maximum velocity. |
| 9121 | Jog forward and reverse motion signals both active | The forward and reverse motion signals of the jog instruction are both active. | Ensure that the forward and reverse motion signals of the jog instruction are not active at the same time. |
| 9122 | Control word not mapped to EtherCAT bus axis | The control word is not mapped to the EtherCAT bus axis. | Add the control word in the PDO and map it to the axis. |
| 9123 | Target position not mapped to EtherCAT bus axis | The target position is not mapped to the EtherCAT bus axis. | Add the target position in the PDO and map it to the axis. |
| 9124 | Target torque not mapped to EtherCAT bus axis | The target torque is not mapped to the EtherCAT bus axis. | Add the target torque in the PDO and map it to the axis. |
| 9125 | Status word not mapped to EtherCAT bus axis | The status word is not mapped to the EtherCAT bus axis. | Add the status word in the PDO and map it to the axis. |
| 9126 | Current position not mapped to EtherCAT bus axis | The current position is not mapped to the EtherCAT bus axis. | Add the feedback position in the PDO and map it to the axis. |
| 9127 | 0x60fd not mapped to EtherCAT bus axis | 0x60fd is not mapped to the EtherCAT bus axis. | Add 0x60fd in the PDO and map it to the axis. |
| 9128 | Current torque not mapped to EtherCAT bus axis | The current torque is not mapped to the EtherCAT bus axis. | Add the current torque in the PDO and map it to the axis. |
| 9129 | Probe control word not mapped to EtherCAT bus axis | The probe control word is not mapped to the EtherCAT bus axis. | Add the probe control word in the PDO and map it to the axis. |
| 9130 | Probe status word not mapped to EtherCAT bus axis | The probe status word is not mapped to the EtherCAT bus axis. | Add the probe status word in the PDO and map it to the axis. |
| 9131 | Probe position not mapped to EtherCAT bus axis | The probe position is not mapped to the EtherCAT bus axis. | Add the probe position in the PDO and map it to the axis. |
| 9132 | Probe channel occupied by interrupt positioning instruction | An interrupt positioning instruction is being executed and the probe channel is occupied. | The probe instruction and interrupt positioning instruction must not occupy the same probe channel at the same time. When the two instructions are called simultaneously in the program, the interrupt positioning instruction takes priority. |
| 9133 | Imaginary axis mode enabled | The imaginary axis mode is enabled. | The current instruction does not support the imaginary axis mode. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9134 | Imaginary axis probe in use | The imaginary axis probe is being used. | The H5U supports two imaginary axis probes. Check whether the current probe is out of range. |
| 9135 | Interrupt signal not triggered in interrupt positioning | The interrupt signal is not triggered in the interrupt positioning instruction. | During execution of the interrupt positioning instruction, no interrupt signal is detected after positioning is completed. |
| 9136 | Probe channel occupied by another instruction during interrupt positioning | The probe channel is occupied by another instruction during the interrupt positioning process. | Ensure that the probe channel is not occupied during the interrupt positioning process. |
| 9137 | Control mode 0x6060 not mapped to bus driver | The control mode 0x6060 is not mapped to the bus driver. | Add 0x6060 in the PDO and map it to the axis. |
| 9138 | Control mode 0x6061 not mapped to bus driver | The control mode 0x6061 is not mapped to the bus driver. | Add 0x6061 in the PDO and map it to the axis. |
| 9139 | MC_Home called repeatedly during homing | The MC_Home instruction is called repeatedly during homing. | Do not call the MC_Home instruction repeatedly during homing. |
| 9140 | Target torque exceeded maximum value | The target torque of the instruction exceeds the maximum value. | Check whether the target torque of the instruction exceeds the positive and negative torque limits. |
| 9141 | Maximum velocity not mapped to bus driver | The maximum velocity is not mapped to the bus driver. | Add 0x607f in the PDO and map it to the axis. |
| 9142 | Immediate stop instruction active | The immediate stop instruction is active. | Check whether the immediate stop instruction has been called. |
| 9143 | Immediate stop instruction called repeatedly | The immediate stop instruction is called repeatedly. | Check whether the immediate stop instruction is called repeatedly. |
| 9144 | Limit reached during jogging | The limit is reached during jogging. | Check whether the limit is active. |
| 9145 | Target position exceeded 9999999 | The precision is reduced if a single-precision floating-point number exceeds 9999999. Therefore, the target position must not exceed this value. | 1. Check whether the target position is correct. Set the target position again.<br>2. Change the gear ratio to ensure that the target position is not greater than 9999999. |
| 9146 | Target velocity exceeded 9999999 | The precision is reduced if a single-precision floating-point number exceeds 9999999. Therefore, the target velocity must not exceed this value. | 1. Check whether the target velocity is correct. Set the target velocity again.<br>2. Change the gear ratio to ensure that the target velocity is not greater than 9999999. |
| 9147 | Target acceleration exceeded 9999999 | The precision is reduced if a single-precision floating-point number exceeds 9999999. Therefore, the target acceleration must not exceed this value. | 1. Check whether the target acceleration is correct. Set the target acceleration again. 2. Change the gear ratio to ensure that the target acceleration is not greater than 9999999. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9148 | Target deceleration exceeded 9999999 | The precision is reduced if a single-precision floating-point number exceeds 9999999. Therefore, the target deceleration must not exceed this value. | 1. Check whether the target deceleration is correct. Set the target deceleration again.<br>2. Change the gear ratio to ensure that the target deceleration is not greater than 9999999. |
| 9149 | Axis in sync control mode, abortion not allowed | 1. A single-axis motion instruction is called when the axis is performing interpolation in sync control mode. The single-axis motion instruction reports an error. | 1. Do not call single-axis motion instructions during interpolation. |
| 9150 | MC_Halt in execution, abortion not allowed | The MC_ MoveSuperImposer instruction is called while the MC_Halt instruction is still active. | Do not call the MC_MoveSuperImposer instruction while the MC_Halt instruction is still active. |
| 9151 | MC_MoveVelocityCSV PulseWidth out of range | The variable PulseWidth of the MC_MoveVelocityCSV instruction is out of range. | Ensure that the parameter value is within the allowable range. |
| 9152 | Object dictionary 60FFh not associated in I/O mapping of bus servo axis when MC_ MoveVelocityCSV is called | The object dictionary 60FFh is not associated in I/O mapping of the bus servo axis when the MC_ MoveVelocityCSV instruction is called. | Ensure that the object dictionary 60FFh is associated in I/O mapping of the bus servo axis when the MC_ MoveVelocityCSV instruction is called. |
| 9153 | Probe terminal not configured | The probe terminal is not configured. | Check whether the software tool version supports configuration of the probe terminal ID. |
| 9154 | MC_SetAxisConfigPara ParameterIndex out of range | The value of ParameterIndex of the MC_ SetAxisConfigPara instruction is out of range. | Ensure that the parameter value is within the allowable range. |
| 9155 | Instruction execution not allowed when axis configuration parameters are being modified | The configuration parameters of the axis are being modified, and execution of this instruction is not allowed before the modification is completed. | Perform the enable operation after axis initialization is completed. |
| 9156 | Multi-execution of MC_ SetAxisConfigPara not allowed | MC_SetAxisConfigPara does not support multi-execution. | Note that this instruction does not support re-execution or multi-execution. |
| 9157 | Gear/cam motion instruction not supported by axis | The gear/cam motion instruction is not supported by the axis due to axis properties. | Ensure that the axis is not in single-axis mode or that the PLC supports the motion instruction. |
| 9200 | Failed to obtain cam table configuration file | Failed to obtain the cam table configuration file. | 1. Check whether the board software and software tool match.<br>2. Re-download the cam configuration table. |
| 9201 | Failed to obtain master axis | Failed to obtain the master axis. | 1. Check whether the master axis called in the program exists.<br>2. Check whether the master axis has reported an error. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9202 | Failed to obtain slave axis | Failed to obtain the slave axis. | 1. Check whether the slave axis called in the program exists.<br>2. Check whether the slave axis has reported an error. |
| 9203 | Failed to obtain cam table | Failed to obtain the cam table. | Check whether the cam table called exists. |
| 9204 | Number of cams executed simultaneously in the PLC program exceeded maximum value | The number of cams executed simultaneously in the PLC program exceeds the maximum allowable value. | Check whether the number of cams executed simultaneously in the program exceeds the threshold. |
| 9205 | No cam node found | The corresponding cam node is not found. | This instruction can be called only when the slave axis is in cam engagement state. |
| 9206 | Master axis changed during cam engagement | The master axis is changed during cam engagement. | Do not change the master axis during cam engagement. |
| 9207 | MC_CamIn StartMode out of range | StartMode of the MC_CamIn instruction is out of range. | Ensure that the parameter value is within the specified range. |
| 9208 | MC_CamIn StartPosition exceeded maximum value | StartPosition of the MC_CamIn instruction exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number in the motion control instruction does not exceed 9999999. |
| 9209 | MC_CamIn MasterStartDistance exceeded maximum value | MasterStartDistance of the MC_CamIn instruction exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number in the motion control instruction does not exceed 9999999. |
| 9210 | MC_CamIn MasterScaling exceeded maximum value | MasterScaling of the MC_CamIn instruction exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number in the motion control instruction does not exceed 9999999. |
| 9211 | MC_CamIn SlaveScaling exceeded maximum value | SlaveScaling of the MC_CamIn instruction exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number in the motion control instruction does not exceed 9999999. |
| 9212 | MC_CamIn MasterOffset exceeded maximum value | MasterOffset of the MC_CamIn instruction exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number in the motion control instruction does not exceed 9999999. |
| 9213 | MC_CamIn SlaveOffset exceeded maximum value | SlaveOffset of the MC_CamIn instruction exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number in the motion control instruction does not exceed 9999999. |
| 9214 | MC_CamIn MasterScaling not positive | MasterScaling of the MC_CamIn instruction is not a positive number. | Set this parameter to a positive number. |
| 9215 | MC_CamIn SlaveScaling not positive | SlaveScaling of the MC_CamIn instruction is not a positive number. | Set this parameter to a positive number. |
| 9216 | MC_CamIn/MC_GearIn ReferenceType out of range | ReferenceType of the MC_CamIn/MC_GearIn instruction is out of range. | Ensure that the parameter value is within the specified range. |
| 9217 | MC_CamIn Direction out of range | Direction of the MC_CamIn instruction is out of range. | Ensure that the parameter value is within the specified range. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9218 | MC_CamIn BufferMode out of range | BufferMode of the MC_CamIn instruction is out of range. | Ensure that the parameter value is within the specified range. |
| 9219 | Master axis phases in cam table node array not in ascending order | The master axis phases in the node array of the cam table are not sorted in ascending order. | Sort the master axis phases in ascending order when customizing cam table nodes. |
| 9220 | Curve type setting of cam table node array out of range | The curve type setting of the node array of the cam table is out of range. | Check whether the curve type of the cam node array is set incorrectly. |
| 9221 | MC_CamOut target deceleration exceeded maximum value | The target deceleration of the MC_CamOut instruction exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number in the motion control instruction does not exceed 9999999. |
| 9222 | MC_CamOut target deceleration out of range | The target deceleration of the MC_CamOut instruction is out of range and causes stop upon a fault. | Ensure that the target deceleration is within the specified range. |
| 9223 | MC_Phasing target acceleration exceeded maximum value | The target acceleration of the MC_Phasing instruction exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number in the motion control instruction does not exceed 9999999. |
| 9224 | MC_Phasing target acceleration out of range | The target acceleration of the MC_Phasing instruction is out of range. | Ensure that the target acceleration is within the specified range. |
| 9225 | MC_Phasing target velocity exceeded maximum value | The target velocity of the MC_Phasing instruction exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number in the motion control instruction does not exceed 9999999. |
| 9226 | MC_Phasing target velocity out of range | The target velocity of the MC_Phasing instruction is out of range. | Ensure that the target deceleration is within the specified range. |
| 9227 | MC_CamOut curve type setting out of range | The curve type setting of the MC_CamOut instruction is out of range. | Ensure that the curve type setpoint in the instruction is within the specified range. |
| 9228 | MC_CamOut Mode out of range | The value of Mode of the MC_CamOut instruction is out of range. | Ensure that the value of Mode is within the specified range. |
| 9229 | Cam node array empty detected by MC_GenerateCamTable | The MC_GenerateCamTable instruction detects that the cam node array is empty. | Contact Inovance for technical support. |
| 9230 | MC_GenerateCamTable node quantity input exceeded maximum value | The node quantity specified by the MC_GenerateCamTable instruction exceeds the maximum allowable value. | Check whether the target node quantity specified in the instruction is beyond the specified range. |
| 9231 | MC_GenerateCamTable Mode out of range | The value of Mode of the MC_GenerateCamTable instruction is out of range. | Ensure that the parameter value is within the specified range. |
| 9232 | MC_GenerateCamTable node quantity input too small | The node quantity specified by the MC_GenerateCamTable instruction is too small. | Ensure that the node quantity is 2 or more. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9233 | MC_GearIn RatioNumerator equal to 0 | The value of RatioNumerator of the MC_GearIn instruction is 0. | Set this parameter to a non-zero floating-point number. |
| 9234 | MC_GearIn RatioDenominator not greater than 0 | The value of RatioDenominator of the MC_GearIn instruction is not greater than 0. | Set this parameter to a floating-point number greater than 0. |
| 9235 | MC_GenerateCamTable in execution when MC_SaveCamTable is called | The MC_GenerateCamTable instruction is being executed when the MC_SaveCamTable instruction is called. | Do not call the MC_SaveCamTable instruction before the cam table data update operation is completed. |
| 9236 | MC_SaveCamTable in execution when MC_GenerateCamTable is called | The MC_SaveCamTable instruction is being executed on the cam table when the MC_GenerateCamTable instruction is called. | Do not call the MC_GenerateCamTable instruction before the cam table is saved. |
| 9237 | Failed to open cam table during execution of MC_SaveCamTable | Failed to open the cam table file during execution of the MC_SaveCamTable instruction. | 1. Check whether the PLC memory runs out.<br>2. Replace the PLC. |
| 9238 | Failed to write cam point quantity when saving the cam table | Failed to write the cam point quantity when the cam table is being saved. | 1. Check whether the PLC memory runs out.<br>2. Replace the PLC. |
| 9239 | Failed to write data when saving cam table | Failed to write data when the cam table is being saved. | 1. Check whether the PLC memory runs out.<br>2. Replace the PLC. |
| 9240 | Phase of the first point not 0 | The phase of the first point is not 0. | Ensure that the phase of the first point is 0. |
| 9241 | Displacement of the first point not 0 | The displacement of the first point is not 0. | Ensure that the displacement of the first point is 0. |
| 9242 | MC_GearOut Mode out of range | The value of Mode of the MC_GearOut instruction is out of range. | Ensure that the value of Mode is within the specified range. |
| 9243 | MC_Phasing target deceleration exceeded maximum value | The target deceleration of the MC_Phasing instruction exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number in the motion control instruction does not exceed 9999999. |
| 9244 | MC_GearIn target deceleration exceeded maximum value | The target deceleration of the MC_GearIn instruction exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number in the motion control instruction does not exceed 9999999. |
| 9245 | MC_CamIn Periodic out of range | The value of Periodic of the MC_CamIn instruction is out of range. | Ensure that the parameter value is within the specified range. |
| 9246 | Cam table phase exceeded maximum value | The phase in the cam table exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number does not exceed 9999999. |
| 9247 | Absolute value of cam table displacement exceeded maximum value | The absolute value of the displacement in the cam table exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number does not exceed 9999999. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9248 | Absolute value of cam table link velocity exceeded maximum value | The absolute value of the link velocity in the cam table exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number does not exceed 9999999. |
| 9249 | Gear node empty | The gear node is empty. | Contact Inovance for technical support. |
| 9250 | Master axis same as slave axis | The master axis and slave axis are the same. | Do not use the same axis as both the master axis and slave axis of the cam gear. |
| 9251 | Master axis configuration address greater than or equal to slave axis address | The configuration address of the master axis is greater than or equal to that of the slave axis. | When ReferenceType is set to set position of the current cycle, ensure that the configuration address of the master axis is less than that of the slave axis. |
| 9252 | Master axis filter coefficient fFilter[0] corresponding to the slave axis out of range | The master axis filter coefficient fFilter[0] corresponding to the slave axis is out of range. | Ensure that the value of this variable is between 0 and 1 (0 and 1 included). |
| 9253 | Master axis filter coefficient fFilter[1] corresponding to the slave axis out of range | The master axis filter coefficient fFilter[1] corresponding to the slave axis is out of range. | Ensure that the value of this variable is between 0 and 1 (0 and 1 included). |
| 9254 | Master axis filter coefficient fFilter[2] corresponding to the slave axis out of range | The master axis filter coefficient fFilter[2] corresponding to the slave axis is out of range. | Ensure that the value of this variable is between 0 and 1 (0 and 1 included). |
| 9255 | Sum of master axis filter coefficients corresponding to the slave axis not 1 | The sum of the master axis filter coefficients corresponding to the slave axis is not 1. | Ensure that the sum of the master axis filter coefficients corresponding to the slave axis is 1. |
| 9256 | Improper StartPosition and MasterStartDistance in MC_CamIn | The start position and start distance of the master axis in the MC_CamIn instruction are improper. | If the master axis works in linear mode and Direction in the instruction is set to positive, ensure that the cam synchronization point is not less than the cam engagement point. |
| 9257 | Improper StartPosition and MasterStartDistance in MC_CamIn | The start position and start distance of the master axis in the MC_CamIn instruction are improper. | If the master axis works in linear mode and Direction in the instruction is set to negative, ensure that the cam synchronization point is not greater than the cam engagement point. |
| 9258 | MC_GearOut target deceleration exceeded maximum value | The target deceleration of the MC_GearOut instruction exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number in the motion control instruction does not exceed 9999999. |
| 9259 | MC_Phasing target deceleration out of range | The target deceleration of the MC_Phasing instruction is out of range and causes stop upon a fault. | Ensure that the target deceleration is within the specified range. |
| 9260 | MC_GearIn target deceleration out of range | The target deceleration of the MC_GearIn instruction is out of range and causes stop upon a fault. | Ensure that the target deceleration is within the specified range. |
| 9261 | MC_GearOut target deceleration out of range | The target deceleration of the MC_GearOut instruction is out of range and causes stop upon a fault. | Ensure that the target deceleration is within the specified range. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9262 | MC_GearIn target acceleration exceeded maximum value | The target acceleration of the MC_GearIn instruction exceeds the maximum allowable value. | Ensure that the absolute value of the floating-point number in the motion control instruction does not exceed 9999999. |
| 9263 | MC_GearIn target acceleration out of range | The target acceleration of the MC_GearIn instruction is out of range. | Ensure that the target acceleration is within the specified range. |
| 9264 | MC_Phasing curve type setting out of range | The curve type setting of the MC_Phasing instruction is out of range. | Ensure that the curve type setpoint in the instruction is within the specified range. |
| 9265 | MC_GearIn curve type setting out of range | The curve type setting of the MC_GearIn instruction is out of range. | Ensure that the curve type setpoint in the instruction is within the specified range. |
| 9266 | MC_GearOut curve type setting out of range | The curve type setting of the MC_GearOut instruction is out of range. | Ensure that the curve type setpoint in the instruction is within the specified range. |
| 9267 | Slave axis changed during cam operation | The slave axis is modified during the cam operation. | Do not modify the slave axis during the cam operation. |
| 9268 | MC_Phasing PhasingMode out of range | The value of PhasingMode of the MC_Phasing instruction is out of range. | Ensure that the value of the parameter is within the specified range. |
| 9269 | Axis not in cam control mode when MC_CamOut is called | The current axis is not in cam control mode when the MC_CamOut instruction is called. | Ensure that the axis works in cam control mode when the MC_CamOut instruction is called. |
| 9270 | Axis not in gear control mode when MC_GearOut is called | The current axis is not in gear control mode when the MC_GearOut instruction is called. | Ensure that the axis works in gear control mode when the MC_GearOut instruction is called. |
| 9271 | Master axis position change too large within a single EtherCAT cycle during cam/gear operation | The position change of the master axis is too large within a single EtherCAT cycle during cam/gear operation. | Ensure that the position change of the master axis is not greater than half a cam cycle within a single EtherCAT cycle. |
| 9272 | MC_ GetCamTableDistance Phase out of range | The point specified by Phase in the MC_ GetCamTableDistance instruction does not fall between the start and end points. | Ensure that the point specified by Phase is within the specified curve. |
| 9273 | Slave axis changed during execution of MC_ GearIn | The slave axis is changed during execution of the MC_GearIn instruction. | Do not change the slave axis during execution of the MC_GearIn instruction. |
| 9274 | MC_DigitalCamSwitch Channel out of range | The value of Channel of the MC_DigitalCamSwitch instruction is out of range. | Ensure that the parameter value is within the specified range. |
| 9275 | No axis found | The axis is not found. | Ensure that the axis specified by Axis exists. |
| 9276 | Number of tappets allowed to be executed at the same time out of range | The number of tappets allowed to be executed at the same time is out of range. | Ensure that the number of tappets allowed to be executed at the same time is within the allowable range. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9277 | MC_DigitalCamSwitch ReferenceType out of range | The value of ReferenceType of the MC_ DigitalCamSwitch instruction is out of range. | Ensure that the parameter value is within the specified range. |
| 9278 | MC_DigitalCamSwitch Number out of range | The value of Number of the MC_DigitalCamSwitch instruction is out of range. | Ensure that the parameter value is within the specified range. |
| 9279 | MC_DigitalCamSwitch Switches array empty | The Switches array of the MC_DigitalCamSwitch instruction is empty. | Check whether the length of the Switches array meets requirements. |
| 9280 | Tappet array fPosition out of range | The value of fPosition of the tappet array is out of range. | Ensure that the parameter value is within the specified range. |
| 9281 | Tappet array iMode out of range | The value of iMode of the tappet array is out of range. | Ensure that the parameter value is within the specified range. |
| 9282 | Tappet array iDirection out of range | The value of iDirection of the tappet array is out of range. | Ensure that the parameter value is within the specified range. |
| 9283 | Tappet array fParameter out of range | The value of fParameter of the tappet array is out of range. | Ensure that the parameter value is within the specified range. |
| 9284 | Time setting out of range in time mode | When the tappet comparison point is set to time mode, the time setting is out of range. | Ensure that the parameter value is within the specified range. |
| 9285 | Selected axis not under cam control when MC_ DigitalCamSwitch ReferenceType is set to 3 | The selected axis is not under cam control when ReferenceType of the MC_ DigitalCamSwitch instruction is set to 3. | Call the MC_DigitalCamSwitch instruction after cam control takes effect. |
| 9286 | Axis communication interrupted during tappet execution | Axis communication is interrupted during tappet execution. | Ensure that axis communication is not interrupted during tappet execution. |
| 9287 | Duplicate comparison position start points | The comparison position start points are the same during tappet execution. | Ensure that the start points are not duplicate. |
| 9288 | Comparison position start point same as end point | The comparison position start and end point are the same during tappet execution. | Ensure that the start and end points are not duplicate. |
| 9289 | Selected tappet terminal in use | The selected tappet terminal is being used by another function. | Check whether the terminal is set as the pulse output axis. |
| 9290 | Failed to execute MC_ DigitalCamSwitch due to improper motion control axis state | The MC_DigitalCamSwitch instruction cannot be executed because the state of the motion control axis is improper. | Do not execute the MC_DigitalCamSwitch instruction in homing mode. |
| 9291 | MasterSyncPosition setting in MC_GearInPos out of range | The MasterSyncPosition setting in the MC_ GearInPos instruction is out of range. | Ensure that the parameter value is within the specified range. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9292 | SlaveSyncPosition setting in MC_GearInPos out of range | The SlaveSyncPosition setting in the MC_GearInPos instruction is out of range. | Ensure that the parameter value is within the specified range. |
| 9293 | MasterStarDistance in MC_GearInPos out of range | The MasterStarDistance setting in the MC_GearInPos instruction is out of range. | Ensure that the parameter value is within the specified range. |
| 9294 | Velocity setting in MC_GearInPos over system limit | The Velocity setting in the MC_GearInPos instruction exceeds the system limit. | Ensure that the parameter value is within the specified range. |
| 9295 | Velocity setting in MC_GearInPos over setting limit | The Velocity setting in the MC_GearInPos instruction exceeds the setting limit. | Ensure that the parameter value is within the specified range. |
| 9296 | Acceleration setting in MC_GearInPos over system limit | The Acceleration setting in the MC_GearInPos instruction exceeds the system limit. | Ensure that the parameter value is within the specified range. |
| 9297 | Acceleration setting in MC_GearInPos over setting limit | The Acceleration setting in the MC_GearInPos instruction exceeds the setting limit. | Ensure that the parameter value is within the specified range. |
| 9298 | Deceleration setting in MC_GearInPos over system limit | The Deceleration setting in the MC_GearInPos instruction exceeds the system limit. | Ensure that the parameter value is within the specified range. |
| 9299 | Deceleration setting in MC_GearInPos over setting limit | The Deceleration setting in the MC_GearInPos instruction exceeds the setting limit. | Ensure that the parameter value is within the specified range. |
| 9300 | AvoidReversal in MC_GearInPos out of range | The AvoidReversal setting in the MC_GearInPos instruction is out of range. | Ensure that the parameter value is within the specified range. |
| 9301 | Zero master axis speed when MC_GearInPos instruction is started | The master axis speed is zero when the MC_GearInPos instruction is started. | Ensure that the master axis speed is not zero when starting this instruction. |
| 9302 | Zero master axis displacement in catching phase of MC_GearInPos | The master axis did not move during the catching phase of the MC_GearInPos instruction. | When MasterStarDistance is set to 0, ensure that the input MasterSyncPosition does not overlap with the current position of the master axis. |
| 9303 | Slave axis speed not zero before entering chasing phase after MC_GearInPos is started | When the MC_GearInPos instruction is started, the speed of the slave axis is not zero before entering the catching phase. | Ensure that the slave axis remains stationary before entering the catching phase. |
| 9304 | Failed to enter catching phase of MC_GearInPos | The MC_GearInPos instruction cannot enter the catching phase. | Ensure that the master axis can enter the catching phase under the current position and motion direction conditions. |
| 9305 | Slave axis over-speed during MC_GearInPos operation | During the operation of the MC_GearInPos instruction, the speed of the slave axis exceeds the limit. | Ensure that the parameter value is within the specified range. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9400 | Maximum axis group quantity exceeded | The number of axis groups exceeds the maximum allowable value. | Reduce the number of axis groups in the project so that it does not exceed the maximum value. |
| 9401 | Faulty axis in axis group | An axis in the axis group is faulty. | Locate the faulty axis, view the fault codes of the axis, and rectify the fault. |
| 9402 | Number of buffered interpolation instructions exceeded 8 | The number of buffered interpolation instructions is greater than 8. | Check whether the number of buffered interpolation instructions is greater than 8. |
| 9403 | Axis reused | An axis in the axis group is reused. | Each axis can be used in only one axis group. Check whether there is a reused axis in the axis group and replace it with an unused axis. |
| 9404 | Failed to create axis group | The x-axis or y-axis does not exist. | Check whether the x-axis and y-axis exist. An axis group consists of at least the x-axis and y-axis. |
| 9405 | Specified z-axis non-existent | The z-axis is specified in the instruction but does not exist in the configuration. | Check whether the z-axis specified in the instruction exists. |
| 9406 | Specified auxiliary axis non-existent | The auxiliary axis is specified in the instruction but does not exist in the configuration. | Check whether the auxiliary axis specified in the instruction exists. |
| 9407 | Axis group ID duplicated | The specified axis group ID has been used. | Change the axis group ID because the axis group ID must be unique. |
| 9408 | Axis configuration failed | Failed to configure the axis. | Check whether any axis in the axis group fails to be configured. If yes, check whether the board software and the background match. |
| 9409 | Axis ID less than 0 | The axis ID is less than 0. | Check whether the ID of an axis in the axis group is less than 0. |
| 9410 | Axis group not released | The axis group is not released because the same MC_SetAxesGroup instruction is triggered repeatedly in a short time period. | Do not re-trigger the MC_SetAxesGroup instruction while its Busy signal output is still active. |
| 9411 | MC_GroupStop aborted | The MC_GroupStop instruction is aborted. | Check whether an instruction with higher priority is called while the MC_GroupStop instruction is still active. |
| 9412 | Circular interpolation instruction CircAxes out of range | The value of CircAxes of the circular interpolation instruction is out of range. | Check whether the value of CircAxes of the circular interpolation instruction is out of range. |
| 9413 | Circular interpolation instruction CircMode out of range | The value of CircMode of the circular interpolation instruction is out of range. | Check whether the value of CircMode of the circular interpolation instruction is out of range. |
| 9414 | Circular interpolation instruction PathChoice out of range | The value of PathChoice of the circular interpolation instruction is out of range. | Check whether the value of PathChoice of the circular interpolation instruction is out of range. |
| 9415 | Stop instruction StopMode out of range | The value of StopMode of the stop instruction is out of range. | Check whether the value of StopMode of the stop instruction is out of range. |
| 9416 | X-axis set to ring mode | The x-axis is set to ring mode. | Do not set the motion control axis to the ring mode in an interpolation instruction. |
| 9417 | Y-axis set to ring mode | The y-axis is set to ring mode. | Do not set the motion control axis to the ring mode in an interpolation instruction. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9418 | Z-axis set to ring mode | The z-axis is set to ring mode. | Do not set the motion control axis to the ring mode in an interpolation instruction. |
| 9419 | Auxiliary axis set to ring mode | The auxiliary axis is set to ring mode. | Do not set the motion control axis to the ring mode in an interpolation instruction. |
| 9420 | Circular interpolation instruction triggered repeatedly | The circular interpolation instruction is triggered repeatedly. | Do not re-trigger the same circular interpolation instruction while its Busy signal output is still active. |
| 9421 | Linear interpolation instruction triggered repeatedly | The linear interpolation instruction is triggered repeatedly. | Do not re-trigger the same linear interpolation instruction while its Busy signal output is still active. |
| 9422 | Failed to obtain the axis group | Failed to obtain the axis group. | Check whether the axis group specified by GroupID has been created by calling MC_SetAxesGroup. |
| 9423 | Axis configuration failed | Failed to configure the axis. | Check whether an instruction is triggered when axis configuration is not completed. Check whether the communication state of all axes in the axis group is Axis ready. |
| 9424 | Axis disabled | An axis is disabled. | Do not call the interpolation instruction when any axis is in Disabled state. |
| 9425 | Axis in execution of single-axis motion instruction | The interpolation instruction is triggered when an axis is executing a single-axis motion instruction. | Do not call the interpolation instruction when any axis is executing single-axis motion instructions and not in StandStill state. |
| 9426 | Axis in Stopping state | An axis is in Stopping state. | Do not call the interpolation instruction when any axis is in Stopping state after executing the MC_Stop instruction. |
| 9427 | Axis group in Stopping state | The axis group is in Stopping state. | Do not call the interpolation instruction while the MC_GroupStop instruction is still active. |
| 9428 | Axis in Homing state | An axis is in Homing state. | Do not call the interpolation instruction when any axis is in Homing state after executing the MC_Home instruction. |
| 9429 | Axis in execution of the position setting instruction | An axis is executing the position setting instruction. | Do not call the interpolation instruction when any axis is setting the current position by executing the MC_SetPosition instruction. |
| 9430 | Axis in commissioning state | An axis is in commissioning state. | Do not call the interpolation instruction when any axis is in commissioning state. |
| 9431 | Axis in commissioning state during interpolation, aborted instruction execution of other axes | An axis enters the commissioning state during interpolation, which aborts instruction execution of other axes. | Check whether any axis enters the commissioning state during interpolation and aborts instruction execution of other axes. |
| 9432 | Failed to request memory | Failed to request the memory. | Check whether the memory runs out. Contact the manufacturer. |
| 9433 | Target velocity less than or equal to 0 | The target velocity is 0 or less than 0. | Ensure that the target velocity of the instruction is greater than 0. |
| 9434 | Target acceleration less than or equal to 0 | The target acceleration is 0 or less than 0. | Ensure that the target acceleration of the instruction is greater than 0. |
| 9435 | Target deceleration less than or equal to 0 | The target deceleration is 0 or less than 0. | Ensure that the target deceleration of the instruction is greater than 0. |
| 9436 | Curve type setting out of range | The curve type setting is out of range. | Check whether the curve type is set to a value other than the T-shaped curve for the interpolation instruction. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9437 | Improper AbsRelMode | AbsRelMode is set incorrectly. | Check whether the parameter is set to a value other than the absolute positioning and relative positioning modes. |
| 9438 | Improper BufferMode | BufferMode is set incorrectly. | Check whether the value of BufferMode is proper. |
| 9439 | Improper InsertMode | InsertMode is set incorrectly. | Check whether the value of InsertMode is proper. |
| 9440 | Axis stopped due to a fault | An axis stops due to a fault. | Locate the faulty axis and rectify the fault based on the fault code. |
| 9441 | MC_GroupStop called repeatedly | The MC_GroupStop instruction is called repeatedly. | Do not re-trigger an MC_GroupStop instruction or call other MC_GroupStop instructions while an MC_GroupStop instruction is still active. |
| 9442 | Data buffer area not empty | The data buffer area is not empty. It is an internal fault. | Contact the manufacturer. |
| 9443 | Not a circle | No circle can be drawn due to improper parameter settings. | Update the parameter settings. |
| 9444 | Not a circle | The start, end, and border points in the circular interpolation instruction are the same point, and no circle can be drawn. | Check the input parameters of the circular interpolation instruction and ensure that the start, end, and border points can form a circle. |
| 9445 | Instruction buffer area full | The instruction buffer area is full. | Contact Inovance for technical support. |
| 9446 | X-axis exceeded maximum velocity | The velocity of the x-axis exceeds the maximum allowable velocity. | Ensure that the target velocity of the x-axis is not greater than the maximum allowable velocity. |
| 9447 | Y-axis exceeded maximum velocity | The velocity of the y-axis exceeds the maximum allowable velocity. | Ensure that the target velocity of the y-axis is not greater than the maximum allowable velocity. |
| 9448 | Z-axis exceeded maximum velocity | The velocity of the z-axis exceeds the maximum allowable velocity. | Ensure that the target velocity of the z-axis is not greater than the maximum allowable velocity. |
| 9449 | Auxiliary axis exceeded maximum velocity | The velocity of the auxiliary axis exceeds the maximum allowable velocity. | Ensure that the target velocity of the auxiliary axis is not greater than the maximum allowable velocity. |
| 9450 | Failed to obtain the number of axis groups | Failed to obtain the number of axis groups. | Update the software tool to the latest version. |
| 9451 | Internal fault | An internal fault occurs. | Contact the manufacturer. |
| 9452 | Instruction called when the axis is in StandStill state | The instruction is called when the axis is in StandStill state. | Do not call this instruction when the axis is StandStill state. |
| 9453 | Maximum velocity exceeded | The maximum velocity specified on the axis group configuration interface is exceeded. | Check whether the target velocity of the instruction is greater than the maximum velocity specified on the axis group configuration interface. |
| 9454 | Maximum acceleration (deceleration) exceeded | The maximum allowable acceleration (deceleration) is exceeded. | Check whether the target acceleration (deceleration) of the instruction is greater than the maximum acceleration (deceleration) specified on the axis group configuration interface. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9455 | Axis group fault due to linear interpolation instruction error | The axis group becomes faulty due to an error reported by the linear interpolation instruction. | Identify the first linear interpolation instruction that reports the error and troubleshoot the fault based on the fault code. |
| 9456 | Axis group fault due to circular interpolation instruction error | The axis group becomes faulty due to an error reported by the circular interpolation instruction. | Identify the first circular interpolation instruction that reports the error and troubleshoot the fault based on the fault code. |
| 9457 | Axis group fault due to axis group stop instruction error | The axis group becomes faulty due to an error reported by the axis group stop instruction. | Identify the first axis group stop instruction that reports the error and troubleshoot the fault based on the fault code. |
| 9458 | Axis group fault due to axis group pause instruction error | The axis group becomes faulty due to an error reported by the axis group pause instruction. | Identify the first axis group pause instruction that reports the error and troubleshoot the fault based on the fault code. |
| 9459 | X-axis performing the interpolation algorithm of another axis group | The x-axis in the axis group is performing the interpolation algorithm of another axis group. | An axis can be configured in different axis groups at the same time. However, ensure that it executes the interpolation instruction of only one axis group at the same time. |
| 9460 | Y-axis performing the interpolation algorithm of another axis group | The y-axis in the axis group is performing the interpolation algorithm of another axis group. | An axis can be configured in different axis groups at the same time. However, ensure that it executes the interpolation instruction of only one axis group at the same time. |
| 9461 | Z-axis performing the interpolation algorithm of another axis group | The z-axis in the axis group is performing the interpolation algorithm of another axis group. | An axis can be configured in different axis groups at the same time. However, ensure that it executes the interpolation instruction of only one axis group at the same time. |
| 9462 | Auxiliary axis performing the interpolation algorithm of another axis group | The auxiliary axis in the axis group is performing the interpolation algorithm of another axis group. | An axis can be configured in different axis groups at the same time. However, ensure that it executes the interpolation instruction of only one axis group at the same time. |
| 9463 | Axes in synchronous mode but not under axis group control when the MC_GroupStop instruction is called | When the MC_GroupStop instruction is called, the axes are in synchronous mode but not under axis group control, such as interpolation control or cam control. | Note that the MC_GroupStop instruction can be called only when the axes in the axis group are in synchronous mode under axis group control. Do not call the MC_GroupStop instruction when the axes enter the synchronous mode due to other instructions. |
| 9464 | Axes in synchronous mode but not under axis group control when the linear or circular interpolation instruction is called | When the linear or circular interpolation instruction is called, the axes are in synchronous mode but not under axis group control, such as interpolation control or cam control. | Note that the linear or circular interpolation instruction can be called only when the axes in the axis group are in synchronous mode under axis group control. Do not call the linear or circular interpolation instruction when the axes enter the synchronous mode due to other non-axis-group instructions. |
| 9465 | Axes in synchronous mode but not under axis group control when the MC_GroupHalt instruction is called | When the MC_GroupHalt instruction is called, the axes are in synchronous mode but not under axis group control, such as interpolation control or cam control. | Note that the MC_GroupHalt instruction can be called only when the axes in the axis group are in synchronous mode under axis group control. Do not call the MC_GroupHalt instruction when the axes enter the synchronous mode due to other instructions. |

| Fault Code | Message | Description | Troubleshooting |
| --- | --- | --- | --- |
| 9466 | Unreasonable NumOfTurns in MC_MoveEllipse | The NumOfTurns parameter in the MC_MoveEllipse instruction is set unreasonably. | Ensure that the parameter value is within the allowable range. |
| 9467 | Unreasonable AddLength in MC_MoveEllipse | The AddLength parameter in the MC_MoveEllipse instruction is set unreasonably. | Ensure that the parameter value is within the allowable range. |
| 9468 | Shutdown due to MC_MoveEllipse failure | MC_MoveEllipse instruction fails and causes shutdown. | Find the MC_MoveEllipse instruction that caused the failure and check the fault code of the instruction to further confirm the fault. |
| 9469 | Unreasonable CircAxes in MC_MoveEllipse | The CircAxes parameter in the MC_MoveEllipse instruction is set unreasonably. | Ensure that the parameter value is within the allowable range. |
| 9470 | Unreasonable CircMode in MC_MoveEllipse | The CircMode parameter in the MC_MoveEllipse instruction is set unreasonably. | Ensure that the parameter value is within the allowable range. |
| 9471 | Unreasonable PathChoice in MC_MoveEllipse | The PathChoice parameter in the MC_MoveEllipse instruction is set unreasonably. | Ensure that the parameter value is within the allowable range. |
| 9472 | Unreasonable Velocity in MC_MoveEllipse | The Velocity parameter in the MC_MoveEllipse instruction is set unreasonably. | Ensure that the parameter value is within the allowable range. |
| 9473 | Unreasonable Acceleration in MC_MoveEllipse | The Acceleration parameter in the MC_MoveEllipse instruction is set unreasonably. | Ensure that the parameter value is within the allowable range. |
| 9474 | Unreasonable Deceleration in MC_MoveEllipse | The Deceleration parameter in the MC_MoveEllipse instruction is set unreasonably. | Ensure that the parameter value is within the allowable range. |
| 9475 | Unreasonable BufferMode in MC_MoveEllipse | The BufferMode parameter in the MC_MoveEllipse instruction is set unreasonably. | Ensure that the parameter value is within the allowable range. |
| 9476 | Cannot form ellipse due to unreasonable center point, long axis length, and short axis length | The set center point, long axis length, and short axis length are unreasonable and cannot form an ellipse. | Ensure that the parameter value is within the allowable range. |
| 9477 | Interpolation not supported by X-axis | The property of the X-axis in the axis group instruction does not support interpolation motion. | Ensure that the X-axis is not in single-axis mode. |
| 9478 | Interpolation not supported by Y-axis | The property of the Y-axis in the axis group instruction does not support interpolation motion. | Ensure that the Y-axis is not in single-axis mode. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9479 | Interpolation not supported by Z-axis | The property of the Z-axis in the axis group instruction does not support interpolation motion. | Ensure that the Z-axis is not in single-axis mode. |
| 9480 | Interpolation not supported by auxiliary axis | The property of the auxiliary axis in the axis group instruction does not support interpolation motion. | Ensure that the auxiliary axis is not in single-axis mode. |
| 9501 | EtherCAT bus drive error | A drive error occurs. The fault code in the object dictionary 0x603F of the drive is 0x%x{16:16}. | 1. Determine the drive fault type according to the bus drive guide and rectify the fault. |
| 9502 | Drive disabled | The drive is disabled. | 1. Check whether the drive status word 0x6041 switches to the disabled state during motion.<br>2. Check whether communication is disconnected during motion. |
| 9503 | Limit reached | The limit is reached. | 1. Check whether the software limit is configured and reached.<br>2. Check whether the hardware limit is reached. |
| 9505 | Failed to modify the control mode | Failed to modify the control mode. | 1. Check for interference in network communication.<br>2. Check whether the drive supports the object dictionary 0x6060. |
| 9508 | Homing failed | Homing failed. | 1. Identify the cause of the drive homing failure based on the fault code.<br>2. Check whether homing timed out. |
| 9509 | Axis internal calculation precision error | An axis internal calculation precision error occurs. | Check whether the floating-point data of the instruction falls beyond the single-precision floating-point number range. |
| 9510 | Following error out of range | The following error is out of range. | 1. Check whether the acceleration is too large.<br>2. Check whether the set following error is too small. |
| 9512 | Servo drive disconnected during operation | The servo drive is disconnected during operation. | 1. Check whether the drive works properly.<br>2. Check whether the network cable is properly connected.<br>3. Check for strong interference in communication. |
| 9513 | Homing failed due to a drive fault | Homing failed due to a drive fault. | Check the fault code of the drive to eliminate the fault. |
| 9514 | Homing failed because the homing offset exceeded 32 bits | Homing failed because the homing offset exceeded 32 bits. | Check whether the homing offset multiplied by the gear ratio exceeds 32 bits; if yes, change the gear ratio. |
| 9515 | Homing failed due to loss of the slave | Homing failed because the EtherCAT drive is lost. | Contact Inovance for technical support. |
| 9516 | Homing failed because the SDO failed to write to object dictionary 0x607C | Homing failed because the SDO failed to write to object dictionary 0x607C. | 1. Check whether the drive supports 0x607C.<br>2. Check the network communication quality. |
| 9517 | Homing failed because the SDO failed to write 6 to object dictionary 0x6060 | Homing failed because the SDO failed to write 6 to object dictionary 0x6060. | 1. Set 0x6060 in the PDO.<br>2. Check the network communication quality. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9518 | Homing failed because the SDO failed to read object dictionary 0x6061 | Homing failed because the SDO failed to read object dictionary 0x6061. | 1. Set 0x6061 in the PDO.<br>2. Check the network communication quality. |
| 9519 | Homing failed because the SDO failed to write 8 into object dictionary 0x6060 | Homing failed because the SDO failed to write 8 into object dictionary 0x6060. | 1. Set 0x6060 in the PDO.<br>2. Check the network communication quality. |
| 9551 | Failed to switch the control mode | Failed to switch the control mode. | Check for interference in network communication. |
| 9552 | Target velocity equal to 0 | The target velocity is 0. | Check whether the target velocity of position instructions is appropriate. |
| 9601 | Axis stopped due to MC_ MoveAbsolute parameter exception | The axis stops due to parameter exception of the MC_MoveAbsolute instruction. | Check the instruction that reports the error, and further determine the fault based on the fault code of the instruction. |
| 9602 | Axis stopped due to MC_ MoveRelative parameter exception | The axis stops due to parameter exception of the MC_MoveRelative instruction. | Check the instruction that reports the error, and further determine the fault based on the fault code of the instruction. |
| 9603 | Axis stopped due to MC_ MoveVelocity exception | The axis stops due to exception of the MC_ MoveVelocity instruction. | Check the instruction that reports the error, and further determine the fault based on the fault code of the instruction. |
| 9604 | Axis stopped due to MC_ Jog exception | The axis stops due to exception of the MC_Jog instruction. | Check the instruction that reports the error, and further determine the fault based on the fault code of the instruction. |
| 9605 | Axis stopped due to MC_ MoveVelocityCSV exception | The axis stops due to exception of the MC_ MoveVelocityCSV instruction. | Check the instruction that reports the error, and further determine the fault based on the fault code of the instruction. |
| 9606 | Axis stopped due to MC_ MoveBuffer exception | The axis stops due to exception of the MC_ MoveBuffer instruction. | Check the instruction that reports the error, and further determine the fault based on the fault code of the instruction. |
| 9607 | Axis stopped due to MC_ MoveFeed parameter exception | The axis stops due to parameter exception of the MC_MoveFeed instruction. | Check the instruction that reports the error, and further determine the fault based on the fault code of the instruction. |
| 9608 | Axis stopped due to MC_ Stop parameter exception | The axis stops due to parameter exception of the MC_Stop instruction. | Check the instruction that reports the error, and further determine the fault based on the fault code of the instruction. |
| 9609 | Axis stopped due to MC_ MoveTorque parameter exception | The axis stops due to parameter exception of the MC_MoveTorque instruction. | Check the instruction that reports the error, and further determine the fault based on the fault code of the instruction. |
| 9610 | Axis stopped due to MC_ Halt parameter exception | The axis stops due to parameter exception of the MC_Halt instruction. | Check the instruction that reports the error, and further determine the fault based on the fault code of the instruction. |
| 9611 | Axis stopped due to MC_ MoveSuperImposed parameter exception | The axis stops due to parameter exception of the MC_MoveSuperImposed instruction. | Check the instruction that reports the error, and further determine the fault based on the fault code of the instruction. |
| 9612 | Axis stopped due to MC_ SyncMoveVelocity error | The axis stops due to an error reported by the MC_ SyncMoveVelocity instruction. | Check the instruction that reports the error, and further determine the fault based on the fault code of the instruction. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9613 | Axis stopped due to MC_ SyncTorqueControl error | The axis stops due to an error reported by the MC_ SyncTorqueControl instruction. | Check the instruction that reports the error, and further determine the fault based on the fault code of the instruction. |
| 9614 | Axis stopped due to MC_ FollowVelocity error | The axis stops due to an error reported by the MC_ FollowVelocity instruction. | Check the instruction that reports the error, and further determine the fault based on the fault code of the instruction. |
| 9701 | Failed to request memory for the encoder axis instruction | The encoder axis instruction failed to request the memory. | 1. Check whether the PLC memory runs out.<br>2. Contact the manufacturer. |
| 9702 | 1. Encoder axis type error<br>2. Requested encoder axis non-existent<br>3. Instruction not supported in offline commissioning | 1. The encoder axis type is incorrect.<br>2. The requested encoder axis does not exist.<br>3. The instruction is not supported in offline commissioning. | 1. This instruction does not support the set axis type. Check whether the axis type setting is incorrect.<br>2. The instruction is not supported in offline commissioning. |
| 9703 | Axis configuration failed | Failed to configure the axis. | Check whether the board software and the software tool match. |
| 9704 | Counter operation command not configured in I/O mapping of encoder axis | Counter operation command is not configured in I/O mapping of the encoder axis. | Configure Counter operation command in I/O mapping of the encoder axis. |
| 9705 | Counter status not configured in I/O mapping of encoder axis | Counter status is not configured in I/O mapping of the encoder axis. | Configure Counter status in I/O mapping of the encoder axis. |
| 9706 | Encoder present position not configured in I/O mapping of encoder axis | Encoder present position is not configured in I/O mapping of the encoder axis. | Configure Encoder present position in I/O mapping of the encoder axis. |
| 9707 | Pulse rate not configured in I/O mapping of encoder axis | Pulse rate is not configured in I/O mapping of the encoder axis. | Configure Pulse rate in I/O mapping of the encoder axis. |
| 9708 | Positive limit not greater than negative limit | The positive limit of the encoder axis is not greater than the negative limit. | Ensure that the positive limit of the encoder axis is greater than the negative limit. |
| 9709 | Positive limit greater than 2147483647 after being converted into the pulse unit | The positive limit of the encoder axis is greater than 2147483647 after being converted into the pulse unit. | Ensure that the positive limit of the encoder axis is less than or equal to 2147483647 after being converted into the pulse unit. |
| 9710 | Negative limit less than –2147483648 after being converted into the pulse unit | The negative limit of the encoder axis is less than –2147483648 after being converted into the pulse unit. | Ensure that the negative limit of the encoder axis is greater than or equal to –2147483648 after being converted into the pulse unit. |
| 9711 | revolution cycle in ring mode greater than 2147483647 after being converted into the pulse unit | The revolution cycle of the encoder axis in ring mode is greater than 2147483647 after being converted into the pulse unit. | Ensure that the revolution cycle of the encoder axis in ring mode is less than or equal to 2147483647 after being converted into the pulse unit. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9712 | Encoder axis changed while ENC_Counter is active | The encoder axis is changed while the ENC_ Counter instruction is still active. | Do not change the encoder axis while the ENC_ Counter instruction is still active. |
| 9713 | GR10-2HCE module faulty | The GR10-2HCE module is faulty. | Check the fault code object dictionary of the GR10-2HCE module and troubleshoot the fault according to the fault code. |
| 9714 | Failed to reset the encoder axis fault | Failed to reset the encoder axis fault. | 1. The current fault of the encoder axis does not support reset.<br>2. The encoder shaft enters the faulty state immediately after the fault is reset. Check the axis fault codes and slave fault codes to further determine the fault type. |
| 9715 | ENC_Reset called when the encoder axis is not faulty | The ENC_Reset instruction is called when the encoder axis is not faulty. | Do not call the ENC_Reset instruction when the encoder axis is not faulty. |
| 9716 | ENC_Preset TriggerMode out of range | The value of TriggerMode of the ENC_Preset instruction is out of range. | Ensure that the parameter value is within the allowable range. |
| 9717 | ENC_Preset Position greater than 9999999 | The value of Position of the ENC_Preset instruction is greater than 9999999. | Set Position of the ENC_Preset instruction to a value less than or equal to 9999999. |
| 9718 | Physical output command not configured in I/O mapping of encoder axis | Physical output command is not configured in I/O mapping of the encoder axis. | Configure Physical output command in I/O mapping of the encoder axis. |
| 9719 | Preset position or comparison output position greater than positive limit | The preset position or comparison output position of the encoder axis instruction is greater than the positive limit. | Ensure that the preset position or comparison output position of the encoder axis instruction is less than or equal to the positive limit. |
| 9720 | Preset position or comparison output position less than negative limit | The preset position or comparison output position of the encoder axis instruction is less than the negative limit. | Ensure that the preset position or comparison output position of the encoder axis instruction is greater than or equal to the negative limit. |
| 9721 | Preset position or comparison output position greater than 2147483647 or less than –2147483648 after being converted into the pulse unit | The preset position or comparison output position of the encoder axis instruction is greater than 2147483647 or less than –2147483648 after being converted into the pulse unit. | Ensure that the preset position or comparison output position of the encoder axis instruction is between –2147483648 and +2147483647 after being converted into the pulse unit. |
| 9722 | Preset position or comparison output position greater than or equal to revolution cycle in ring mode | The preset position or comparison output position of the encoder axis instruction is greater than or equal to the revolution cycle in ring mode. | Ensure that the preset position or comparison output position of the encoder axis instruction is less than the revolution cycle in ring mode. |
| 9723 | ENC_TouchProbe ProbeID out of range | The value of ProbeID of the ENC_TouchProbe instruction is out of range. | Ensure that the parameter value is within the allowable range. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9724 | ENC_TouchProbe TriggerEdge out of range | The value of TriggerEdge of the ENC_TouchProbe instruction is out of range. | Ensure that the parameter value is within the allowable range. |
| 9725 | ENC_TouchProbe TerminalSource out of range | The value of TerminalSource of the ENC_TouchProbe instruction is out of range. | Ensure that the parameter value is within the allowable range. |
| 9726 | ENC_TouchProbe TriggerMode out of range | The value of TriggerMode of the ENC_TouchProbe instruction is out of range. | Ensure that the parameter value is within the allowable range. |
| 9727 | Probe status word not associated in I/O mapping of the encoder axis | The probe status word is not associated in I/O mapping of the encoder axis. | Ensure that the probe status word is associated in I/O mapping of the encoder axis. |
| 9728 | Probe feedback position not associated in I/O mapping of the encoder axis | The probe feedback position is not associated in I/O mapping of the encoder axis. | Ensure that the probe feedback position is associated in I/O mapping of the encoder axis. |
| 9729 | Control word not associated in I/O mapping of the encoder axis | The control word is not associated in I/O mapping of the encoder axis. | Ensure that the control word is associated in I/O mapping of the encoder axis. |
| 9730 | Window start position not less than end position | The probe window function of the encoder axis is enabled, but the start position of the window is not less than the end position. | Ensure that the start position of the probe window is less than the end position. |
| 9731 | Xn0 not assigned with probe function | The Xn0 terminal is not assigned with the probe function. | Assign the probe function to the Xn0 terminal. |
| 9732 | Xn1 not assigned with probe function | The Xn1 terminal is not assigned with the probe function. | Assign the probe function to the Xn1 terminal. |
| 9742 | Compare mode not configured in I/O mapping of encoder axis | Compare mode is not configured in I/O mapping of the encoder axis. | Configure Compare mode in I/O mapping of the encoder axis. |
| 9743 | Compare pulse/time not configured in I/O mapping of encoder axis | Compare pulse/time is not configured in I/O mapping of the encoder axis. | Configure Compare pulse/time in I/O mapping of the encoder axis. |
| 9744 | Compare size/step not configured in I/O mapping of encoder axis | Compare size/step is not configured in I/O mapping of the encoder axis. | Configure Compare size/step in I/O mapping of the encoder axis. |
| 9745 | Compare point value 1 not configured in I/O mapping of encoder axis | Compare point value 1 is not configured in I/O mapping of the encoder axis. | Configure Compare point value 1 in I/O mapping of the encoder axis. |
| 9746 | Compare point value 2 not configured in I/O mapping of encoder axis | Compare point value 2 is not configured in I/O mapping of the encoder axis. | Configure Compare point value 2 in I/O mapping of the encoder axis. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9747 | Physical output status not configured in I/O mapping of encoder axis | Physical output status is not configured in I/O mapping of the encoder axis. | Configure Physical output status in I/O mapping of the encoder axis. |
| 9748 | Compare error code not configured in I/O mapping of encoder axis | Compare error code is not configured in I/O mapping of the encoder axis. | Configure Compare error code in I/O mapping of the encoder axis. |
| 9749 | Current compare number/position not configured in I/O mapping of encoder axis | Current compare number/ position is not configured in I/O mapping of the encoder axis. | Configure Current compare number/position in I/O mapping of the encoder axis. |
| 9750 | Failed to obtain the array start address of the single-axis array comparison output instruction | Failed to obtain the start address of the array of the single-axis array comparison output instruction. | 1. Check whether the PLC memory is sufficient.<br>2. Check whether the background and board software match.<br>3. Check whether the array of the instruction is out of bounds. |
| 9751 | Failed to obtain the axis group start address of the axis group array comparison output instruction | Failed to obtain the start address of the axis group of the axis group array comparison output instruction. | 1. Check whether the PLC memory is sufficient.<br>2. Check whether the background and board software match.<br>3. Check whether the array of the instruction is out of bounds. |
| 9752 | Bus encoder axis not associated with slave | The bus encoder axis is not associated with any slave. | Associate the bus encoder axis with a slave. |
| 9753 | X-axis and y-axis of the axis group array comparison instruction not associated with the same slave | The x-axis and y-axis of the axis group array comparison instruction are not associated with the same slave. | Associate the x-axis and y-axis of the axis group comparison output instruction with the same slave. |
| 9754 | X-axis of the axis group array comparison instruction not associated with the first channel of the slave | The x-axis of the axis group array comparison instruction is not associated with the first channel of the slave. | Associate the x-axis of the axis group comparison output instruction with the first channel of the slave. |
| 9755 | Y-axis of the axis group array comparison instruction not associated with the second channel of the slave | The y-axis of the axis group array comparison instruction is not associated with the second channel of the slave. | Associate the y-axis of the axis group comparison output instruction with the second channel of the slave. |
| 9756 | Yn0 not assigned with the one-dimensional comparison output function | The Yn0 terminal is not assigned with the one-dimensional comparison output function. | Assign the one-dimensional comparison output function to the Yn0 output terminal corresponding to the channel. |
| 9757 | Absolute value of start value of encoder axis step comparison output instruction greater than 9999999 | The absolute value of the start value of the encoder axis step comparison output instruction is greater than 9999999. | Ensure that the absolute value of the floating-point number in the motion instruction does not exceed 9999999. |
| 9758 | Absolute value of end value of encoder axis step comparison output instruction greater than 9999999 | The absolute value of the end value of the encoder axis step comparison output instruction is greater than 9999999. | Ensure that the absolute value of the floating-point number in the motion instruction does not exceed 9999999. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9759 | Absolute value of the step of the encoder axis step comparison output instruction greater than 9999999 | The absolute value of the step of the encoder axis step comparison output instruction is greater than 9999999. | Ensure that the absolute value of the floating-point number in the motion instruction does not exceed 9999999. |
| 9760 | Absolute value of Parameter of the encoder axis step comparison output instruction greater than 9999999 | The absolute value of Parameter of the encoder axis step comparison output instruction is greater than 9999999. | Ensure that the absolute value of the floating-point number in the motion instruction does not exceed 9999999. |
| 9761 | Mode of the encoder axis comparison output instruction out of range | The value of Mode of the encoder axis comparison output instruction is out of range. | Ensure that the parameter value is within the allowable range. |
| 9762 | Time for time control of the encoder axis comparison output out of range | The time for time control of the encoder axis comparison output is out of range. | Ensure that the parameter value is within the allowable range. |
| 9763 | Step of the encoder axis step comparison output instruction equal to 0 | The step of the encoder axis step comparison output instruction is 0. | Set the step of the step comparison output instruction to a value other than 0. |
| 9764 | Start position of the step comparison output instruction equal to end position | The start position of the step comparison output instruction of the encoder axis is equal to the end position. | Ensure that the start position of the step comparison output instruction is not equal to the end position. |
| 9765 | Start position of the step comparison output instruction less than end position, but step negative | The start position of the step comparison output instruction of the encoder axis is less than the end position, but the step is negative. | Set the step to a positive value. |
| 9766 | Start position of the step comparison output instruction greater than end position, but step positive | The start position of the step comparison output instruction of the encoder axis is greater than the end position, but the step is positive. | Set the step to a negative value. |
| 9767 | Size of the encoder axis array comparison output instruction out of range | The value of Size of the encoder axis array comparison output instruction is out of range. | Ensure that the parameter value is within the allowable range. |
| 9768 | Absolute value of the target position of the encoder axis array comparison output instruction greater than 9999999 | The absolute value of the target position of the encoder axis array comparison output instruction is greater than 9999999. | Ensure that the absolute value of the floating-point number in the motion instruction does not exceed 9999999. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9769 | Axis performing one-dimensional comparison output, must not be aborted by a two-dimensional comparison output instruction | The axis is performing one-dimensional comparison output and must not be aborted by a two-dimensional comparison output instruction. | Wait for the one-dimensional comparison output to complete or stop the one-dimensional comparison output before executing the two-dimensional comparison output instruction. |
| 9770 | EtherCAT slave disconnected during operation | The EtherCAT slave is disconnected during operation. | Check whether the EtherCAT slave is disconnected during operation. |
| 9771 | Bus encoder axis in offline commissioning mode | The bus encoder axis is in offline commissioning mode. | The bus encoder axis does not support the offline commissioning mode. |
| 9772 | DI terminal not assigned with the preset position function | The DI terminal is not assigned with the preset position function. | Assign the preset position function to the DI terminal before calling the preset position instruction. |
| 9773 | Parameter in comparison instruction out of range when the pulse output mode is selected | The value of Parameter in the comparison instruction is out of range when the pulse output mode is selected. | Do not set Parameter to 0 or a negative value when the pulse output mode is selected in the comparison instruction. |
| 9774 | 2HCE module failed when the comparison output instruction is called | The 2HCE module fails when the comparison output instruction is called. | 1. Ensure that the input parameters are within the allowable range.<br>2. Check whether I/O mapping of the encoder axis is manually modified and whether it meets the I/O mapping configuration requirements of the comparison output instruction. |
| 9775 | Set position in ring mode less than 0 | The set position in ring mode is less than 0. | Set the position in ring mode to a value greater than or equal to 0. |
| 9776 | Y00 not assigned with the two-dimensional comparison output function | The Y00 terminal is not assigned with the two-dimensional comparison output function. | Assign the two-dimensional comparison output function to the Y00 output terminal corresponding to the channel. |
| 9777 | Axis performing two-dimensional comparison output, cannot be aborted by a one-dimensional comparison output instruction | The axis is performing two-dimensional comparison output and cannot be aborted by a one-dimensional comparison output instruction. | Wait for the two-dimensional comparison output to complete or stop the two-dimensional comparison output before calling the one-dimensional comparison output instruction. |
| 9800 | Failed to read the number of motion control axes | Failed to read the number of motion control axes. | Change the background version. |
| 9801 | Motion control axis quantity out of range | The number of motion control axes is out of range. | Reduce the number of axes since the H5U supports at most 32 axes. |
| 9802 | Axis failed to request internal space | The axis failed to request internal storage space. | 1. Check whether the memory runs out.<br>2. Contact the manufacturer. |
| 9803 | Failed to obtain axis parameters | Failed to obtain axis parameters. | Change the background version. |
| 9804 | Failed to obtain the slave | Failed to obtain the slave. | Change the background version. |
| 9805 | Failed to obtain the system variable | Failed to obtain the system variable. | 1. Check whether the memory runs out. 2. Return the machine to the manufacturer for analysis. |

| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9806 | Improper gear ratio settings | Parameters related to the gear ratio are set improperly. | 1. Ensure that the numerator and denominator of the gear ratio are greater than 0.<br>2. Ensure that the number of pulses per revolution of the motor/encoder is greater than 0.<br>3. Ensure that the displacement per revolution of the rotary table is between 0.000001 and 9999999. |
| 9807 | Improper software limiting parameters | The software limiting parameters are set improperly. | 1. Ensure that the positive limit is not greater than 9999999.<br>2. Ensure that the negative limit is not greater than 9999999.<br>3. Ensure that the negative limit is not greater than the positive limit. |
| 9808 | Improper linear/rotary mode | The linear/rotary mode parameter is set improperly. | Note that only the linear mode and rotary mode are supported. |
| 9809 | Improper revolution cycle | The revolution cycle is set improperly. | Ensure that the revolution cycle is between 0.01 and 9999999. |
| 9810 | Improper encoder mode | The encoder mode is set improperly. | Ensure that the encoder mode is set properly. Note that only the incremental mode and absolute value mode are supported. |
| 9811 | Improper homing parameter setting | The homing parameter is set improperly. | 1. Do not modify the homing mode of the bus servo axis. If you want to modify the homing mode of the bus servo axis, write to the SDO.<br>2. Check whether the homing mode is set properly. Note that only the values 17 to 30 and 35 are supported. |
| 9812 | Limit, home, or probe terminal Modbus address out of range | The Modbus address setting of the limit, home, or probe terminal is out of range. | 1. Check whether the set address is out of the range of Modbus addresses.<br>2. Select an address among X0 to X7 for the home signal. 3. Select an address among X0 to X7 for the probe signal. |
| 9813 | Improper pulse output mode setting of the local pulse axis | The pulse output mode of the local pulse axis is set improperly. | Check whether the pulse output mode of the local pulse axis is set improperly. |
| 9814 | Improper limiting deceleration | The limiting deceleration is set improperly. | Ensure that the limiting deceleration is between 0.0001 and 9999999. |
| 9815 | Improper deceleration upon axis fault | The deceleration upon axis fault is set improperly. | Ensure that the deceleration upon axis fault is between 0.0001 and 999999. |
| 9816 | Improper maximum velocity | The maximum velocity is set improperly. | Ensure that the maximum velocity is between 0.0001 and 999999. |
| 9817 | Improper maximum positive torque | The maximum positive torque is set improperly. | Ensure that the maximum positive torque is between 1 and 65534. |
| 9818 | Improper maximum negative torque | The maximum negative torque is set improperly. | Ensure that the maximum negative torque is between 1 and 65534. |
| 9819 | Improper maximum jogging velocity | The maximum jogging velocity is set improperly. | Ensure that the maximum jogging velocity is between 0.0001 and the maximum velocity. |
| 9820 | Improper maximum acceleration | The maximum acceleration is set improperly. | Ensure that the maximum acceleration is between 0.0001 and 9999999. |
| 9821 | Improper following error threshold | The following error threshold is set improperly. | Ensure that the following error threshold is between 0.0001 and 9999999. |

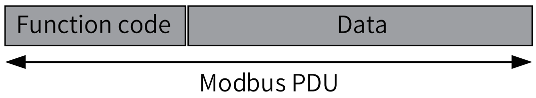
| Fault Code | Message | Description | Troubleshooting |
|---|---|---|---|
| 9822 | Improper velocity reach threshold | The velocity reach threshold is set improperly. | Ensure that the velocity reach threshold is between 0.0001 and 9999999. |
| 9823 | Improper homing velocity | The homing velocity is set improperly. | 1. Ensure that the homing velocity is between 0.0001 and 9999999. 2. Ensure that the homing velocity is not greater than the maximum velocity. 3. Ensure that the value obtained by multiplying the homing velocity by the gear ratio is between 1 and 2148483647. |
| 9824 | Improper homing approach velocity | The homing approach velocity is set improperly. | 1. Ensure that the homing approach velocity is between 0.0001 and 9999999. 2. Ensure that the homing approach velocity is not greater than the maximum velocity. 3. Ensure that the value obtained by multiplying the homing approach velocity by the gear ratio is between 1 and 2148483647. 4. Ensure that the homing approach velocity is less than the homing velocity. |
| 9825 | Homing position mode setting out of range | The homing position mode setting is out of range. | Ensure that the parameter value is within the allowable range. |
| 9826 | Improper homing acceleration | The homing acceleration setting is improper. | 1. Ensure that the homing acceleration is between 0.0001 and 9999999. 2. Ensure that the homing acceleration is not greater than the maximum acceleration. |
| 9827 | Homing timeout time out of range | The homing timeout time is out of range. | Ensure that the homing timeout time is greater than or equal to 1. |

# 20 Appendix

## 20.1 Modbus Protocol

### 20.1.1 Modbus Message Description

The Modbus application protocol defines a simple protocol data unit (PDU) independent of the underlying communication layers.




The mapping of Modbus protocol on different buses or networks can introduce some additional fields on the protocol data unit. The client initiating a Modbus transaction builds a Modbus PDU and then adds an additional field to build an appropriate communication PDU.

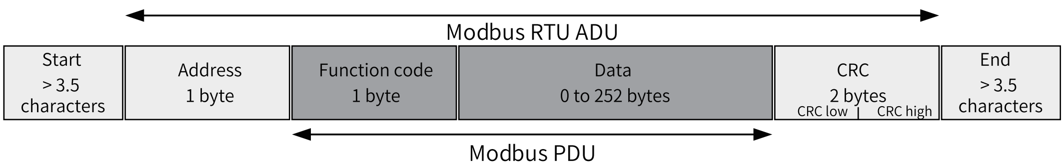
#### Data encoding

Modbus uses a "big-Endian" representation for addresses and data items. This means that when multiple bytes are transmitted, the most significant bit is sent first. Example:

| Register Size | Value | Description |
|---|---|---|
| 16-bit | 0x1234 | The first byte sent is 0x12, then 0x34. |

### 20.1.2 Modbus-RTU Message Frame

When a device communicates over a Modbus serial link in the Remote Terminal Unit (RTU) mode, each 8-bit byte in the message consists of two 4-bit hexadecimal characters. The RTU mode features high data density, leading to higher throughput than the ASCII mode at the same baud rate. However, each message must be transmitted as a continuous character stream.




### 20.1.3 Modbus-ASCII Message Frame

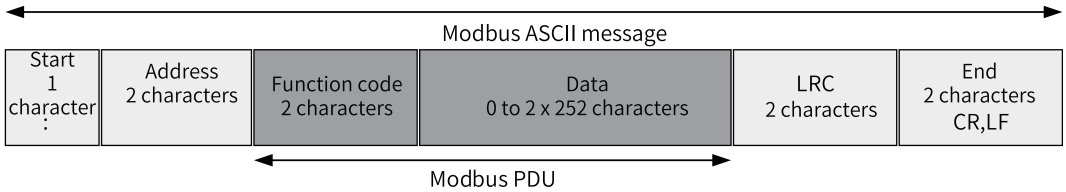
When a device on a Modbus serial link is configured to communicate in the American Standard Code for Information Interchange (ASCII) mode, each 8-bit byte in the message is sent as two ASCII characters. This mode is used when a communication link or device cannot comply with the timing management of the RTU mode.

***Note***

Note: This mode is less efficient than the RTU mode because one byte requires two characters.

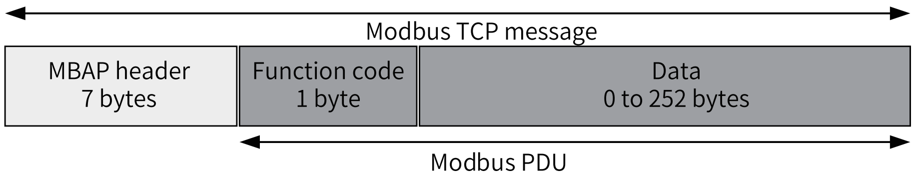
For example, the byte 0x5B is encoded as two characters: 0x35 and 0x42 (0x35 = "5" and 0x42 = "B" in ASCII encoding).

In the ASCII mode, a message is delimited by special characters at the beginning and end of the frame. A message must start with a colon (:) (ASCII hexadecimal 3A) and end with a carriage return–line feed (CR LF) pair (ASCII hexadecimal 0D and 0A).




## 20.1.4 Modbus-TCP Message Frame

The following figure illustrates the encapsulation of Modbus requests or responses in a Modbus-TCP/IP network.




TCP/IP uses a special message header to identify the Modbus application data unit. Such a message header is called the Modbus Protocol Application Header (MBAP).

In the MBAP header, a single-byte unit identifier is used instead of the Modbus slave address field that is commonly used on a Modbus serial link. The unit identifier is used for communication between devices (such as bridges, routers, and gateways) that support multiple independent Modbus terminal units through a single IP address.

The MBAP header includes the following fields.

| Field | Length | Description | Client | Server |
|---|---|---|---|---|
| Transaction meta identifier | 2 bytes | Identifier of the Modbus request/response transaction being processed | Started by the client | Copied by the server from the received request |
| Protocol identifier | 2 bytes | 0: Modbus protocol | Started by the client | Copied by the server from the received request |
| Length | 2 bytes | Number of bytes of the next field | Started by the client (request) | Started by the server (response) |
| Unit identifier | 1 byte | Identifier of the remote slave connected on a serial link or other bus | Started by the client | Copied by the server from the received request |

- The header contains 7 bytes.
- Transaction processing identifier: used to pair transaction processing. In the response, the Modbus server copies the transaction identifier from the request.
- Protocol identifier: used for multiplexing within the system. The value 0 indicates the Modbus protocol.
- Length: indicates the number of bytes of the next field, including the unit identifier and data field.

- Unit identifier: used for routing within the system. This field is specifically used for communication with Modbus or Modbus+ serial link slaves through gateways between Ethernet TCP-IP networks and Modbus serial links. The Modbus client sets this field in the request, and the server must return the same value in the response.

## 20.1.5 Function Code Definitions

### 20.1.5.1 Modbus Data Model

Modbus bases its data model on a series of tables that have distinguishing characteristics. The four primary tables are:

| Table | Object Type | Access Type | Comments |
|---|---|---|---|
| Discrete inputs | Single bit | Read-only | This type of data can be provided by an I/O system. |
| Coils | Single bit | Read-write | This type of data can be altered by an application program. |
| Input registers | 16-bit | Read-only | This type of data can be provided by an I/O system. |
| Holding registers | 16-bit | Read-write | This type of data can be altered by an application program. |

### 20.1.5.2 Function Code List

| Function Code | Definition |
|---|---|
| 01 (0x01) | Read coils |
| 02 (0x02) | Read discrete inputs |
| 03 (0x03) | Read multiple registers |
| 04 (0x04) | Read input registers |
| 05 (0x05) | Write single coil |
| 06 (0x06) | Write single register |
| 15 (0x0F) | Write multiple coils |
| 16 (0x10) | Write multiple registers |

### 20.1.5.3 Function Code Explanation

## 01 (0x01): Read coils/02 (0x02): Read discrete inputs

This function code is used to read 1 to 2000 contiguous status of coils (or discrete inputs) in a remote device.

Table 20–1 Request PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | 0x01: Read coils/0x02: Read discrete inputs |
| 2 | Coil starting address | 2 | Upper bits are followed by lower bits. See coil addressing. For details, see . "7.5.2 Parameters and Addresses" on page 256 |
| 3 | Number of coils | 2 | Upper bits are followed by lower bits (N). The maximum value of N is 2000. |

Table 20–2 Response PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | 0x01: Read coils/0x02: Read discrete inputs |
| 2 | Number of bytes | 1 | Value: (N + 7)/8 |
| 3 | Coil status | (N + 7)/8 | Every 8 coils are combined into one byte. If the number of coils is not a multiple of 8, undefined bits are filled with 0. The first 8 coils are in the first byte, and the coil with the smallest address is in the least significant bit. This pattern continues for the rest of the coils. |

Table 20–3 Error response PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | Function code + 0x80; 0x81: Read coils/0x82: Read discrete inputs |
| 2 | Exception code | 1 | 0x01, 0x02, 0x03, or 0x04. See the exception code list. |

## 03 (0x03): Read multiple registers/04 (0x04): Read input registers

This function code is used to read the content of a contiguous block of holding registers (or input registers) in a remote device.

Table 20–4 Request PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | 0x03: Read multiple registers/0x04: Read input registers |
| 2 | Register starting address | 2 | Upper bits are followed by lower bits. See register addressing. For details, see . *"7.5.2 Parameters and Addresses" on page 256* |
| 3 | Number of registers | 2 | Upper bits are followed by lower bits (N). The maximum value of N is 125. |

Table 20–5 Response PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | 0x03: Read multiple registers/0x04: Read input registers |
| 2 | Number of bytes | 1 | Value: N x 2 |
| 3 | Register value | N x 2 | Every two bytes represents one register value, with upper bits followed by lower bits. The register with the minimum address is in the foremost. |

Table 20–6 Error response PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | Function code + 0x80; 0x83: Read multiple registers/0x84: Read input registers |
| 2 | Exception code | 1 | 0x01, 0x02, 0x03, or 0x04. See the exception code list. |

## 05 (0x05): Write single coil

This function code is used to write a single output to either ON or OFF in a remote device.

Table 20–7 Request PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | 0x05: Write single coil |
| 2 | Coil address | 2 | Upper bits are followed by lower bits. See coil addressing. For details, see . *"7.5.2 Parameters and Addresses" on page 256* |
| 3 | Coil status | 2 | Upper bits are followed by lower bits. ON is 0xFF00, while OFF is 0x0000. |

Table 20–8 Response PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | 0x05: Write single coil |
| 2 | Coil address | 2 | Upper bits are followed by lower bits. See coil addressing. For details, see . *"7.5.2 Parameters and Addresses" on page 256* |
| 3 | Coil status | 2 | Upper bits are followed by lower bits. Active when the value is other than 0 |

Table 20–9 Error response PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | Function code + 0x80; 0x85: Write single coil |
| 2 | Exception code | 1 | 0x01, 0x02, 0x03, or 0x04. See the exception code list. |

## 06 (0x06): Write single register

This function code is used to write a single holding register in a remote device.

Table 20–10 Request PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | 0x06: Write single register |
| 2 | Register address | 2 | Upper bits are followed by lower bits. See register addressing. For details, see . *"7.5.2 Parameters and Addresses" on page 256* |
| 3 | Register value | 2 | Upper bits are followed by lower bits. |

Table 20–11 Response PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | 0x06: Write single register |
| 2 | Register address | 2 | Upper bits are followed by lower bits. See register addressing. For details, see . *"7.5.2 Parameters and Addresses" on page 256* |
| 3 | Register value | 2 | Upper bits are followed by lower bits. |

Table 20–12 Error response PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | Function code + 0x80; 0x86: Write single register |
| 2 | Exception code | 1 | 0x01, 0x02, 0x03, or 0x04. See the exception code list. |

## 15 (0x0F): Write multiple coils

This function code is used to force each coil in a sequence of coils to either ON or OFF in a remote device.

Table 20–13 Request PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | 0x0F: Write multiple coils |
| 2 | Coil starting address | 2 | Upper bits are followed by lower bits. See coil addressing. For details, see . *"7.5.2 Parameters and Addresses" on page 256* |
| 3 | Number of coils | 2 | Upper bits are followed by lower bits (N). The maximum value of N is 1968. |
| 4 | Number of bytes | 1 | Value: (N + 7)/8 |
| 5 | Coil status | (N + 7)/8 | Every 8 coils are combined into one byte. If the number of coils is not a multiple of 8, undefined bits are filled with 0. The first 8 coils are in the first byte, and the coil with the smallest address is in the least significant bit. This pattern continues for the rest of the coils. |

Table 20–14 Response PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | 0x0F: Write multiple coils |
| 2 | Coil starting address | 2 | Upper bits are followed by lower bits. See coil addressing. For details, see . *"7.5.2 Parameters and Addresses" on page 256* |
| 3 | Number of coils | 2 | Upper bits are followed by lower bits. |

Table 20–15 Error response PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | Function code + 0x80; 0x8F: Write multiple coils |
| 2 | Exception code | 1 | 0x01, 0x02, 0x03, or 0x04. See the exception code list. |

## 16 (0x10): Write multiple registers

This function code is used to write a block of contiguous registers (1 to 123 registers) in a remote device.

Table 20–16 Request PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | 0x10: Write multiple registers |
| 2 | Register starting address | 2 | Upper bits are followed by lower bits. See register addressing. For details, see . *"7.5.2 Parameters and Addresses" on page 256* |
| 3 | Number of registers | 2 | Upper bits are followed by lower bits (N). The maximum value of N is 123. |
| 4 | Number of bytes | 1 | Value: N x 2 |
| 5 | Register value | N x 2 | Register value |

Table 20–17 Response PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | 0x10: Write multiple registers |
| 2 | Register starting address | 2 | Upper bits are followed by lower bits. See register addressing. For details, see . *"7.5.2 Parameters and Addresses" on page 256* |
| 3 | Number of registers | 2 | Upper bits are followed by lower bits. |

Table 20–18 Error response PDU

| No. | Meaning of Data (Byte) | Number of Bytes | Description |
|---|---|---|---|
| 1 | Function code | 1 | Function code + 0x80; 0x90: Write multiple registers |
| 2 | Exception code | 1 | 0x01, 0x02, 0x03, or 0x04. See the exception code list. |

### 20.1.6 Exception Code List

| Code | Name | Description |
|---|---|---|
| 0x01 | Illegal function code | The function code received in the query is not an allowable action for the server (or slave). This may be because the function code is only applicable to new devices, and is not implementable in the unit selected. It could also indicate that the server (or slave) is in the wrong state to process a request of this type, for example, because it is unconfigured and is being asked to return register values. |
| 0x02 | Illegal data address | The data address received in the query is not an allowable address for the server (or slave). More specifically, the combination of reference number and transfer length is invalid. For a controller with 100 registers, a request with the offset 96 and the length 4 will succeed, but a request with the offset 96 and the length 5 will result in exception code 0x02. |
| 0x03 | Illegal data value | A value contained in the query data field is not an allowable value for server (or slave). This indicates a fault in the structure of the remainder of a complex request, such as that the implied length is incorrect. It specifically does not mean that a data item submitted for storage in a register has a value outside the expectation of the application program, since the Modbus protocol is unaware of the significance of any particular value of any particular register. |
| 0x04 | Slave device failure | An unrecoverable error occurred while the server (or slave) was attempting to perform the requested action. |

## 20.2 Firmware Programming and Upgrade

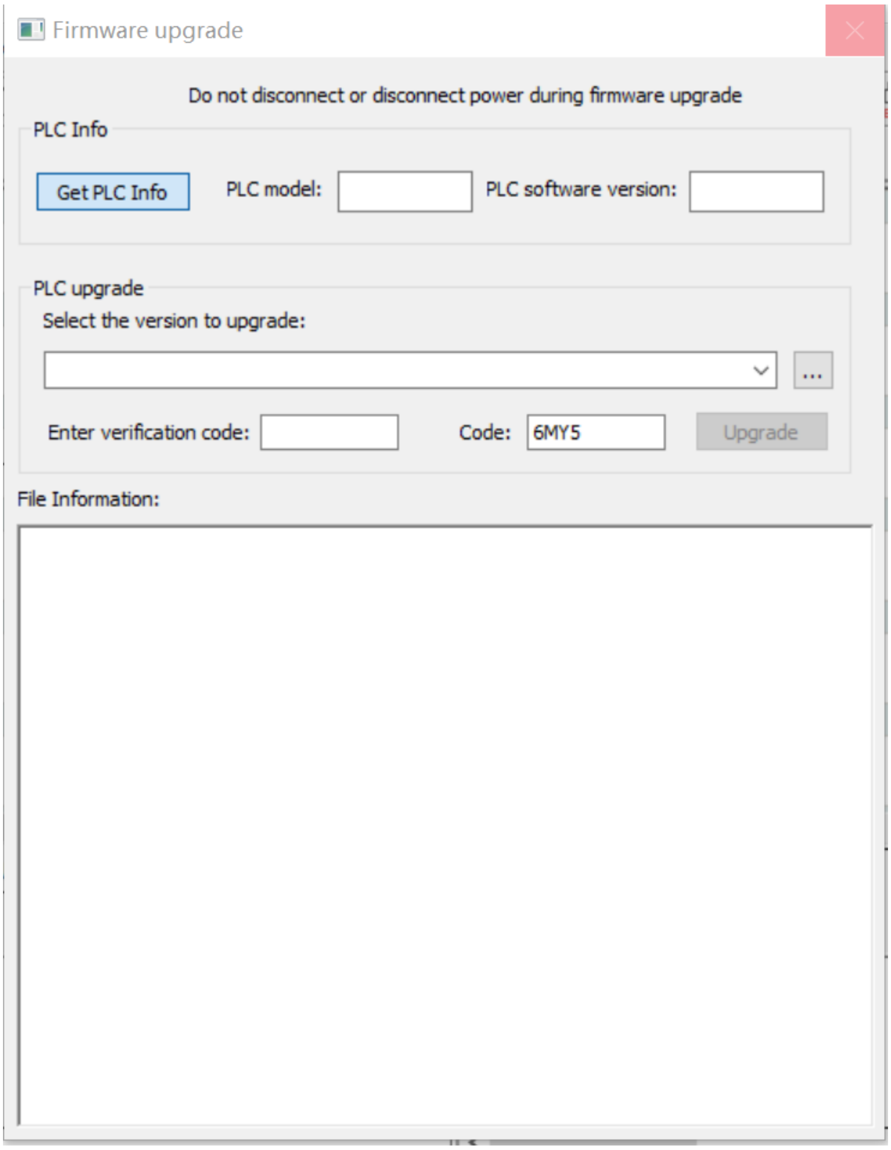
### 20.2.1 Firmware Programming

Caution

- The PLC firmware programming function of AutoShop is only available for the Easy series.
- When multiple AutoShop software applications are opened, only one of them is allowed to perform programming, while others cannot access the "Firmware burning" function.
- The Easy series models involve two programming files: one for the Easy30X, Easy32X, and Easy50X models, and the other for the Easy52X models.

**Prerequisite:** USB cable and firmware programming file are ready. You can log in to the official website of Inovance (*www.inovance.com*) to obtain the firmware programming file.

1. Turn off the PLC power.
2. In the menu bar, choose "Tools" > "Firmware burning". The "Firmware burning" page is displayed.




3. Click "..." and select the firmware programming file.
4. Plug the USB cable (if the USB cable is already connected, remove and re-plug it). A dialog box pops up to prompt whether to program. Click "OK" to start programming.
   After the programming succeeds, a prompt box indicating the programming is succeeded will be displayed.

## 20.2.2 Firmware Upgrade

### 20.2.2.1 Firmware Upgrade Through Ethernet

1. In the menu bar, choose "Tools" > "Firmware upgrade". The "Firmware upgrade" dialog box is displayed.
2. Select the firmware version to be upgraded, enter the verification code, and click "Upgrade".
3. Wait for the "Upgrade successful" prompt box to pop up, and the firmware upgrade is completed.

***Note***

During firmware upgrade, ensure that the PLC is powered normally. Powering off the PLC during upgrade may cause the PLC to fail to start or function normally. In most of such cases, firmware upgrade can still be done by using an SD card. Otherwise, the PLC needs to be returned to the factory for repair.

### 20.2.2.2 Firmware Upgrade Through SD Cards

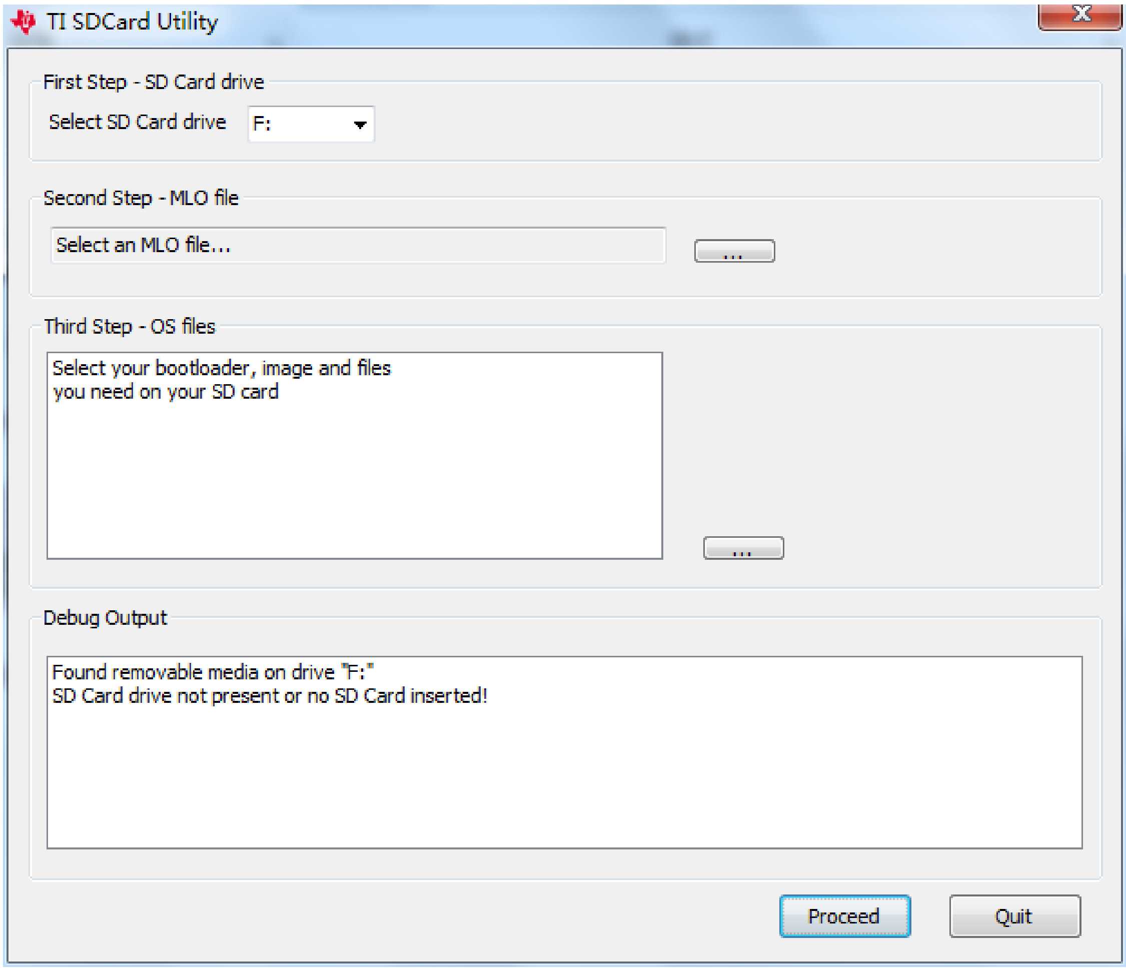
**Warning**

During upgrade using an SD card, power-off is strictly prohibited. Otherwise, the PLC may become unusable or other serious abnormalities may occur.

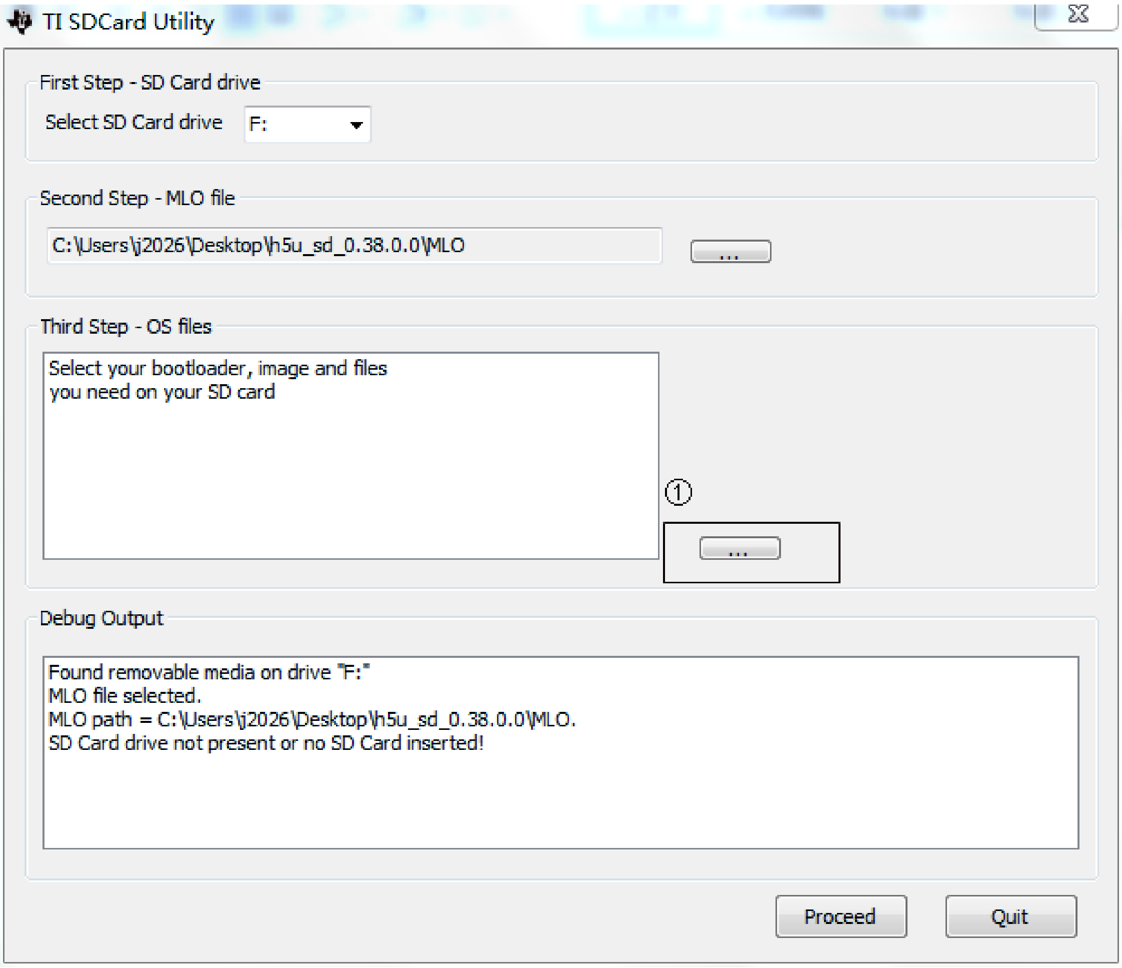
To upgrade the firmware using an SD card, program the SD card first according to the following steps.

1. Prepare hardware.
   Prepare an SD (TF) card as shown in the figure, with the card storage capacity no more than 32 G.

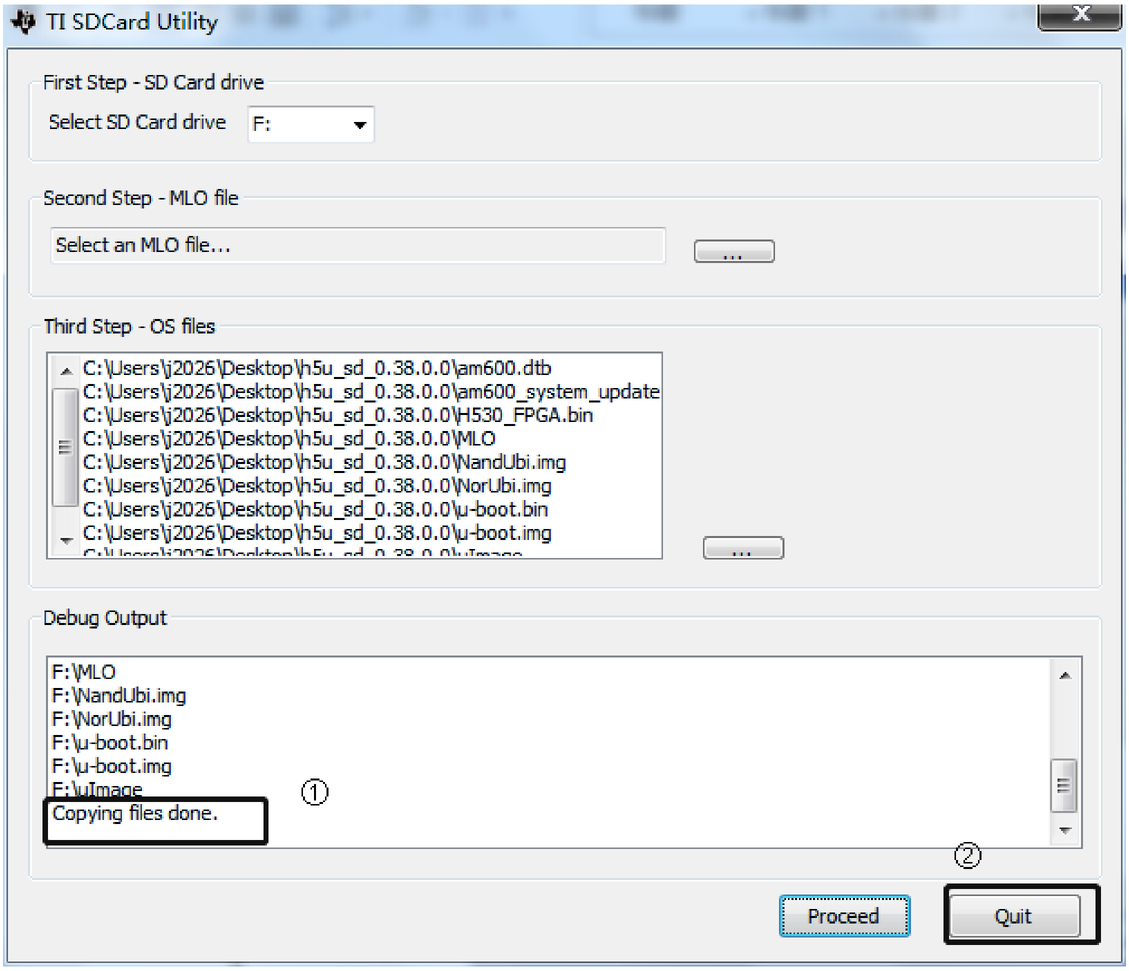

2. Insert the SD card into a card reader and plug the card reader into the USB port of the computer.
3. Double-click the SD card programming tool to open it.
   Tool download address: http://bbs.inovance.com/t-1797.html
4. The following interface is displayed and shows which disk the card reader is located, as shown in the following figure.




5. Select the MLO file in the upgrade package and click "Open".
6. Click the button specified in the following figure to open the folder where the programming content is located. Press Ctrl+A to select all the files and then click "Open".




7. Click "Proceed". After the following interface appears, click "Format" and then "Start" to format the SD card.
8. After the formatting, click "Close" to start programming. After the programming is completed, the following interface is displayed.




9. Insert the SD card into the SD card slot of the controller.
10. Power off the PLC and then power it on. When the LED display shows UU, it indicates that the upgrade has started. The upgrade process may take about one minute. When the upgrade succeeds, the LED display shows 00 or CC. Remove the SD card to complete the upgrade.

***Note***

- During firmware upgrade, ensure that the PLC is powered normally. Powering off the PLC during upgrade may cause the PLC to fail to start or function normally. In such a case, try again to upgrade the firmware using the SD card. If the upgrade fails, send the PLC to the factory for repair.
- During firmware upgrade, if the LED display shows flashing ER, it means that the upgrade is successful but the PLC detects a program error or communication error during running.

## 20.3 Applying the Function of Download File Generation

### 20.3.1 Generating Down Files

#### 20.3.1.1 Overview

The download file function refers to the ability of the PLC project to compile and generate a Down file, which can be downloaded without opening the original project.

- Batch update or upgrade PLC projects using an SD card.

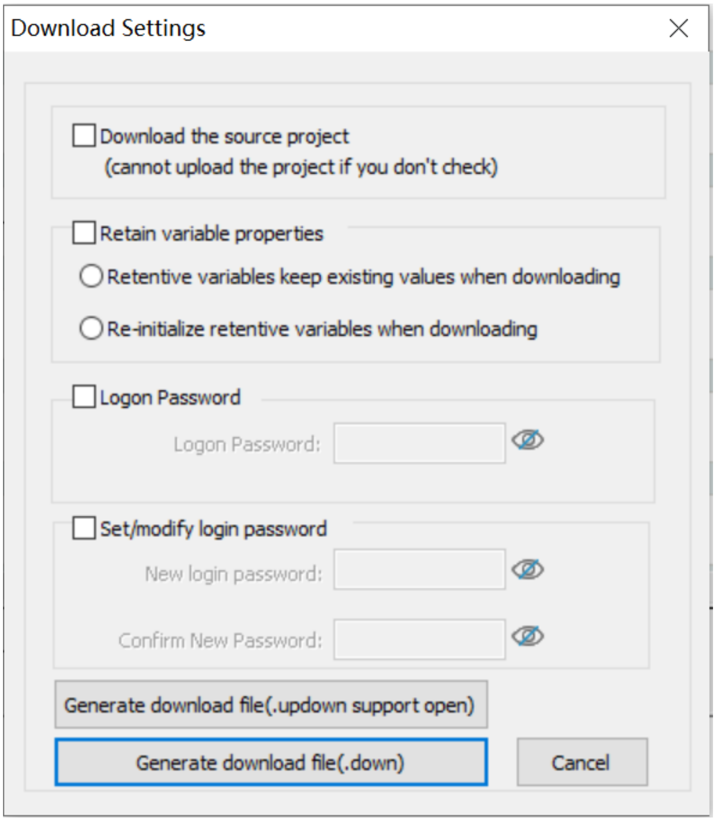
- Update a PLC project using AutoShop software tool.

### 20.3.1.2 Generating Down Files

## Generating Down files

Before downloading a Down file, generate the Down file in the AutoShop background. The specific steps are as follows.

1. Open the PLC project and choose "File" > "Generate download file (D)".
2. In the "Download Settings" dialog box that is displayed, set the download file properties, and then click "Generate download file (.down)".




Interface:

- "Download the source project": Select this option to enable project uploading, or deselect this option to disable project uploading.
- "Retain variable properties"
  Retain existing values of retentive variables when downloading; or

  Re-initialize retentive variables when downloading.
- "Logon password"
  If the PLC does not have a login password, leave this option deselected.

  If the PLC has a login password, this option must be selected and the PLC login password must be entered. If this option is not selected or the password is incorrect, the upgrade will fail.
- "Set/modify login password"

To modify the current login password of the PLC, fill out the "Logon Password", "New Login Password", and "Confirm New Password" fields.

To set a login password when the PLC does not have a login password, just fill out the "New Login Password" and "Confirm New Password" fields.

- : shows or hides passwords.

### Note

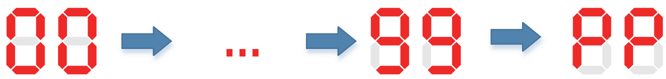
The password takes effect immediately after the Down file is upgraded.

After the password takes effect, the PLC will log out the current user.

3. Select the archive path for the Down file and click "OK".

## 20.3.1.3 Upgrading Down Files Through SD Cards

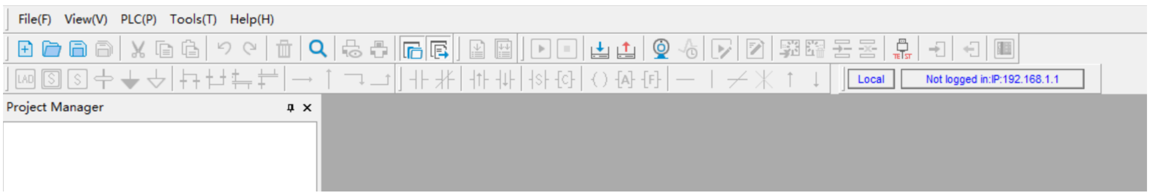
Put the Down file compiled using AutoShop in the "PLCProgram" directory of the SD card, and then insert the SD card into the PLC main module. Press and hold the MFK key on the PLC panel for three seconds to enter the "Sd" menu. Press the MFK key again to start programming the user program in the SD card into the PLC host. The LED display shows the programming progress (00 to 99), and shows "PP" after the programming is completed.



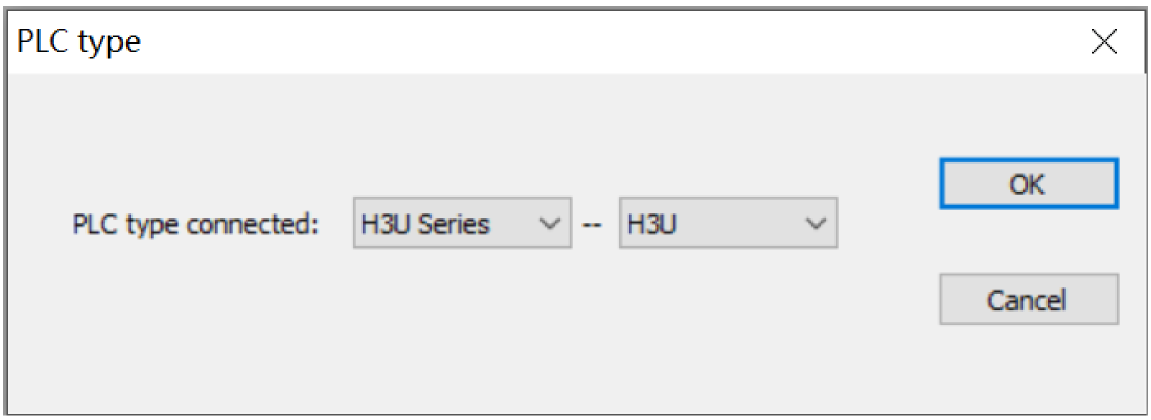
If the password is incorrect, the indicator prompts E5, indicating a password verification error.

## 20.3.1.4 Downloading Down Files Through AutoShop

To download the generated Down file, close the project first, as shown in the following figure.




Click the Download button and select the PLC type connected.



Click "Download". If the password verification fails, the system pops up a prompt box, and you need to enter the correct password.

***Note***

If the PLC is in the logged-in state when the Down file is downloaded in the background, the PLC will be logged out first.

#### 20.3.1.5 Compatibility

When a Down file generated by AutoShop V4.0.0.0 is downloaded to PCB software of V3.0.0.0 or earlier version, errors such as Down upgrade failure, file format error, and parsing failure may occur.

### 20.3.2 Generating Updown Files

#### 20.3.2.1 Overview

Updown files are Down files that can be uploaded. Updown files enable upload and download of user programs.
AutoShop allows you to compile a project into an Updown file, and open the Updown file in AutoShop to further edit the project.

Updown files can be downloaded and uploaded through HMI, enabling quick copy and transfer of projects between different PLCs.

Updown files can be downloaded and uploaded using SD cards.

Updown files can also be downloaded and uploaded through AutoShop, making project management flexible.

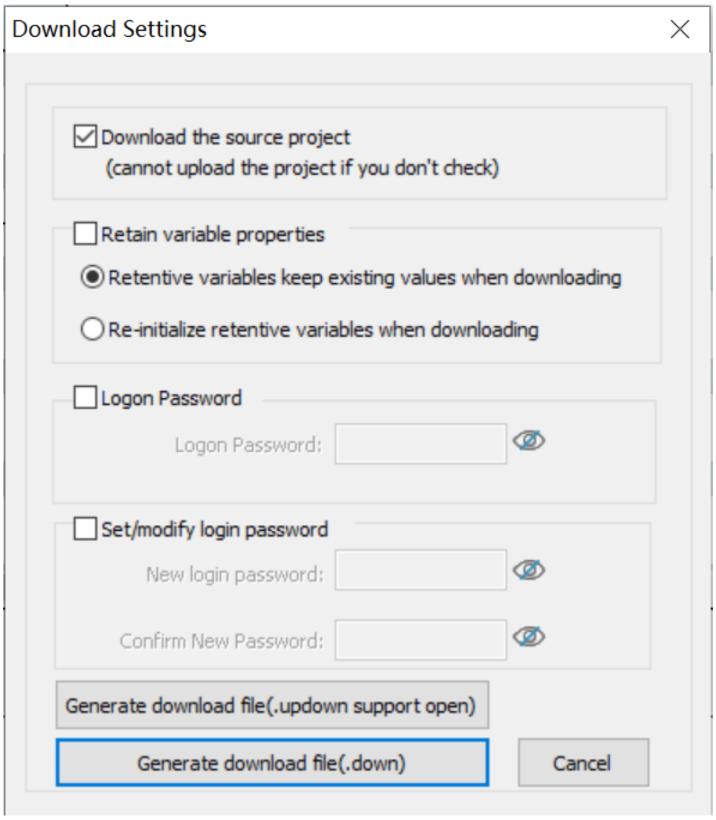
Operations involved are:

| Function | Tool |
| --- | --- |
| Compile and generate Updown files | AutoShop |
| Open and edit Updown files | AutoShop |
| Upload and download Updown files through AutoShop | AutoShop |
| Upload and download Updown files through HMI | HMI (IT7000) |
| Upload and download Updown files through SD cards | SD card |

#### 20.3.2.2 Generating Updown Files

Follow these steps to generate an Updown file:

1. In the programmed and compiled project, choose "File" > "Generate download file". The "Download Settings" dialog box is displayed.
2. Click "Generate download file(.updown support open)" to generate an Updown file.




Interface:

- "Download the source project": When this option is selected, the Updown file generated includes the project source code. Only Updown files with this option selected can be opened and edited.
- "Retain variable properties"
  Retain existing values of retentive variables when downloading; or

  Re-initialize retentive variables when downloading.
- "Logon password"
  The PLC login password, which must be consistent with the login password of the target PLC to complete the download of the Updown file.

  If the target PLC does not have a login password, do not select the "Logon Password" option.
- "Set/modify login password"
  After a successful Updown file download, the target PLC's login password is updated to the "New Login Password".
- : shows or hides passwords.

3. Select the archive path for the Updown file and click "OK".

#### 20.3.2.3 Opening Updown Files

Follow these steps to open and edit an Updown file:

1. Choose "File" > "Open Project".
2. In the "Open" window that is displayed, select the "*.updown" file you want to open.

3. After selecting the file, click "Open" to open the Updown file. If the Updown file is password-protected, enter the password for verification before the file can be opened.

***Note***

If the Updown file has "Set/modify login password" enabled, use the "Set/modify login password" of the Updown file for verification.

If the Updown file only has "Logon Password" enabled, use the "Logon Password" of the Updown file for verification.

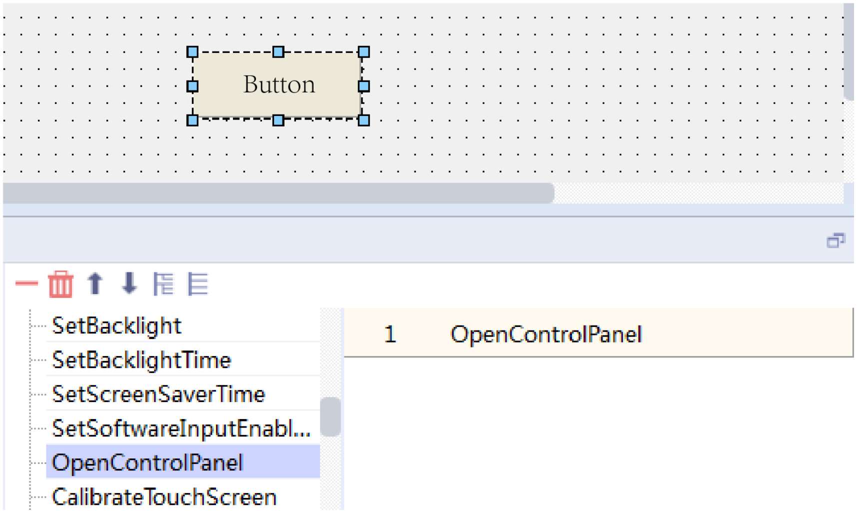
### 20.3.2.4 Uploading and Downloading Updown Files Through HMI

Uploading or downloading Updown files through HMI requires a firmware version of 0.8.8.27 or later.

## Downloading Updown files

1. Enter the control panel of the IT7000 series HMI.

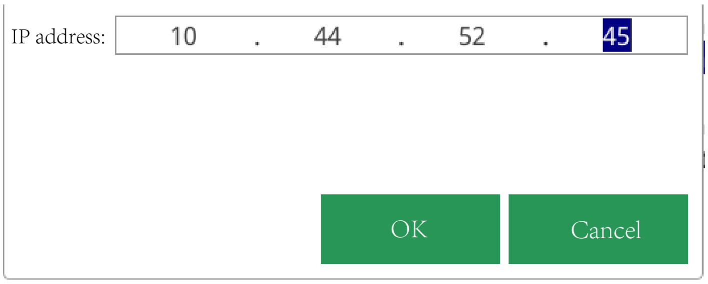
- In InoTouchPad, create an IT7000 project, configure a button, and configure the system function "OpenControlPanel" for the button to enter the control panel.




- Power on the IT7000 HMI and press and hold the screen to enter the control panel.

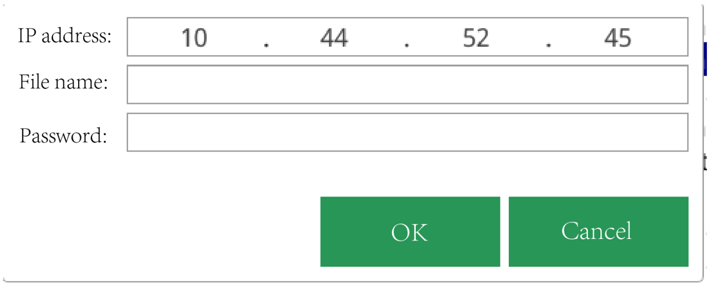
2. Click the "Download" menu in the control panel.
3. In the window that is displayed, select the corresponding mounted device and the Updown file to be downloaded.
4. Select the target device series and click "Download".


5. In the window that is displayed, enter the IP address of the PLC device and click "OK".




## Uploading Updown files

The steps for upload are similar to those for download. The control panel interface is as shown in the following figure.




### *Note*

To upload a file, you need to enter the device IP and rename the file to make the file name end with ".updown", for example, "test.updown".

The password for upload is the password of the uploaded Updown file.

Both Down and Updown files can be downloaded, but only Updown files can be uploaded.

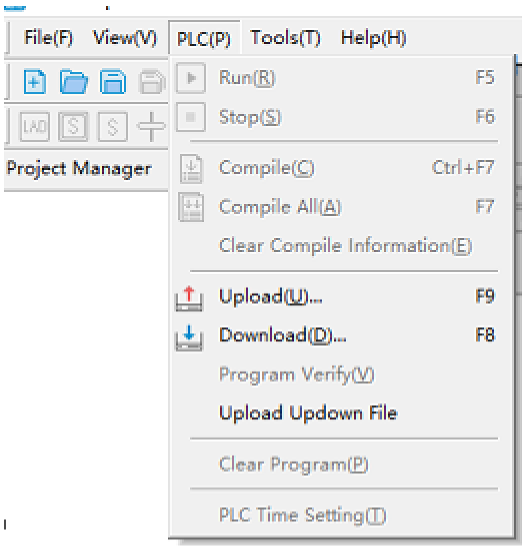
### 20.3.2.5 Uploading and Downloading Updown Files Through AutoShop

## Downloading Updown files

Close the project. Click the Download button in the toolbar. After connecting to the PLC, select the "*.updown" file to be downloaded in the window that is displayed, as shown in the following figure.

## Uploading Updown files

Close the project. Choose "PLC" > "Upload Updown File".

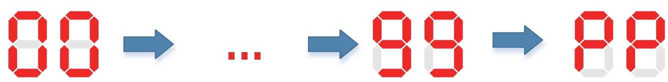



***Note***

If an Updown file that has been downloaded to the PLC is downloaded again in the Down format or through the background, inconsistency may occur between the Updown file uploaded and the actual project running in the PLC.

#### 20.3.2.6 Uploading and Downloading Updown Files Through SD Cards

Put the Updown file compiled using AutoShop in the "PLCProgram" directory of the SD card, and then insert the SD card into the PLC main module. Press and hold the MFK key on the PLC panel for three seconds to enter the "Sd" menu. Press the MFK key again to start programming the user program in the SD card into the PLC host. The LED display shows the programming progress (00 to 99), and shows "PP" after the programming is completed.




If the password is incorrect, the indicator prompts E5, indicating a password verification error.

## 20.4 Applying Customized Variables in Communication

### 20.4.1 Overview

In the function of customized variables, addresses of variables are automatically allocated by the software. Therefore, the variables cannot be accessed directly using fixed addresses. Customized variables can be accessed in the following two ways:

- HMI tag communication: only available for Inovance IT7000 series touch screens
- Mapping address: applicable to all devices that support the Modbus protocol

## 20.4.2 Example Project Requirements

Write an H5U marquee program and have the corresponding bit elements and control word status displayed through the IT7000 HMI.

## 20.4.3 PLC Programming

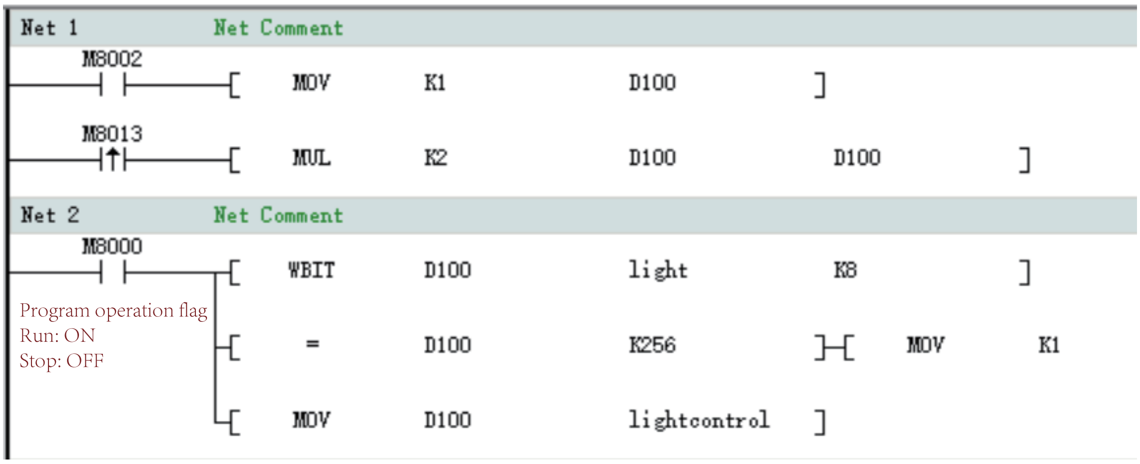
### 20.4.3.1 Accessing Customized Variables Through HMI Tag Communication

#### Creating a PLC project

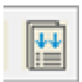
Create a PLC project. For details, see *"2.4.2 Creating a Project" on page 38*.

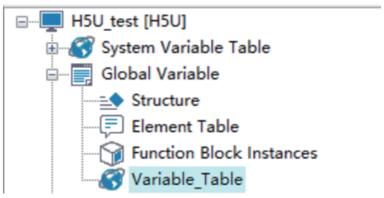
#### Writing a PLC program

Write a program as shown in the following figure, where "light" is an array containing eight Bool-type variables and "light_control" is an INT-type variable used for HMI display.

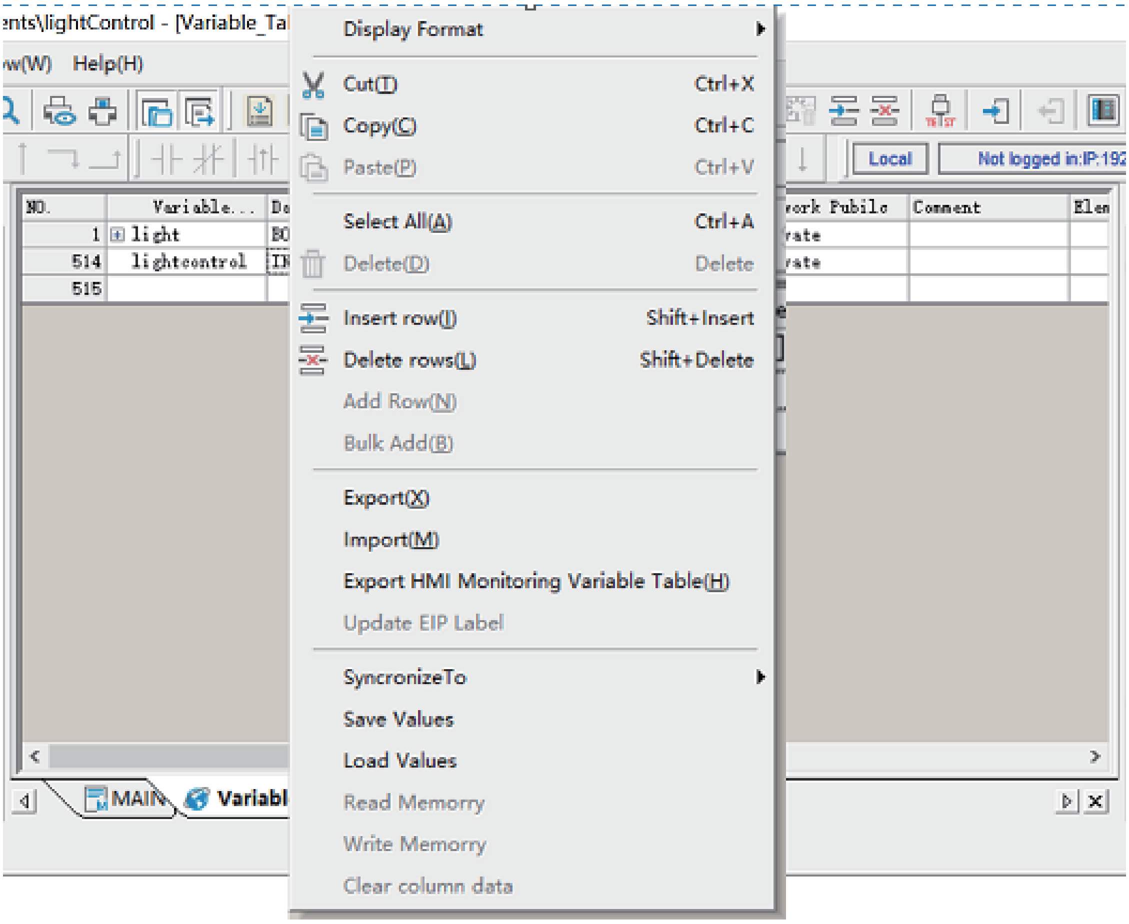



#### Compiling the project and export the variable table

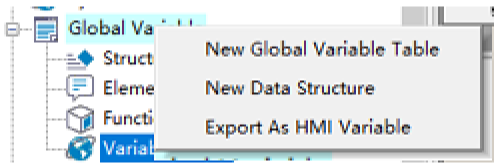
1. After writing the project, click the compile button  to complete the program compilation.
2. After the compilation is completed, double-click "Variable Table" in the project management pane on the left to enter the variable table interface.




3. Right-click the variable table and click "Export HMI Monitoring Variable Table".




4. In the window that is displayed, set an archive path and file name, and then click "Save" to complete the export of the variable table.
5. (Optional) To export all customized variables, right-click "Global Variables" and select "Export As HMI Variable".




## Downloading the PLC program

After exporting the variable table, click the download button  to download the program to the PLC.

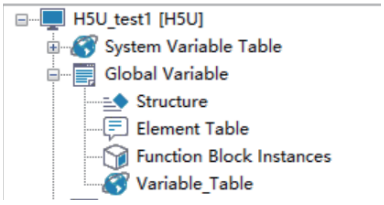
## Setting the PLC IP address

For setting the PLC IP address, see "2.2 Communication Connection".

### 20.4.3.2 Accessing Customized Variables Through Mapping Address

1. Create a project and write a PLC program.
2. Allocate variable addresses.

a. In the project management pane, double-click "Variable Table" to enter the variable table interface.

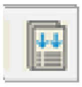



b. Allocate soft element addresses for custom variables.

The light variable is a BOOL-type array and occupies M0 to M7, a total of eight bits, after being mapped to M0.

| NO. | Data Type | Initial Value | Power Down Hold | Network Pubilc | Comment | Element Addr. | Length |
|---|---|---|---|---|---|---|---|
| 1 | BOOL[8] | ... | Non Retained | Private | | M0 | nBitLen:8 |
| 10 | INT | 0 | Retained | Private | | D1000 | nBitLen:16 |
| 11 | | | | | | | |

c. Compile the project to automatically generate the allocated addresses.

Click the compile button  to compile the program. After the compilation is completed, the software automatically generates the allocated addresses.

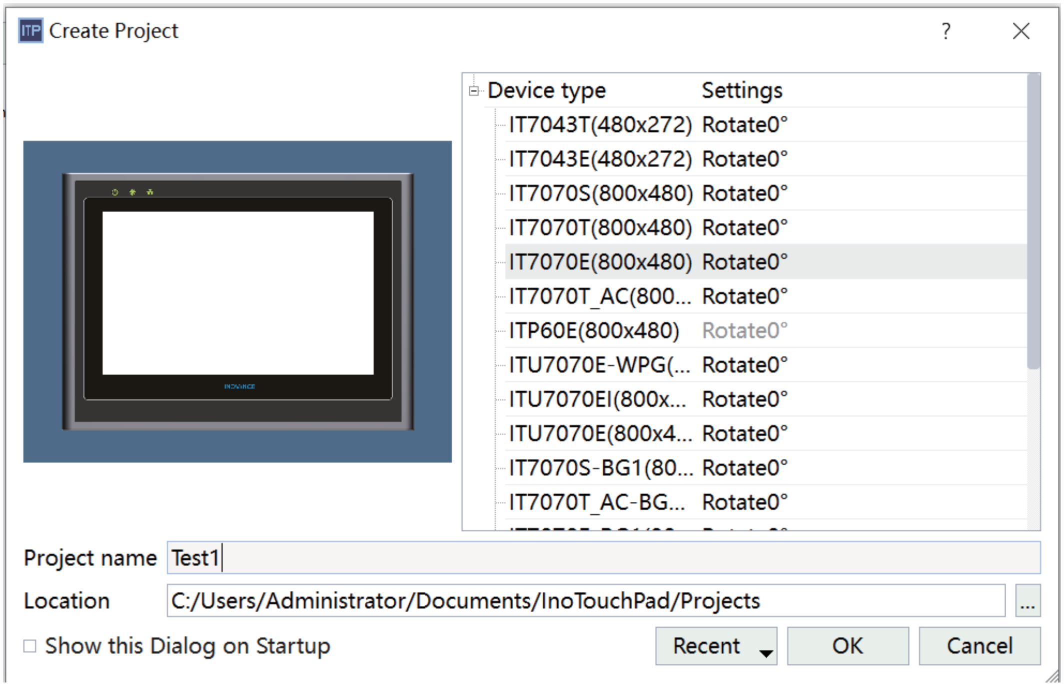
3. Download the PLC program and set the PLC IP address.

## 20.4.4 HMI Configuration

### 20.4.4.1 Accessing Customized Variables Through HMI Tag Communication

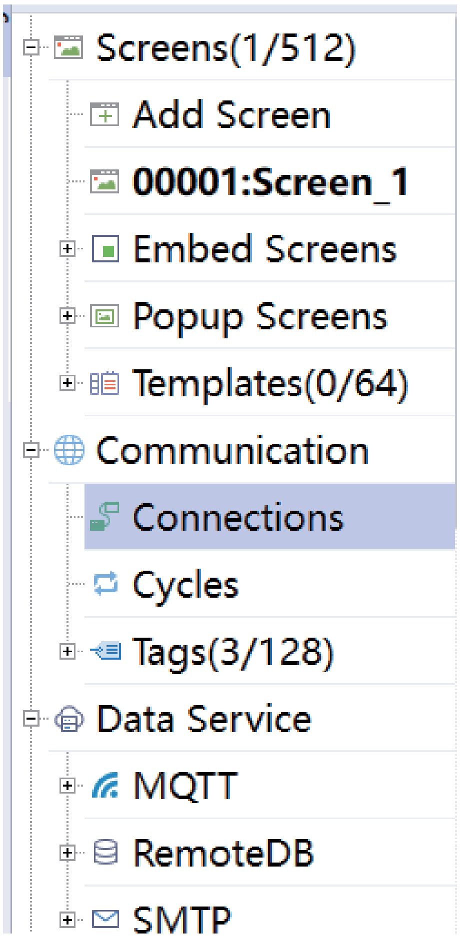
### 1 Creating an HMI project

Open InoTouchPad. Create a project. Set an archive path, name, and device type for the project, and then click "OK".

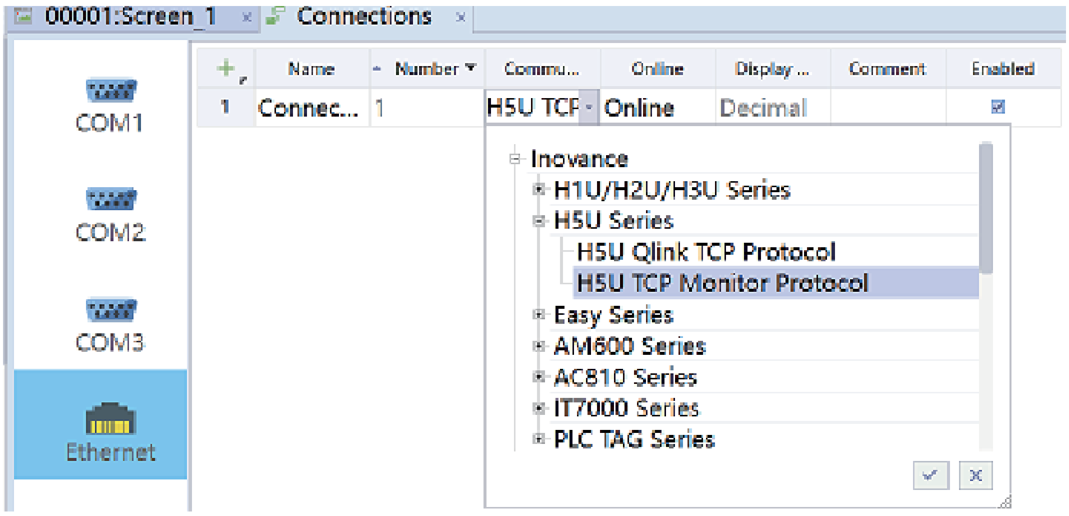


## 2 Creating a communication connection

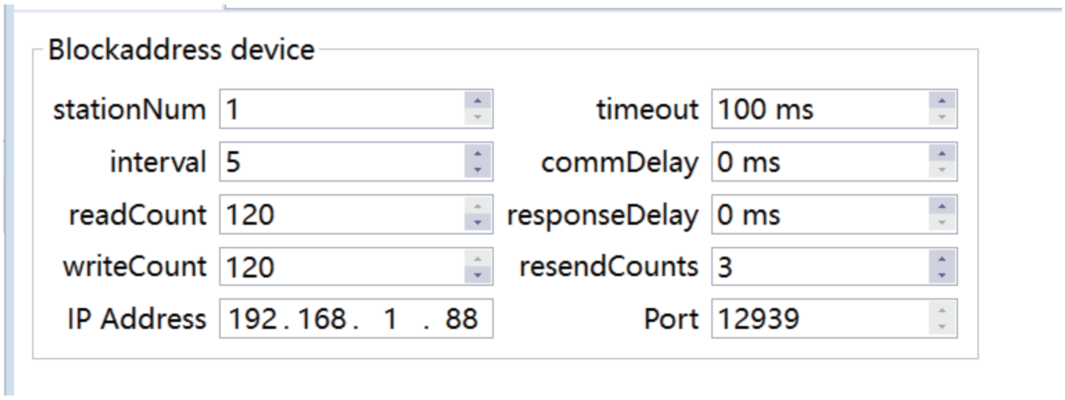
1. In the project management pane on the left, double-click the connection tab.




2. On the connection management page, click the "+" icon to add a connection, and select the H5U TCP monitoring protocol.

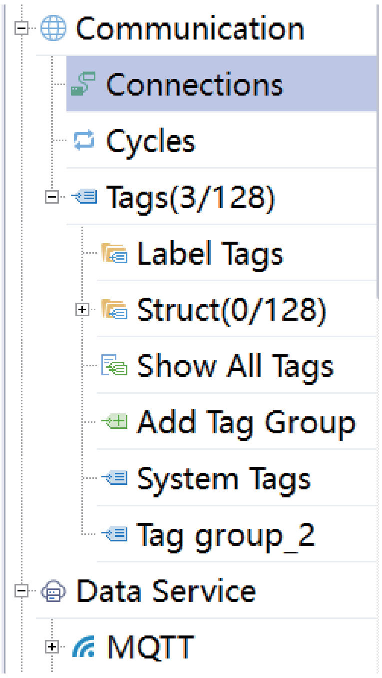



3. Enter the IP address of the connected PLC to complete the setup.

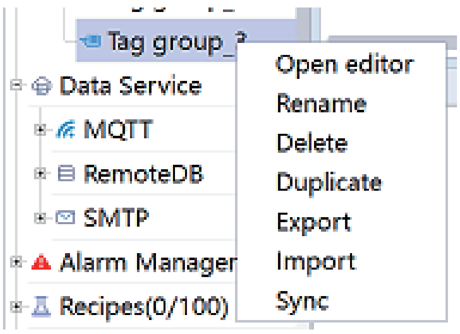



## 3 Adding variables

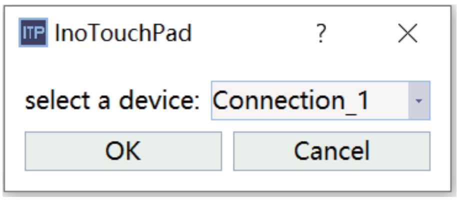
1. Click "Variable" to expand the variable menu. Click "Add variable group" to add a variable group.




2. Right-click the newly added variable group and select "Import".




3. In the pop-up window, select the variable table exported from the PLC, and click "Open".
4. Select the created H5U connection and click "OK".

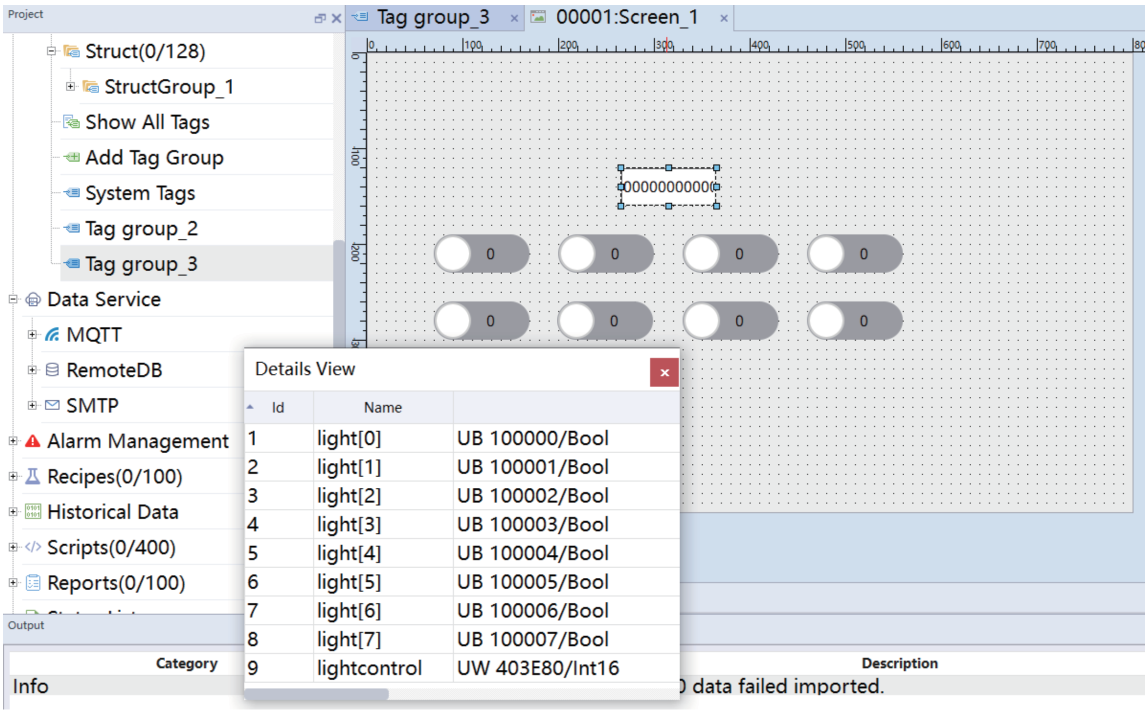



5. The variables are successfully added to the HMI variable table.

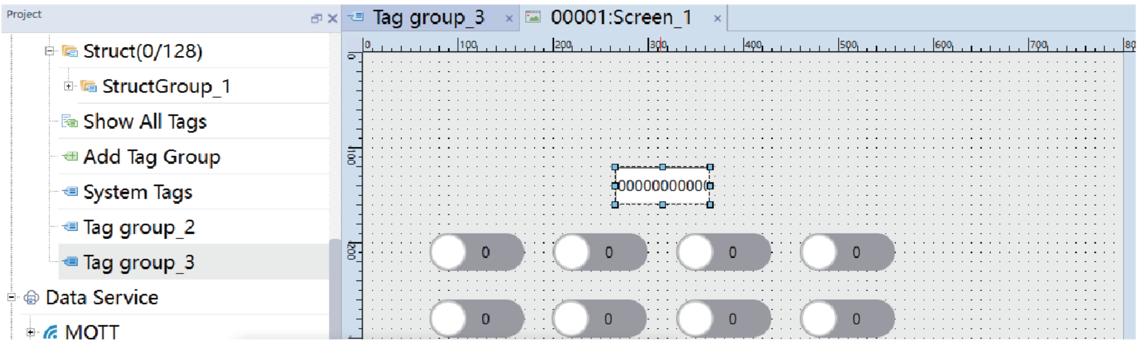
| + | Name | Number | Connect... | Data type | Length | Array c... | Address | Acquisit... | Acquisit... | Data log Id |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | light[0] | 1 | Connec... | Bool | 1 | 1 | UB 100... | 100ms | Cyclic o... | <Undefin... |
| 2 | light[1] | 2 | Connec... | Bool | 1 | 1 | UB 100... | 100ms | Cyclic o... | <Undefin... |
| 3 | light[2] | 3 | Connec... | Bool | 1 | 1 | UB 100... | 100ms | Cyclic o... | <Undefin... |
| 4 | light[3] | 4 | Connec... | Bool | 1 | 1 | UB 100... | 100ms | Cyclic o... | <Undefin... |
| 5 | light[4] | 5 | Connec... | Bool | 1 | 1 | UB 100... | 100ms | Cyclic o... | <Undefin... |
| 6 | light[5] | 6 | Connec... | Bool | 1 | 1 | UB 100... | 100ms | Cyclic o... | <Undefin... |
| 7 | light[6] | 7 | Connec... | Bool | 1 | 1 | UB 100... | 100ms | Cyclic o... | <Undefin... |
| 8 | light[7] | 8 | Connec... | Bool | 1 | 1 | UB 100... | 100ms | Cyclic o... | <Undefin... |
| 9 | lightco... | 9 | Connec... | Int16 | 2 | 1 | UW 40... | 100ms | Cyclic o... | <Undefin... |

## 4 Configuring HMI

The HMI allows you to directly drag variables for programming. Drag variables from the detailed view to the programming interface one by one to complete programming.

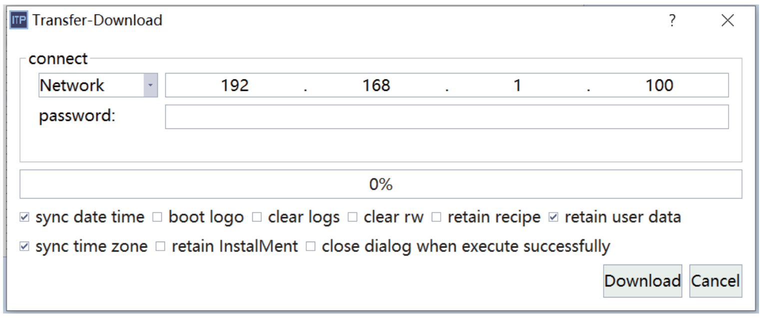



Double-click the value I/O field, set the display format to binary, and set the character field length to eight bits for easy observation.




## Downloading the HMI program

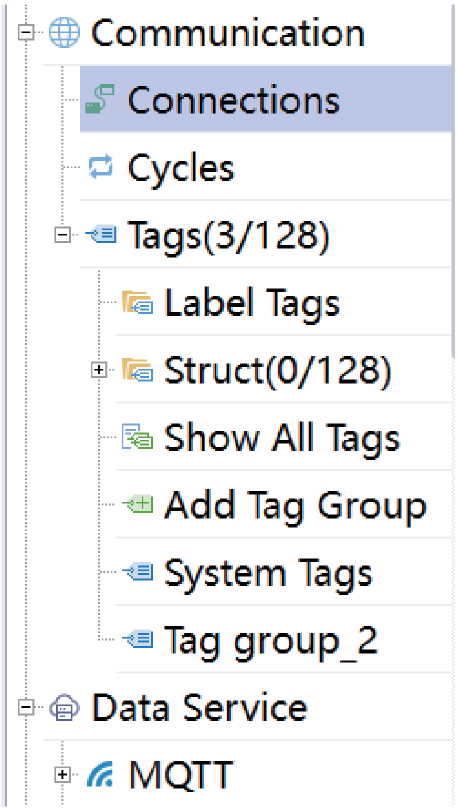
Click . In the window that is displayed, set the target HMI IP and click "Download". Wait for the progress bar to reach 100% to complete the HMI program download.



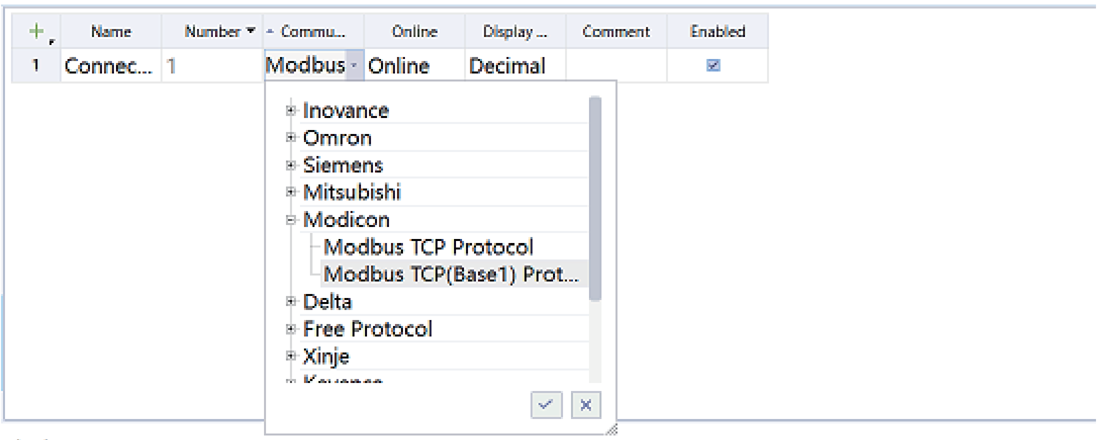

### 20.4.4.2 Accessing Customized Variables Through Mapping Address

1. Create an HMI project.
2. Create a communication connection.

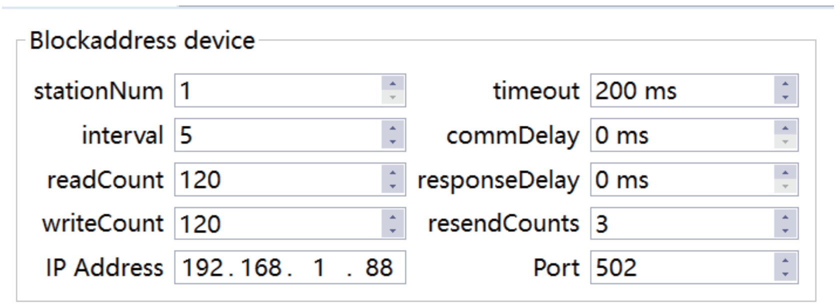
 a. In the project management pane on the left, double-click the connection tab.




b. On the connection management page, click the "+" icon to add a connection, and select the Modbus-TCP monitoring protocol.




c. Enter the IP address of the connected PLC and set the port number to 502 to complete the setup.




3. Add variables.

a. Click "Variable" to expand the variable menu. Click "Add variable group" to add a variable group.

b. Double-click the newly created variable group to open it.

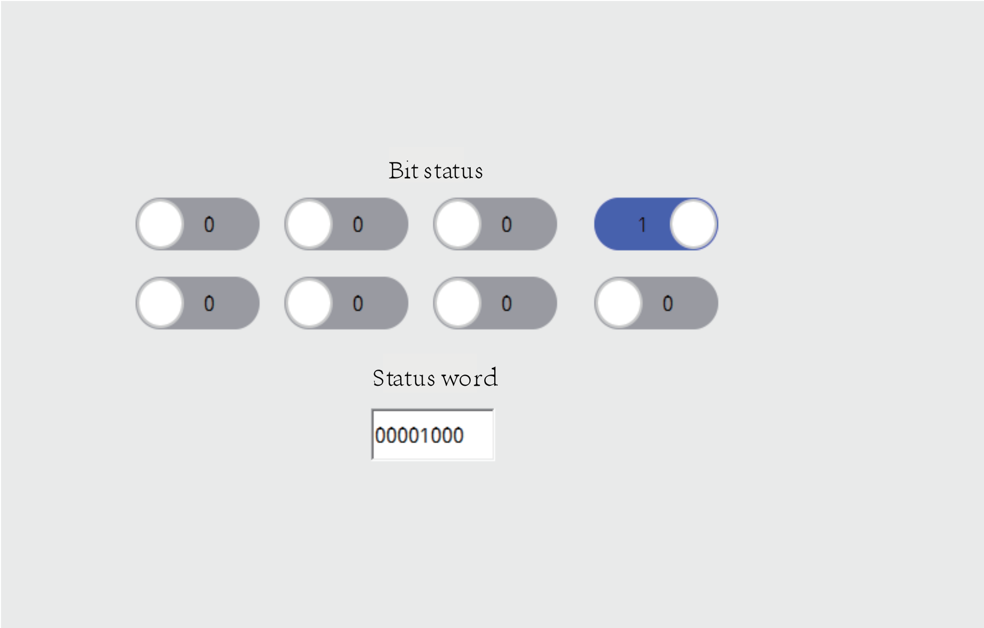
c. Add variables to be monitored.

Addresses of the added variables depend on the addresses allocated in the PLC.

4. Configure HMI and download the HMI project.

### 20.4.5 Example Running Results

After communication is established through the tag communication function, the bit states of customized variables and the corresponding status words can be monitored through the HMI.



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