OMRON

Machine Automation Controller

NJ-series

# CPU Unit Software

## User's Manual

**NJ501-1300**
**NJ501-1400**
**NJ501-1500**

CPU Unit


SYSMAC
always in control

W501-E1-01

# Introduction

Thank you for purchasing an NJ-series CPU Unit.
This manual contains information that is necessary to use the NJ-series CPU Unit. Please read this manual and make sure you understand the functionality and performance of the NJ-series CPU Unit before you attempt to use it in a control system.
Keep this manual in a safe place where it will be available for reference during operation.

## Intended Audience

This manual is intended for the following personnel, who must also have knowledge of electrical systems (an electrical engineer or the equivalent).

- Personnel in charge of introducing FA systems.
- Personnel in charge of designing FA systems.
- Personnel in charge of installing and maintaining FA systems.
- Personnel in charge of managing FA systems and facilities.

For programming, this manual is intended for personnel who understand the programming language specifications in international standard IEC 61131-3 or Japanese standard JIS B3503.

## Applicable Products

This manual covers the following products.

- NJ-series CPU Units
  - NJ501-1300
  - NJ501-1400
  - NJ501-1500

# Relevant Manuals

There are three manuals that provide basic information on the NJ-series CPU Units: the *NJ-series CPU Unit Hardware User's Manual*, the *NJ-series CPU Unit Software User's Manual* (this manual), and the *NJ-series Instructions Reference Manual*.

Most operations are performed from the Sysmac Studio Automation Software. Refer to the *Sysmac Studio Version 1 Operation Manual* (Cat. No. W504) for information on the Sysmac Studio.

Other manuals are necessary for specific system configurations and applications.

Read all of the manuals that are relevant to your system configuration and application to make the most of the NJ-series CPU Unit.

| | NJ-series User's Manuals | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Basic information | | | | | | | | |
| | NJ-series CPU Unit Hardware User's Manual | NJ-series CPU Unit Software User's Manual | NJ-series Instructions Reference Manual | NJ-series CPU Unit Motion Control User's Manual | NJ-series CPU Unit Built-in EtherCAT Port User's Manual | NJ-series Motion Control Instructions Reference Manual | NJ-series CPU Unit Built-in EtherNet/IP Port User's Manual | NJ-series Troubleshooting Manual | CJ-series Special Unit Operation Manuals for NJ-series CPU Unit |
| Introduction to NJ-series Controllers | ● | | | | | | | | |
| Setting devices and hardware | | | | | | | | | |
| Using motion control | | | | ● | | | | | |
| Using EtherCAT | ● | | | | ● | | | | |
| Using EtherNet/IP | | | | | | | ● | | |
| Using CJ-series Units | | | | | | | | | ● |
| Software settings | | ● | | | | | | | |
| Using motion control | | | | ● | | | | | |
| Using EtherCAT | | | | | ● | | | | |
| Using EtherNet/IP | | | | | | | ● | | |
| Programming | | ● | ● | | | | | | |
| Using motion control | | | | ● | | ● | | | |
| Using EtherCAT | | | | | ● | | | | |
| Using CJ-series Units | | | | | | | | | ● |
| Programming error processing | | | | | | | | ● | |
| Testing operation and debugging | | ● | | | | | | | |
| Using motion control | | | | ● | | | | | |
| Using EtherCAT | | | | | ● | | | | |
| Using EtherNet/IP | | | | | | | ● | | |
| Troubleshooting and managing errors in an NJ-series Controller | △ Use the relevant manuals for references according to any error that occurs. | △ | | △ | △ | | △ | ● | |
| Maintenance | ● | | | | | | | | |
| Using EtherCAT | | | | | ● | | | | |
| Using EtherNet/IP | | | | | | | ● | | |
| Using CJ-series Units | | | | | | | | | ● |

# Manual Configuration

## NJ-series CPU Unit Hardware User's Manual (Cat. No. W500)

| Section | Description |
|---|---|
| **Section 1<br>Introduction** | This section provides an introduction to the NJ-series Controllers and their features, and gives the NJ-series Controller specifications. |
| **Section 2<br>System Configuration** | This section describes the system configuration used for NJ-series Controllers. |
| **Section 3<br>Configuration Units** | This section describes the parts and functions of the configuration devices in the NJ-series Controller configuration, including the CPU Unit and Configuration Units. |
| **Section 4<br>Installation and Wiring** | This section describes where and how to install the CPU Unit and Configuration Units and how to wire them. |
| **Section 5<br>Troubleshooting** | This section describes the event codes, error confirmation methods, and corrections for errors that can occur. |
| **Section 6<br>Inspection and Maintenance** | This section describes the contents of periodic inspections, the service life of the Battery and Power Supply Units, and replacement methods for the Battery and Power Supply Units. |
| **Appendices** | The appendices provide the specifications of the Basic I/O Units, Unit dimensions, load short-circuit protection detection, line disconnection detection, and measures for EMC Directives. |

## NJ-series CPU Unit Software User's Manual (Cat. No. W501) (This Manual)

| Section | Description |
|---|---|
| **Section 1<br>Introduction** | This section provides an introduction to the NJ-series Controllers and their features, and gives the NJ-series Controller specifications. |
| **Section 2<br>CPU Unit Operation** | This section describes the variables and control systems of the CPU Unit and CPU Unit status. |
| **Section 3<br>I/O Ports, Slave Configuration, and Unit Configuration** | This section describes how to use I/O ports, how to create the slave configuration and unit configuration and how to assign functions. |
| **Section 4<br>Controller Setup** | This section describes the initial settings of the function modules. |
| **Section 5<br>Designing Tasks** | This section describes the task system and types of tasks. |
| **Section 6<br>Programming** | This section describes programming, including the programming languages and the variables and instructions that are used in programming. |
| **Section 7<br>Simulation, Transferring Projects to the Physical CPU Unit, and Operation** | This section describes simulation of Controller operation and how to use the results of simulation. |
| **Section 8<br>CPU Unit Status** | This section describes CPU Unit status. |
| **Section 9<br>CPU Unit Functions** | This section describes the functionality provided by the CPU Unit. |
| **Section 10<br>Communications Setup** | This section describes how to go online with the CPU Unit and how to connect to other devices. |
| **Section 11<br>Example of Actual Application Procedures** | This section describes the procedures that are used to actually operate an NJ-series Controller. |
| **Section 12<br>Troubleshooting** | This section describes the event codes, error confirmation methods, and corrections for errors that can occur. |
| **Appendices** | The appendices provide the CPU Unit specifications, task execution times, system-defined variable lists, data attribute lists, CJ-series Unit memory information, CJ-series Unit memory allocation methods, and data type conversion information. |

## NJ-series CPU Unit Motion Control User's Manual (Cat. No. W507)

| Section | Description |
|---|---|
| **Section 1**<br>**Introduction to the Motion Control Function Module** | This section describes the features, system configuration, and application flow for the Motion Control Function Module. |
| **Section 2**<br>**Motion Control Configuration and Principles** | This section outlines the internal structure of the CPU Unit and describes the configuration and principles of the MC Function Module. |
| **Section 3**<br>**Configuring Axes and Axes Groups** | This section describes the concept of axes and axes groups, the settings for axes that are required for the MC Test Run operations to function on the Sysmac Studio, and the instructions for creating and configuring axes and axes groups using the Sysmac Studio. |
| **Section 4**<br>**Checking Wiring from the Sysmac Studio** | This section describes the MC Test Run operations of the Sysmac Studio. You can use the MC Test Run operations to monitor sensor signals, check Servomotor wiring, and more, all without any programming. |
| **Section 5**<br>**Motion Control Parameters** | This section provides information on the axis parameters and axes group parameters that are used for motion control. |
| **Section 6**<br>**Motion Control Programming** | This section provides the specifications of a motion control program and the operating procedures that are required up through actual program development. |
| **Section 7**<br>**Manual Operation** | This section describes manual operation when the MC Function Module is used together with an OMRON G5-series Servo Drive. |
| **Section 8**<br>**Homing** | This section describes homing. |
| **Section 9**<br>**Motion Control Functions** | This section describes the motion control functions that are used when connected to OMRON G5-series Servo Drives with built-in EtherCAT communications. |
| **Section 10**<br>**Sample Programming** | This section describes basic application methods for homing, error monitoring, and other functions, and provides programming samples for absolute positioning, cam operation, and other axis operations. |
| **Section 11**<br>**Troubleshooting** | This section describes the items to check when problems occur in the MC Function Module. It includes error diagnosis and countermeasures for error indications, and error diagnosis and countermeasures for operating conditions. |
| **Appendices** | The appendices describe settings and connection methods for OMRON G5-series Servo Drive objects. |

## NJ-series Instructions Reference Manual (Cat. No. W502)

| Section | Description |
|---|---|
| **Section 1**<br>**Instruction Set** | This section provides a table of the instructions that are described in this manual. |
| **Section 2**<br>**Instruction Descriptions** | This section describes instruction specifications in detail. |
| **Appendices** | The appendices provide a table of error codes and other supplemental information to use instructions. |

## NJ-series CPU Unit Built-in EtherCAT Port User's Manual (Cat. No. W505)

| Section | Description |
|---|---|
| **Section 1 Introduction** | This section provides an overview of EtherCAT communications, describes the system configuration and specifications, and provides operating procedures. |
| **Section 2 Part Names and Slave Settings** | This section provides the part names and describes the slave settings and Sysmac device functions. |
| **Section 3 EtherCAT Communications** | This section describes the different types of EtherCAT communications, EtherCAT settings, and state transitions. |
| **Section 4 EtherCAT Network Wiring** | This section describes how to connect and wire an EtherCAT network. |
| **Section 5 Setting Up EtherCAT Communications with the Sysmac Studio** | This section describes how to set the network configuration information and how to check EtherCAT communications from the Sysmac Studio. |
| **Section 6 Process Data Communications and SDO Communications** | This section describes the timing of communications, response times, and special instructions for process data communications and SDO communications. It also provides sample programming. |
| **Section 7 System-defined Variables That Are Related to the Built-in EtherCAT Port** | This section describes the system-defined variables that are related to the built-in EtherCAT port. |
| **Section 8 Example of Operations for EtherCAT Communications** | This section provides a series of example operations for when an NJ-series CPU Unit is connected to slaves. |
| **Section 9 Troubleshooting** | This section describes the event codes, error confirmation methods, and corrections for errors that can occur for EtherCAT communications. It also describes how to replace slaves. |
| **Appendices** | The appendices describe the relation of EtherCAT communications to overall CPU Unit status, packet monitoring functions, and multi-vendor application. |

## NJ-series CPU Unit Built-in EtherNet/IP Port User's Manual (Cat. No. W506)

| Section | Description |
|---|---|
| **Section 1**<br>**Introduction** | This section provides an overview and the specifications of the built-in EtherNet/IP port on an NJ-series Controller. It introduces EtherNet/IP communications and describes the system configuration and operating procedures. |
| **Section 2**<br>**Installing Ethernet Networks** | This section describes the Ethernet network configuration devices, network installation, and cable connection methods. |
| **Section 3**<br>**System-defined Variables Related to the Built-in EtherNet/IP Port** | This section describes the system-defined variables that are related to the built-in EtherNet/IP port. |
| **Section 4**<br>**Determining IP Addresses** | This section describes how to set IP addresses for built-in EtherNet/IP ports. |
| **Section 5**<br>**Sysmac Studio Settings for the Built-in EtherNet/IP Port** | This section describes the settings that are required for EtherNet/IP communications. |
| **Section 6**<br>**Testing Communications** | This section describes how to perform communications test with EtherNet/IP nodes to confirm that the built-in EtherNet/IP port is set correctly. |
| **Section 7**<br>**Tag Data Link Functions** | This section introduces tag data link communications and describes the settings that are required to use tag data links. |
| **Section 8**<br>**Message Communications** | This section describes how to use CIP message communications for devices on the EtherNet/IP network, e.g., to read and write data. |
| **Section 9**<br>**Socket Service** | This section describes how to use socket communications to send and receive data with TCP/UDP. |
| **Section 10**<br>**FTP Server** | This section describes how to use the FTP server to download and upload files in the SD Memory Card to and from FTP clients. |
| **Section 11**<br>**Automatic Clock Adjustment** | This section describes how to automatically get clock information from an NTP server to update the clock information in the CPU Unit. |
| **Section 12**<br>**SNMP Agent** | This section describes how to use the SNMP to manage the built-in EtherNet/IP port as an SNMP agent. |
| **Section 13**<br>**Communications Performance and Communications Load** | This section describes tag data links communications, adjustment of the communications load, and communications time. |
| **Section 14**<br>**Troubleshooting** | This section describes how to use event codes and network status to confirm errors and corrections for them. |
| **Appendices** | The appendices provide a functional comparison of EtherNet/IP between NJ-series CPU Units and other series, and describe EDS file management, Windows firewall settings for connections from computers, and details on memory used for CJ-series Units. |

## NJ-series Motion Control Instructions Reference Manual (Cat. No. W508)

| Section | Description |
|---|---|
| **Section 1**<br>**Introduction to Motion Control Instructions** | This section gives an introduction to motion control instructions supported by NJ-series CPU Units. |
| **Section 2**<br>**Variables and Instructions** | This section describes the variables and instructions for the Motion Control Function Module. |
| **Section 3**<br>**Axis Command Instructions** | This section describes the instructions that are used to perform single-axis control for the MC Function Module. |
| **Section 4**<br>**Axes Group Instructions** | This section describes the instructions to perform multi-axes coordinated control for the MC Function Module. |
| **Section 5**<br>**Common Command Instructions** | This section describes the instructions that are used for both axes and axes groups. |
| **Appendices** | The appendices describe the error codes that are generated by the instructions. |

## NJ-series Troubleshooting Manual (Cat. No. W503)

| Section | Description |
|---|---|
| **Section 1**<br>**Overview of Errors** | This section describes the errors that can occur on an NJ-series Controller, the operation that occurs for errors, and methods to confirm errors. |
| **Section 2**<br>**Error Troubleshooting Methods** | This section describes how to handle errors. |
| **Section 3**<br>**Error Tables** | This section lists all of the error events that can occur on NJ-series Controllers. |

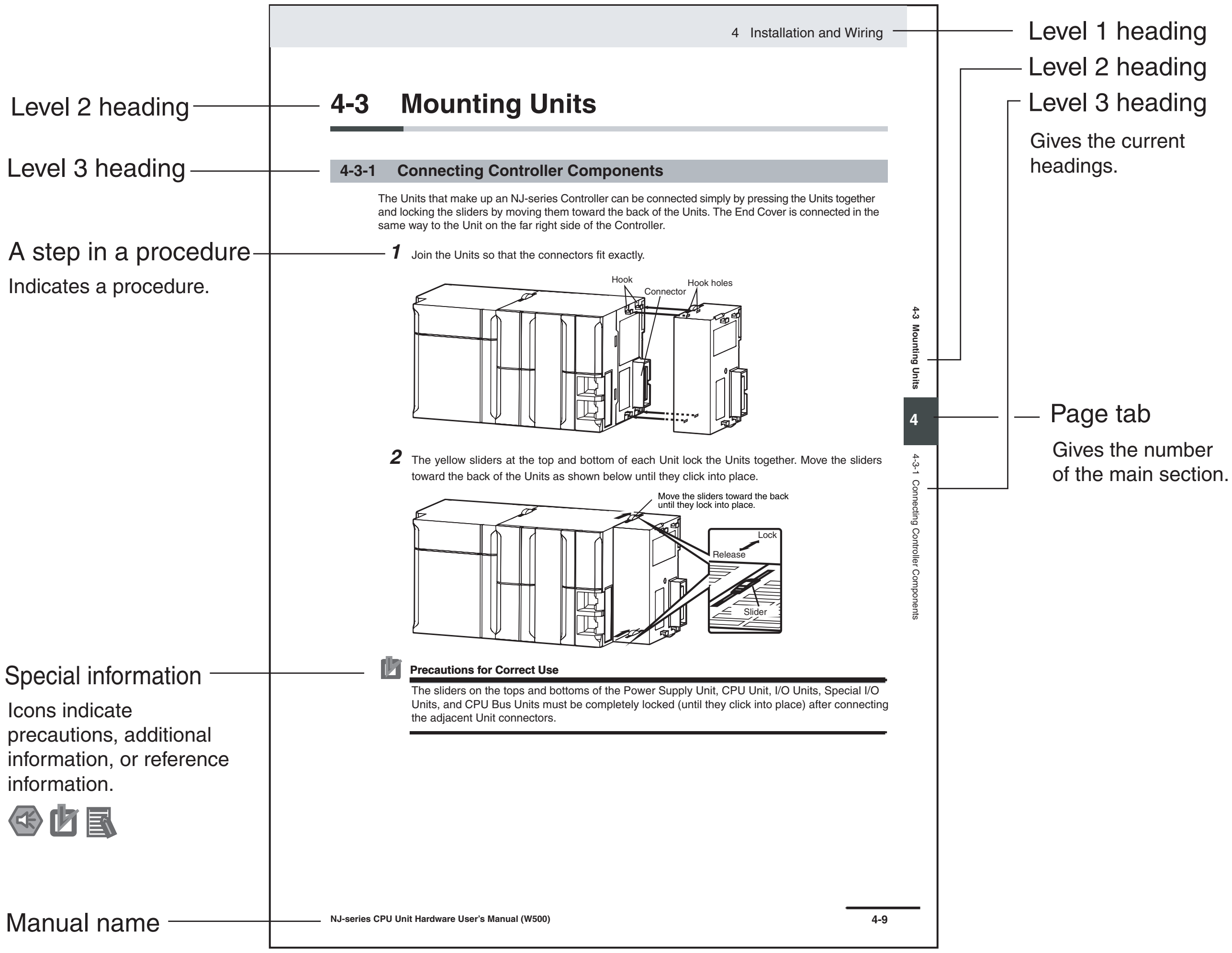
## Sysmac Studio Version 1 Operation Manual (Cat. No. W504)

| Section | Description |
|---|---|
| **Section 1**<br>**Introduction** | This section provides an overview and lists the specifications of the Sysmac Studio and describes its features and components. |
| **Section 2**<br>**Installation and Uninstallation** | This section describes how to install and uninstall the Sysmac Studio. |
| **Section 3**<br>**System Design** | This section describes the basic concepts for designing an NJ-series System with the Sysmac Studio and the basic operating procedures. |
| **Section 4**<br>**Programming** | This section describes how to create programs with the Sysmac Studio. |
| **Section 5**<br>**Online Connections to a Controller** | This section describes how to go online with a Controller. |
| **Section 6**<br>**Debugging** | This section describes how to debug the programs online on the Controller or debug it offline with the Simulator. |
| **Section 7**<br>**Other Functions** | This section describes Sysmac Studio functions other than system design functions. |
| **Section 8**<br>**Reusing Programming** | This section describes how to reuse the programs that you create with the Sysmac Studio. |
| **Section 9**<br>**Support Software Provided with the Sysmac Studio** | This section describes the Support Software that is provided with the Sysmac Studio. |
| **Section 10**<br>**Troubleshooting** | This section describes the error messages that are displayed when you check a program on the Sysmac Studio and how to correct those errors. |
| **Appendices** | The appendices describe the following:<br>Driver Installation for Direct USB Cable Connection<br>Specifying One of Multiple Ethernet Interface Cards<br>Online Help<br>Simulation Instructions |

# Manual Structure

## Page Structure

The following page structure is used in this manual.




This illustration is provided only as a sample. It may not literally appear in this manual.

## Special Information

Special information in this manual is classified as follows:

**Precautions for Safe Use**

Precautions on what to do and what not to do to ensure safe usage of the product.

**Precautions for Correct Use**

Precautions on what to do and what not to do to ensure proper operation and performance.

**Additional Information**

Additional information to read as required.
This information is provided to increase understanding or make operation easier.

**Note** References are provided to more detailed or related information.

## Precaution on Terminology

In this manual, “download” refers to transferring data from the Sysmac Studio to the physical Controller and “upload” refers to transferring data from the physical Controller to the Sysmac Studio.

For the Sysmac Studio, synchronization is used to both upload and download data. Here, “synchronize” means to automatically compare the data for the Sysmac Studio on the computer with the data in the physical Controller and transfer the data in the direction that is specified by the user.

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2 CPU Unit Operation

3 I/O Ports, Slave Configuration, and Unit Configuration

4 Controller Setup

5 Designing Tasks

6 Programming

7 Simulation, Transferring Projects to the Physical CPU Unit, and Operation

8 CPU Unit Status

9 CPU Unit Functions

10 Communications Setup

11 Example of Actual Application Procedures

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# Read and Understand this Manual

Please read and understand this manual before using the product. Please consult your OMRON representative if you have any questions or comments.

## Warranty and Limitations of Liability

### WARRANTY

OMRON's exclusive warranty is that the products are free from defects in materials and workmanship for a period of one year (or other period if specified) from date of sale by OMRON.

OMRON MAKES NO WARRANTY OR REPRESENTATION, EXPRESS OR IMPLIED, REGARDING NON-INFRINGEMENT, MERCHANTABILITY, OR FITNESS FOR PARTICULAR PURPOSE OF THE PRODUCTS. ANY BUYER OR USER ACKNOWLEDGES THAT THE BUYER OR USER ALONE HAS DETERMINED THAT THE PRODUCTS WILL SUITABLY MEET THE REQUIREMENTS OF THEIR INTENDED USE. OMRON DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED.

### LIMITATIONS OF LIABILITY

OMRON SHALL NOT BE RESPONSIBLE FOR SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES, LOSS OF PROFITS OR COMMERCIAL LOSS IN ANY WAY CONNECTED WITH THE PRODUCTS, WHETHER SUCH CLAIM IS BASED ON CONTRACT, WARRANTY, NEGLIGENCE, OR STRICT LIABILITY.

In no event shall the responsibility of OMRON for any act exceed the individual price of the product on which liability is asserted.

IN NO EVENT SHALL OMRON BE RESPONSIBLE FOR WARRANTY, REPAIR, OR OTHER CLAIMS REGARDING THE PRODUCTS UNLESS OMRON'S ANALYSIS CONFIRMS THAT THE PRODUCTS WERE PROPERLY HANDLED, STORED, INSTALLED, AND MAINTAINED AND NOT SUBJECT TO CONTAMINATION, ABUSE, MISUSE, OR INAPPROPRIATE MODIFICATION OR REPAIR.

# Application Considerations

## SUITABILITY FOR USE

OMRON shall not be responsible for conformity with any standards, codes, or regulations that apply to the combination of products in the customer's application or use of the products.

At the customer's request, OMRON will provide applicable third party certification documents identifying ratings and limitations of use that apply to the products. This information by itself is not sufficient for a complete determination of the suitability of the products in combination with the end product, machine, system, or other application or use.

The following are some examples of applications for which particular attention must be given. This is not intended to be an exhaustive list of all possible uses of the products, nor is it intended to imply that the uses listed may be suitable for the products:

- Outdoor use, uses involving potential chemical contamination or electrical interference, or conditions or uses not described in this manual.
- Nuclear energy control systems, combustion systems, railroad systems, aviation systems, medical equipment, amusement machines, vehicles, safety equipment, and installations subject to separate industry or government regulations.
- Systems, machines, and equipment that could present a risk to life or property.

Please know and observe all prohibitions of use applicable to the products.

NEVER USE THE PRODUCTS FOR AN APPLICATION INVOLVING SERIOUS RISK TO LIFE OR PROPERTY WITHOUT ENSURING THAT THE SYSTEM AS A WHOLE HAS BEEN DESIGNED TO ADDRESS THE RISKS, AND THAT THE OMRON PRODUCTS ARE PROPERLY RATED AND INSTALLED FOR THE INTENDED USE WITHIN THE OVERALL EQUIPMENT OR SYSTEM.

## PROGRAMMABLE PRODUCTS

OMRON shall not be responsible for the user's programming of a programmable product, or any consequence thereof.

# Disclaimers

## CHANGE IN SPECIFICATIONS

Product specifications and accessories may be changed at any time based on improvements and other reasons.

It is our practice to change model numbers when published ratings or features are changed, or when significant construction changes are made. However, some specifications of the products may be changed without any notice. When in doubt, special model numbers may be assigned to fix or establish key specifications for your application on your request. Please consult with your OMRON representative at any time to confirm actual specifications of purchased products.

## DIMENSIONS AND WEIGHTS

Dimensions and weights are nominal and are not to be used for manufacturing purposes, even when tolerances are shown.

## PERFORMANCE DATA

Performance data given in this manual is provided as a guide for the user in determining suitability and does not constitute a warranty. It may represent the result of OMRON's test conditions, and the users must correlate it to actual application requirements. Actual performance is subject to the OMRON Warranty and Limitations of Liability.

## ERRORS AND OMISSIONS

The information in this manual has been carefully checked and is believed to be accurate; however, no responsibility is assumed for clerical, typographical, or proofreading errors, or omissions.

# Safety Precautions

## Definition of Precautionary Information

The following notation is used in this manual to provide precautions required to ensure safe usage of an NJ-series Controller. The safety precautions that are provided are extremely important to safety. Always read and heed the information provided in all safety precautions.
The following notation is used.

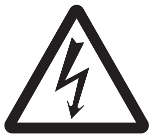
| | |
|---|---|
| ⚠ **WARNING** | Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury. Additionally, there may be severe property damage. |
| ⚠ **Caution** | Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury, or property damage. |

**Precautions for Safe Use**
Indicates precautions on what to do and what not to do to ensure safe usage of the product.

**Precautions for Correct Use**
Indicates precautions on what to do and what not to do to ensure proper operation and performance.

## Symbols

The circle and slash symbol indicates operations that you must not do.
The specific operation is shown in the circle and explained in text.
This example indicates prohibiting disassembly.



The triangle symbol indicates precautions (including warnings).
The specific operation is shown in the triangle and explained in text.
This example indicates a precaution for electric shock.

The triangle symbol indicates precautions (including warnings).
The specific operation is shown in the triangle and explained in text.
This example indicates a general precaution.

The filled circle symbol indicates operations that you must do.
The specific operation is shown in the circle and explained in text.
This example shows a general precaution for something that you must do.

# ⚠ WARNING

## During Power Supply

Do not touch any of the terminals or terminal blocks while the power is being supplied. Doing so may result in electric shock.

Do not attempt to take any Unit apart. In particular, high-voltage parts are present in the Power Supply Unit while power is supplied or immediately after power is turned OFF. Touching any of these parts may result in electric shock. There are sharp parts inside the Unit that may cause injury.

## Fail-safe Measures

Provide safety measures in external circuits to ensure safety in the system if an abnormality occurs due to malfunction of the CPU Unit, other Units, or slaves or due to other external factors affecting operation. Not doing so may result in serious accidents due to incorrect operation.

Emergency stop circuits, interlock circuits, limit circuits, and similar safety measures must be provided in external control circuits.

The Controller outputs may remain ON or OFF due to deposition or burning of the output relays or destruction of the output transistors. As a countermeasure for such problems, external safety measures must be provided to ensure safe operation of the system.

The CPU Unit will turn OFF all outputs from Basic Output Units in the following cases.

- If an error occurs in the power supply
- If the power supply connection becomes faulty
- If a CPU watchdog timer error or CPU reset occurs
- If a major fault level Controller error occurs
- While the CPU Unit is on standby until RUN mode is entered after the power is turned ON

External safety measures must be provided to ensure safe operation of the system even if the outputs turn OFF.

If external power supplies for slaves or other devices are overloaded or short-circuited, the voltage will drop, outputs will turn OFF, and the system may be unable to read inputs. Provide external safety measures in controls with monitoring of external power supply voltage as required so that the system operates safely in such a case.

# ⚠ WARNING

## Fail-safe Measures

Unintended outputs may occur when an error occurs in variable memory or in memory used for CJ-series Units. As a countermeasure for such problems, external safety measures must be provided to ensure safe operation of the system.

Provide measures in the communications system and user program to ensure safety in the overall system even if errors or malfunctions occur in data link communications or remote I/O communications.

If there is interference in remote I/O communications or if a major fault level error occurs, output status will depend on the products that are used.
Confirm the operation that will occur when there is interference in communications or a major fault level error, and implement safety measures.
Correctly set all of the EtherCAT slaves.

The NJ-series Controller continues normal operation for a certain period of time when a momentary power interruption occurs. This means that the NJ-series Controller may receive incorrect signals from external devices that are also affected by the power interruption. Accordingly, take suitable actions, such as external fail-safe measures and interlock conditions, to monitor the power supply voltage of the external device as required.

You must take fail-safe measures to ensure safety in the event of incorrect, missing, or abnormal signals caused by broken signal lines, momentary power interruptions, or other causes. Not doing so may result in serious accidents due to incorrect operation.

## Voltage and Current Inputs

Make sure that the voltages and currents that are input to the Units and slaves are within the specified ranges.
Inputting voltages or currents that are outside of the specified ranges may cause accidents or fire.

## Downloading

Always confirm safety at the destination before you transfer a user program, configuration data, setup data, device variables, or values in memory used for CJ-series Units from the Sysmac Studio. The devices or machines may perform unexpected operation regardless of the operating mode of the CPU Unit.

# ⚠ Caution

## Application

Do not touch any Unit when power is being supplied or immediately after the power supply is turned OFF. Doing so may result in burn injury.

## Wiring

Be sure that all terminal screws and cable connector screws are tightened to the torque specified in the relevant manuals. The loose screws may result in fire or malfunction.

## Online Editing

Execute online editing only after confirming that no adverse effects will be caused by deviations in the timing of I/O. If you perform online editing, the task execution time may exceed the task period, I/O may not be refreshed with external devices, input signals may not be read, and output timing may change.

# Precautions for Safe Use

## Disassembly and Dropping

- Do not attempt to disassemble, repair, or modify any Units. Doing so may result in malfunction or fire.
- Do not drop any Unit or subject it to abnormal vibration or shock. Doing so may result in Unit malfunction or burning.

## Mounting

- The sliders on the tops and bottoms of the Power Supply Unit, CPU Unit, I/O Units, Special I/O Unit, and CPU Bus Units must be completely locked (until they click into place) after connecting the adjacent Unit connectors.

## Installation

- Always connect to a ground of 100 Ω or less when installing the Units. A ground of 100 Ω or less must be installed when shorting the GR and LG terminals on the Power Supply Unit.

## Wiring

- Follow the instructions in this manual to correctly perform wiring.
  Double-check all wiring and switch settings before turning ON the power supply.
- Use crimp terminals for wiring.
  Do not connect bare stranded wires directly to terminals.
- Do not pull on the cables or bend the cables beyond their natural limit.
  Do not place heavy objects on top of the cables or other wiring lines. Doing so may break the cables.
- Mount terminal blocks and connectors only after checking the mounting location carefully.
  Be sure that the terminal blocks, expansion cables, and other items with locking devices are properly locked into place.
- Always remove any dustproof labels that are on the top of the Units when they are shipped before you turn ON the power supply. If the labels are not removed, heat will accumulate and malfunctions may occur.
- Before you connect a computer to the CPU Unit, disconnect the power supply plug of the computer from the AC outlet. Also, if the computer has an FG terminal, make the connections so that the FG terminal has the same electrical potential as the FG (GR) terminal on the Power Supply Unit. A difference in electric potential between the computer and Controller may cause failure or malfunction.
- If the external power supply to an Output Unit or slave has polarity, connect it with the correct polarity. If the polarity is reversed, current may flow in the reverse direction and damage the connected devices regardless of the operation of the Controller.

## Power Supply Design

- Do not exceed the rated supply capacity of the Power Supply Units in the NJ-series Controller. The rated supply capacities are given in the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500).
  If the capacity is exceeded, operation may stop, malfunctions may occur, or data may not be backed up normally for power interruptions.
  Use NJ-series Power Supply Units for both the NJ-series CPU Rack and Expansion Racks.
  Operation is not possible if a CJ-series Power Supply Unit is used with an NJ-series CPU Unit or an NJ-series Power Supply Unit is used with a CJ-series CPU Unit.

- Do not apply voltages or connect loads to the Output Units or slaves in excess of the maximum ratings.
- Surge current occurs when the power supply is turned ON. When selecting fuses or breakers for external circuits, consider the above precaution and allow sufficient margin in shut-off performance. Refer to the relevant manuals for surge current specifications. Refer to the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500) for surge current specifications.
- If the full dielectric strength voltage is applied or turned OFF using the switch on the tester, the generated impulse voltage may damage the Power Supply Unit. Use the adjustment on the tester to gradually increase and decrease the voltage.
- Apply the voltage between the Power Supply Unit's L1 or L2 terminal and the GR terminal when testing insulation and dielectric strength. You do not have to disconnect the LG and GR terminals to perform these tests.
- Do not supply AC power from an inverter or other device with a square-wave output. Internal temperature rise may result in smoking or burning. Always input a sinusoidal wave with the frequency that is given in the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500).
- Install external breakers and take other safety measures against short-circuiting in external wiring.

## Turning ON the Power Supply

- It takes up to approximately 10 to 20 s to enter RUN mode after the power is turned ON. During that time, outputs will be OFF or will be the values specified in the Unit or slave settings, and external communications cannot be performed. Use the RUN output on the Power Supply Unit, for example, to implement fail-safe circuits so that external devices do not operate incorrectly.
- Configure the external circuits so that the power supply to the control system turns ON only after the power supply to the Controller has turned ON. If the power supply to the Controller is turned ON after the control power supply, temporary errors may result in incorrect control system signals because the output terminals on Output Units may momentarily turn ON when power supply is turned ON to the Controller.

## Actual Operation

- Check the user program, data, and parameter settings for proper execution before you use them for actual operation.

## Turning OFF the Power Supply

- Never turn OFF the power supply to the Controller when the BUSY indicator is flashing. While the BUSY indicator is lit, the user program and settings in the CPU Unit are being backed up in the built-in non-volatile memory. This data will not be backed up correctly if the power supply is turned OFF. Also, a major fault level Controller error will occur the next time you start operation, and operation will stop.
- Do not turn OFF the power supply or remove the SD Memory Card while SD Memory Card access is in progress (i.e., while the SD BUSY indicator flashes). Data may become corrupted, and the Controller will not operate correctly if it uses corrupted data. To remove the SD Memory Card from the CPU Unit while the power supply is ON, press the SD Memory Card power supply switch and wait for the SD BUSY indicator to turn OFF before you remove the SD Memory Card.
- Do not disconnect the cable or turn OFF the power supply to the Controller when downloading data or the user program from Support Software.
- Always turn OFF the power supply to the Controller before you attempt any of the following.
  - Mounting or removing I/O Units or the CPU Unit
  - Assembling the Units
  - Setting DIP switches or rotary switches
  - Connecting cables or wiring the system
  - Connecting or disconnecting the connectors

The Power Supply Unit may continue to supply power to the rest of the Controller for a few seconds after the power supply turns OFF. The PWR indicator is lit during this time. Confirm that the PWR indicator is not lit before you perform any of the above.

## Operation

- Confirm that no adverse effect will occur in the system before you attempt any of the following.
  - Changing the operating mode of the CPU Unit (including changing the setting of the Operating Mode at Startup)
  - Changing the user program or settings
  - Changing set values or present values
  - Forced refreshing
- Always sufficiently check the safety at the connected devices before you change the settings of an EtherCAT slave or Special Unit.
- If two different function modules are used together, such as when you use CJ-series Basic Output Units and EtherCAT slave outputs, take suitable measures in the user program and external controls to ensure that safety is maintained in the controlled system if one of the function modules stops. The relevant outputs will stop if a partial fault level error occurs in one of the function modules.
- Always confirm safety at the connected equipment before you reset Controller errors with an event level of partial fault or higher for the EtherCAT Master Function Module.
  When the error is reset, all slaves that were in any state other than Operational state due to a Controller error with an event level of partial fault or higher (in which outputs are disabled) will go to Operational state and the outputs will be enabled.
  Before you reset all errors, confirm that no Controller errors with an event level of partial fault have occurred for the EtherCAT Master Function Module.
- Always confirm safety at the connected equipment before you reset Controller errors for a CJ-series Special Unit. When a Controller error is reset, the Unit where the Controller error with an event level of observation or higher will be restarted.
  Before you reset all errors, confirm that no Controller errors with an event level of observation or higher have occurred for the CJ-series Special Unit. Observation level events do not appear on the Controller Error Tab Page, so it is possible that you may restart the CJ-series Special Unit without intending to do so.
  You can check the status of the *_CJB_UnitErrSta[0,0]* to *_CJB_UnitErrSta[3,9]* error status variables on a Watch Tab Page to see if an observation level Controller error has occurred.

## Battery Backup

- The user program and initial values for the variables are stored in non-volatile memory in the CPU Unit. The present values of variables with the Retain attribute and the values of the Holding, DM, and EM Areas in the memory used for CJ-series Units are backed up by a Battery. If the Battery is not connected or the Battery is exhausted, the CPU Unit detects a Battery-backup Memory Check Error. If that error is detected, variables with a Retain attribute are set to their initial values and the Holding, DM, and EM Areas in memory used for CJ-series Units are cleared to all zeros. Perform thorough verifications and provide sufficient measures to ensure that the devices perform safe operation for the initial values of the variables with Retain attributes and the resulting operation.

## Debugging

- Forced refreshing ignores the results of user program execution and refreshes I/O with the specified values. If forced refreshing is used for inputs for which I/O refreshing is not supported, the inputs will first take the specified values, but they will then be overwritten by the user program. This operation differs from the force-set/reset functionality of the CJ-series PLCs.

- You cannot upload or download information for forced refreshing with the Sysmac Studio.
  After downloading data that contains forced refreshing, change to RUN mode and then use the Sysmac Studio to perform the operation for forced refreshing.
  Depending on the difference in the forced status, the control system may operate unexpectedly.
- Do not specify the same address for the AT specification for more than one variable.
  Doing so would allow the same entity to be accessed with different variable names, which would make the user program more difficult to understand and possibly cause programming mistakes.

## General Communications

- When you use data link communications, check the error information given in the status flags to make sure that no error has occurred in the source device. Write the user program to use the received data only if there is no error. If there is an error in the source device, the data for the data link may contain incorrect values.
- Unexpected operation may result if inappropriate data link tables are set. Even if appropriate data link tables have been set, confirm that the controlled system will not be adversely affected before you transfer the data link tables. The data links start automatically after the data link tables are transferred.
- All CPU Bus Units are restarted when routing tables are transferred from Support Software to the CPU Unit. Restarting these Units is required to read and enable the new routing tables. Confirm that the system will not be adversely affected by restarting before you transfer the routing tables.
- Tag data links will stop between related nodes while tag data link parameters are transferred during Controller operation. Confirm that the system will not be adversely affected before you transfer the tag data link parameters.

## EtherNet/IP Communications

- All related EtherNet/IP nodes are reset when you transfer settings for the built-in EtherNet/IP port (including IP addresses and tag data links settings). This is performed to read and enable the settings. Confirm that the system will not be adversely affected by resetting nodes before you transfer the settings.
- If EtherNet/IP tag data links (cyclic communications) are used with a repeating hub, the communications load on the network will increase. This will increase collisions and may prevent stable communications. Do not use repeating hubs on networks where tag data links are used. Use an Ethernet switch instead.

## EtherCAT Communications

- Make sure that the communications distance, number of nodes connected, and method of connection for EtherCAT are within specifications.
  Do not connect EtherCAT communications to EtherNet/IP, a standard in-house LAN, or other networks. An overload may cause the network to fail or malfunction.
- Malfunctions or unexpected operation may occur for some combinations of EtherCAT revisions of the master and slaves. If you disable the revision check in the network settings, use the Sysmac Studio to check the slave revision settings in the master and the actual slave revisions, and then make sure that functionality is compatible in the slave manuals or other references. You can check the actual slave revisions from the Sysmac Studio or on slave nameplates.
- After you transfer the user program, the CPU Unit is restarted. Communications with the EtherCAT slaves are cut off for up to 45 seconds. During that period, the slave outputs behave according to the slave settings.
  Before you transfer the user program, confirm that the system will not be adversely affected.
- If the Fail-soft Operation parameter is set to stop operation, process data communications will stop for all slaves when an EtherCAT communications error is detected in a slave. For this reason, if Servo Drives are connected, the Servos for all axes will be turned OFF. Make sure that the Fail-soft Operation parameter setting results in safe operation when a device error occurs.

- EtherCAT communications are not always established immediately after the power supply is turned ON. Use the system-defined variables in the user program to confirm that communications are established before attempting control operations.
- If frames sent to EtherCAT slaves are lost due to noise or other causes, slave I/O data is not communicated, and the intended operation is sometimes not achieved. If noise countermeasures are required, use the *_EC_InDataInvalid* (Input Data Disable) system-defined variable as an interlock condition in the user program.
  Refer to the *NJ-series CPU Unit Built-in EtherCAT Port User's Manual* (Cat. No. W505) for details.
  The slave outputs behave according to the slave settings. Refer to the manuals for the slaves for details.
- When an EtherCAT slave is disconnected, communications will stop and control of the outputs will be lost not only for the disconnected slave, but for all slaves connected after it. Confirm that the system will not be adversely affected before you disconnect a slave.
- If you disconnect the cable from an EtherCAT slave to disconnect it from the network, any current communications frames may be lost. If frames are lost, slave I/O data is not communicated, and the intended operation is sometimes not achieved. Perform the following processing for a slave that needs to be replaced.
  Program the *_EC_InDataInvalid* (Input Data Disable) system-defined variable as an interlock condition.
  Set the Impermissible Number of Continuous Timeouts setting in the EtherCAT master to at least 2.
  Refer to the *NJ-series CPU Unit Built-in EtherCAT Port User's Manual* (Cat. No. W505) for details.

## Motion Control

- Confirm the axis number carefully before you perform an MC Test Run.
- The motor is stopped if communications are interrupted between the Sysmac Studio and the CPU Unit during an MC Test Run. Connect the communications cable between the computer and CPU Unit securely and confirm that the system will not be adversely affected before you perform an MC Test Run.
- Always execute the Save Cam Table instruction if you change any of the cam data from the user program in the CPU Unit or from the Sysmac Studio. If the cam data is not saved, the previous condition will be restored when the power is turned ON again, possibly causing unexpected machine operation.
- The positive drive prohibit input (POT), negative drive prohibit input (NOT), and home proximity input (DEC) of the Servo Drive are used by the MC Function Module as the positive limit input, negative limit input, and home proximity input. Make sure that the signal widths for all of these input signals are longer than the control period of the MC Function Module. If the input signal widths are shorter than the control period, the MC Function Module may not be able to detect the input signals, resulting in incorrect operation.

## Battery Replacement

- The Battery may leak, rupture, heat, or ignite. Never short-circuit, charge, disassemble, heat, or incinerate the Battery or subject it to strong shock.
- Dispose of any Battery that has been dropped on the floor or otherwise subjected to excessive shock. Batteries that have been subjected to shock may leak if they are used.
- UL standards require that only an experienced engineer replace the Battery. Make sure that an experienced engineer is in charge of Battery replacement.
- Apply power for at least five minutes before changing the Battery. Install a new Battery within five minutes (at 25°C) of turning OFF the power supply. If power is not supplied for at least 5 minutes, the saved data may be lost.

## Unit Replacement

- We recommend replacing the Battery with the power turned OFF to prevent the CPU Unit's sensitive internal components from being damaged by static electricity and to prevent malfunctions. The Battery can be replaced without turning OFF the power supply. To do so, always touch a grounded piece of metal to discharge static electricity from your body before you start the procedure.
  After you replace the Battery, connect the Sysmac Studio and clear the Low Battery Voltage error.
- Make sure that the required data, including the user program, configurations, settings, variables, and memory used for CJ-series Units, is transferred to a CPU Unit that was replaced and to externally connected devices before restarting operation.
  Be sure to include the routing tables, network parameters, and other CPU Bus Unit data, which are stored in the CPU Unit.

## Disposal

- Dispose of the product and Batteries according to local ordinances as they apply.

  廢電池請回收
- The following information must be displayed for all products that contain primary lithium batteries with a perchlorate content of 6 ppb or higher when shipped to or transported through the State of California, USA.

  Perchlorate Material - special handling may apply.
  See www.dtsc.ca.gov/hazardouswaste/perchlorate.
- The CPU Unit contains a primary lithium battery with a perchlorate content of 6 ppb or higher. Place the above information on the individual boxes and shipping boxes when shipping finished products that contain a CPU Unit to the State of California, USA.

# Precautions for Correct Use

## Storage, Mounting, and Wiring

- Do not operate or store the Controller in the following locations. Operation may stop or malfunctions may occur.
  - Locations subject to direct sunlight
  - Locations subject to temperatures or humidity outside the range specified in the specifications
  - Locations subject to condensation as the result of severe changes in temperature
  - Locations subject to corrosive or flammable gases
  - Locations subject to dust (especially iron dust) or salts
  - Locations subject to exposure to water, oil, or chemicals
  - Locations subject to shock or vibration
- Take appropriate and sufficient countermeasures when installing the Controller in the following locations.
  - Locations subject to strong, high-frequency noise
  - Locations subject to static electricity or other forms of noise
  - Locations subject to strong electromagnetic fields
  - Locations subject to possible exposure to radioactivity
  - Locations close to power lines
- Before touching a Unit, be sure to first touch a grounded metallic object in order to discharge any static build-up.
- Install the Controller away from sources of heat and ensure proper ventilation. Not doing so may result in malfunction, in operation stopping, or in burning.
- An I/O bus check error will occur and the Controller will stop if an I/O Connecting Cable's connector is disconnected from the Rack. Be sure that the connectors are secure.
- Do not allow foreign matter to enter the openings in the Unit. Doing so may result in Unit burning, electric shock, or failure.
- Do not allow wire clippings, shavings, or other foreign material to enter any Unit. Otherwise, Unit burning, failure, or malfunction may occur. Cover the Units or take other suitable countermeasures, especially during wiring work.
- For EtherCAT and EtherNet/IP, use the connection methods and cables that are specified in the *NJ-series CPU Unit Built-in EtherCAT Port User's Manual* (Cat. No. W505) and the *NJ-series CPU Unit Built-in EtherNet/IP Port User's Manual* (Cat. No. W506). Otherwise, communications may be faulty.
- Use the rated power supply voltage for the Power Supply Units. Take appropriate measures to ensure that the specified power with the rated voltage and frequency is supplied in places where the power supply is unstable.
- Make sure that the current capacity of the wire is sufficient. Otherwise, excessive heat may be generated. When cross-wiring terminals, the total current for all the terminals will flow in the wire. When wiring cross-overs, make sure that the current capacity of each of the wires is not exceeded.
- Do not touch the terminals on the Power Supply Unit immediately after turning OFF the power supply. Residual voltage may cause electrical shock.
- If you use reed switches for the input contacts for AC Input Units, use switches with a current capacity of 1 A or greater.
  If the capacity of the reed switches is too low, surge current may fuse the contacts.

## Error Processing

- In applications that use the results of instructions that read the error status, consider the affect on the system when errors are detected and program error processing accordingly. For example, even the detection of a minor error, such as Battery replacement during operation, can affect the system depending on how the user program is written.

## Unit Replacement

- If you replace a CPU Bus Unit or Special I/O Unit, refer to operation manual for the Unit for information on the data required for individual Units and redo the necessary settings.
- The absolute encoder home offset is backed up with a Battery in the CPU Unit.
  When you change the combination of the CPU Unit and Servomotor, e.g., when you add or replace a Servomotor, define home again.
  To restore the information without changing the CPU Unit-Servomotor combination, remove the absolute encoder home offset from the data to restore.

## Task Settings

- If a Task Period Exceeded error occurs, shorten the programs to fit in the task period or increase the setting of the task period.

## Motion Control

- Use the system-defined variable in the user program to confirm that EtherCAT communications are established before you attempt to execute motion control instructions. Motion control instructions are not executed normally if EtherCAT communications are not established.
- Use the system-defined variables to monitor for errors in communications with the slaves that are controlled by the motion control function module. Motion control instructions are not executed normally if an error occur in slave communications.
- Before you start an MC Test Run, make sure that the operation parameters are set correctly.
- Do not download motion control settings during an MC Test Run.

## EtherCAT Communications

- Do not disconnect the EtherCAT slave cables during operation. The outputs will become unstable.
- Set the Servo Drives to stop operation if an error occurs in EtherCAT communications between the Controller and a Servo Drive.

## Battery Replacement

- Be sure to install a replacement Battery within two years of the production date shown on the Battery label.
- Turn ON the power after replacing the Battery for a CPU Unit that has been unused for a long time. Leaving the CPU Unit unused again without turning ON the power even once after the Battery is replaced may result in a shorter Battery life.
- When you replace the Battery, use the CJ1W-BAT01 Battery Set.

## SD Memory Cards

- Insert the SD Memory Card all the way.
- Do not turn OFF the power supply to the Controller during SD Memory Card access. The files may be corrupted.
  If there is a corrupted file in the SD Memory Card, the file is automatically deleted by the restoration function when the power supply is turned ON.

# Regulations and Standards

## Conformance to EC Directives

### Applicable Directives

- EMC Directives
- Low Voltage Directive

### Concepts

#### EMC Directive

OMRON devices that comply with EC Directives also conform to the related EMC standards so that they can be more easily built into other devices or the overall machine. The actual products have been checked for conformity to EMC standards.*
Whether the products conform to the standards in the system used by the customer, however, must be checked by the customer. EMC-related performance of the OMRON devices that comply with EC Directives will vary depending on the configuration, wiring, and other conditions of the equipment or control panel on which the OMRON devices are installed. The customer must, therefore, perform the final check to confirm that devices and the overall machine conform to EMC standards.

* Applicable EMC (Electromagnetic Compatibility) standards are as follows:
EMS (Electromagnetic Susceptibility): EN 61131-2 and EN 61000-6-2
EMI (Electromagnetic Interference): EN 61131-2 and EN 61000-6-4 (Radiated emission: 10-m regulations)

#### Low Voltage Directive

Always ensure that devices operating at voltages of 50 to 1,000 VAC and 75 to 1,500 VDC meet the required safety standards. The applicable directive is EN 61131-2.

#### Conformance to EC Directives

The NJ-series Controllers comply with EC Directives. To ensure that the machine or device in which the NJ-series Controller is used complies with EC Directives, the Controller must be installed as follows:

- The NJ-series Controller must be installed within a control panel.
- You must use reinforced insulation or double insulation for the DC power supplies connected to DC Power Supply Units and I/O Units.
- NJ-series Controllers that comply with EC Directives also conform to the Common Emission Standard (EN 61000-6-4). Radiated emission characteristics (10-m regulations) may vary depending on the configuration of the control panel used, other devices connected to the control panel, wiring, and other conditions.
  You must therefore confirm that the overall machine or equipment complies with EC Directives.

## Conformance to Shipbuilding Standards

The NJ-series Controllers comply with the following shipbuilding standards. Applicability to the shipbuilding standards is based on certain usage conditions. It may not be possible to use the product in some locations. Contact your OMRON representative before attempting to use a Controller on a ship.

### Usage Conditions for NK and LR Shipbuilding Standards

- The NJ-series Controller must be installed within a control panel.
- Gaps in the door to the control panel must be completely filled or covered with gaskets or other material.
- The following noise filter must be connected to the power supply line.

**Noise Filter**

| Manufacturer | Model |
|---|---|
| Cosel Co., Ltd. | TAH-06-683 |

## Trademarks

- Sysmac and SYSMAC are trademarks or registered trademarks of OMRON Corporation in Japan and other countries for OMRON factory automation products.
- Windows, Windows 98, Windows XP, Windows Vista, and Windows 7 are registered trademarks of Microsoft Corporation in the USA and other countries.
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## Software Licenses and Copyrights

This product incorporates certain third party software. The license and copyright information associated with this software is available at http://www.fa.omron.co.jp/nj_info_e/.

# Unit Versions

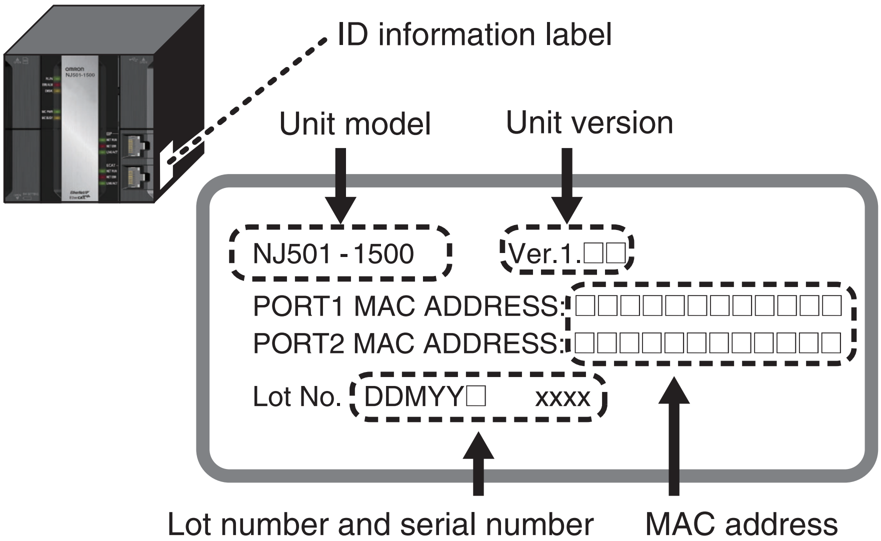
## Unit Versions

A “unit version” has been introduced to manage CPU Units in the NJ Series according to differences in functionality accompanying Unit upgrades.

### Notation of Unit Versions on Products

The unit version is given on the ID information label of the products for which unit versions are managed, as shown below.

Example for NJ-series NJ501-□□□□ CPU Unit:




The following information is provided on the ID information label.

| Item | Description |
|---|---|
| Unit model | Gives the model of the Unit. |
| Unit version | Gives the unit version of the Unit. |
| Lot number and serial number | Gives the lot number and serial number of the Unit.<br>DDMYY: Lot number, □: For use by OMRON, xxxx: Serial number<br>“M” gives the month (1 to 9: January to September, X: October, Y: November, Z: December) |
| MAC address | Gives the MAC address of the built-in port on the Unit. |

### Confirming Unit Versions with Sysmac Studio

You can use the Unit Production Information on the Sysmac Studio to check the unit version of the CPU Unit, CJ-series Special I/O Units, CJ-series CPU Bus Units, and EtherCAT slaves. The unit versions of CJ-series Basic I/O Units cannot be checked from the Sysmac Studio.

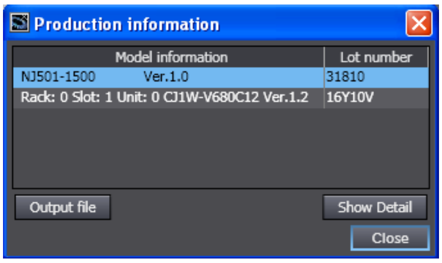
#### ● CPU Unit and CJ-series Units

**1** Double-click **CPU/Expansion Racks** under **Configurations and Setup** in the Multiview Explorer. Or, right-click **CPU/Expansion Racks** under **Configurations and Setup** and select ***Edit*** from the menu.

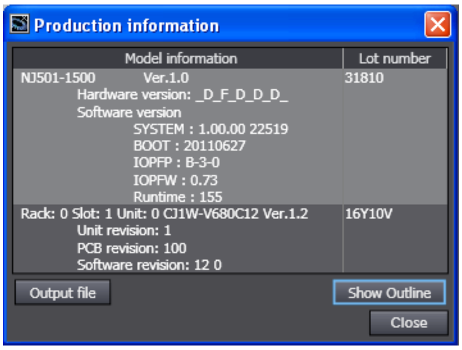
The Unit Editor is displayed for the Controller Configurations and Setup layer.

**2** Right-click any open space in the Unit Editor and select ***Production Information***.

The Production Information Dialog Box is displayed.




Simple Display




Detailed Display

In this example, “Ver.1.0” is displayed next to the unit model.

The following items are displayed.

| CPU Unit | CJ-series Units |
|---|---|
| Unit model | Unit model |
| Unit version | Unit version |
| Lot number | Lot number |
| | Rack number, slot number, and unit number |

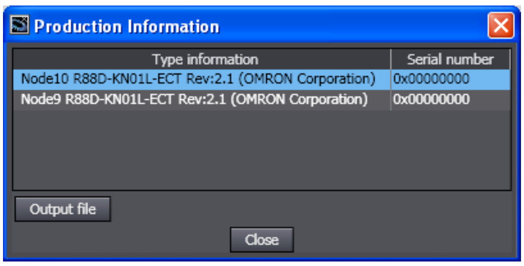
## ● EtherCAT Slaves

**1** Double-click **EtherCAT** under **Configurations and Setup** in the Multiview Explorer. Or, right-click **EtherCAT** under **Configurations and Setup** and select ***Edit*** from the menu.

The EtherCAT Configuration Tab Page is displayed for the Controller Configurations and Setup layer.

**2** Right-click the master in the EtherCAT Configurations Editing Pane and select **Display Production Information**.

The Production Information Dialog Box is displayed.




The following items are displayed.
Node address
Type information*
Serial number

* If the model number cannot be determined (such as when there is no ESI file), the vendor ID, product code, and revision number are displayed.

## Unit Version Notation

In this manual, unit versions are specified as shown in the following table.

| Product nameplate | Notation in this manual | Remarks |
|---|---|---|
| “Ver.1.0” or later to the right of the lot number | Unit version 1.0 or later | Unless unit versions are specified, the information in this manual applies to all unit versions. |

# Related Manuals

The following manuals are related to the NJ-series Controllers. Use these manuals for reference.

| Manual name | Cat. No. | Model numbers | Application | Description |
|---|---|---|---|---|
| NJ-series CPU Unit Hardware User's Manual | W500 | NJ501-□□□□ | Learning the basic specifications of the NJ-series CPU Units, including introductory information, designing, installation, and maintenance. Mainly hardware information is provided. | An introduction to the entire NJ-series system is provided along with the following information on a Controller built with an NJ501 CPU Unit.<br>• Features and system configuration<br>• Introduction<br>• Part names and functions<br>• General specifications<br>• Installation and wiring<br>• Maintenance and inspection<br>Use this manual together with the *NJ-series CPU Unit Software User's Manual* (Cat. No. W501). |
| NJ-series CPU Unit Software User's Manual | W501 | NJ501-□□□□ | Learning how to program and set up an NJ-series CPU Unit. Mainly software information is provided. | The following information is provided on a Controller built with an NJ501 CPU Unit.<br>• CPU Unit operation<br>• CPU Unit features<br>• Initial settings<br>• Programming based on IEC 61131-3 language specifications<br>Use this manual together with the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500). |
| NJ-series CPU Unit Motion Control User's Manual | W507 | NJ501-□□□□ | Learning about motion control settings and programming concepts. | The settings and operation of the CPU Unit and programming concepts for motion control are described. Use this manual together with the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500) and *NJ-series CPU Unit Software User's Manual* (Cat. No. W501). |
| NJ-series Instructions Reference Manual | W502 | NJ501-□□□□ | Learning about the specifications of the instruction set that is provided by OMRON. | The instructions in the instruction set (IEC 61131-3 specifications) are described. When programming, use this manual together with the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500) and *NJ-series CPU Unit Software User's Manual* (Cat. No. W501). |
| NJ-series Motion Control Instructions Reference Manual | W508 | NJ501-□□□□ | Learning about the specifications of the motion control instructions that are provided by OMRON. | The motion control instructions are described. When programming, use this manual together with the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500), NJ-series CPU Unit Software User's Manual (Cat. No. W501) and *NJ-series CPU Unit Motion Control User's Manual* (Cat. No. W507). |
| CJ-series Special Unit Manuals for NJ-series CPU Unit | W490<br>W498<br>W499<br>W491<br>Z310<br>W492<br>W494<br>W497 | CJ1W-□□□□ | Learning how to use CJ-series Units with an NJ-series CPU Unit. | The methods and precautions for using CJ-series Units with an NJ501 CPU Unit are described, including access methods and programming interfaces. Manuals are available for the following Units.<br>Analog I/O Units, Insulated-type Analog I/O Units, Temperature Control Units, ID Sensor Units, High-speed Counter Units, Serial Communications Units, and DeviceNet Units.<br>Use these manuals together with the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500) and *NJ-series CPU Unit Software User's Manual* (Cat. No. W501). |

| Manual name | Cat. No. | Model numbers | Application | Description |
|---|---|---|---|---|
| NJ-series CPU Unit Built-in EtherCAT Port User's Manual | W505 | NJ501-□□□□ | Using the built-in EtherCAT port on an NJ-series CPU Unit. | Information on the built-in EtherCAT port is provided. This manual provides an introduction and provides information on the configuration, features, and setup.<br>Use this manual together with the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500) and *NJ-series CPU Unit Software User's Manual* (Cat. No. W501). |
| NJ-series CPU Unit Built-in EtherNet/IP Port User's Manual | W506 | NJ501-□□□□ | Using the built-in EtherNet/IP port on an NJ-series CPU Unit. | Information on the built-in EtherNet/IP port is provided. Information is provided on the basic setup, tag data links, and other features.<br>Use this manual together with the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500) and *NJ-series CPU Unit Software User's Manual* (Cat. No. W501). |
| NJ-series Troubleshooting Manual | W503 | NJ501-□□□□ | Learning about the errors that may be detected in an NJ-series Controller. | Concepts on managing errors that may be detected in an NJ-series Controller and information on individual errors are described.<br>Use this manual together with the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500) and *NJ-series CPU Unit Software User's Manual* (Cat. No. W501). |
| Sysmac Studio Version 1 Operation Manual | W504 | SYSMAC-SE2□□□ | Learning about the operating procedures and functions of the Sysmac Studio. | Describes the operating procedures of the Sysmac Studio. |
| CX-Integrator CS/CJ/CP/NSJ-series Network Configuration Tool Operation Manual | W464 | | Learning how to configure networks (data links, routing tables, Communications Unit settings, etc.). | Describes operating procedures for the CX-Integrator. |
| CX-Designer User's Manual | V099 | | Learning to create screen data for NS-series Programmable Terminals. | Describes operating procedures for the CX-Designer. |
| CX-Protocol Operation Manual | W344 | | Creating data transfer protocols for general-purpose devices connected to CJ-series Serial Communications Units. | Describes operating procedures for the CX-Protocol. |

# Terminology

| Term | Description |
|---|---|
| absolute encoder home offset | This data is used to restore in the CPU Unit the actual position of a Servo Drive with an absolute encoder. The offset is the difference between the command position after homing and the absolute data that is read from the absolute encoder. |
| array specification | One of the variable specifications. An array variable contains multiple elements of the same data type. The elements in the array are specified by serial numbers called subscripts that start from the beginning of the array. |
| AT | One of the attributes of a variable.<br>This attribute allows the user to specify what is assigned to a variable. An I/O port or an address in memory used for CJ-series Units can be specified. |
| axes group | A functional unit that groups together axes within the Motion Control Function Module. |
| Axes Group Variable | A system-defined variable that is defined as a structure and provides status information and some of the axes parameters for an individual axes group.<br>An Axes Group Variable is used to specify an axes group for motion control instructions and to monitor the command interpolation velocity, error information, and other information for the axes group. |
| axis | A functional unit within the Motion Control Function Module. An axis is assigned to the drive mechanism in an external Servo Drive or the sensing mechanism in an external Encoder Input Slave Unit. |
| Axis Variable | A system-defined variable that is defined as a structure and provides status information and some of the axis parameters for an individual axis.<br>An Axis Variable is used to specify an axis for motion control instructions and to monitor the command position, error information, and other information for the axis. |
| basic data type | Any of the data types that are defined by IEC 61131-3.<br>They include Boolean, bit string, integer, real, duration, date, time of day, date and time, and text string data types.<br>"Basic data type" is used as opposed to derivative data types, which are defined by the user. |
| cam data variable | A variable that represents the cam data as a structure array.<br>A cam data variable is an array structure that consists of phases and displacements. |
| CJ-series CPU Unit | Any of the CJ-series Units that can be used with an NJ-series Controller. |
| Constant | One of the attributes of a variable.<br>If you specify the Constant attribute for a variable, the value of the variable cannot be written by any instructions, ST operators, or CIP message communications. |
| Controller | The range of devices that are directly controlled by the CPU Unit.<br>In the NJ-series System, the Controller includes the CPU Rack, Expansion Racks, and EtherCAT slaves (including general-purpose slaves and Servo Drives). |
| Controller error | Errors that are defined by the NJ-series System.<br>“Controller error” is a collective term for major fault level, partial fault level, minor fault level, and observation Controller events. |
| Controller event | One of the events in the NJ-series System. Controller events are errors and information that are defined by the system for user notification. A Controller event occurs when the system detects a factor that is defined as a Controller event. |
| Controller information | Information that is defined by the NJ-series System that is not an error. It represents an information Controller event. |
| derivative data type | A data type that is defined by the user. Structures, unions, and enumerations are derivative data types. |
| device variable | A variable that is used to access a specific device through an I/O port. |
| download | To transfer data from the Sysmac Studio to the Controller with the synchronization operation of the Sysmac Studio. |
| edge | One of the attributes of a variable.<br>This attribute makes a BOOL variable pass TRUE to a function block when the variable changes from FALSE to TRUE or when it changes from TRUE to FALSE. |

| Term | Description |
|---|---|
| enumeration | One of the derivative data types. This data type takes one item from a prepared name list of enumerators as its value. |
| enumerator | One of the values that an enumeration can take expressed as a character string. The value of an enumeration is one of the enumerators. |
| EtherCAT Master Function Module | One of the function modules. This function module controls the EtherCAT slaves as the EtherCAT master. |
| EtherNet/IP Function Module | One of the function modules. This function module controls the built-in EtherNet/IP port. |
| event log | A function that recognizes and records errors and other events. |
| Event Setup | Settings that define user-defined errors and user-defined information. |
| FB | An acronym for "function block." |
| forced refreshing | Forcing the refreshing of an input from an external device or an output to an external device, e.g., when the user debugs a program.<br>Addresses that are subject to forced refreshing can still be overwritten from the user program. |
| FUN | An abbreviation for "function." |
| function | A POU that is used to create an object that determines a unique output for the same input, such as for data processing. |
| function block | A POU that is used to create an object that can have a different output for the same input, such as for a timer or counter. |
| function module | One of the functional units of the software configuration of the CPU Unit. |
| general-purpose slave | Any of the EtherCAT slaves that cannot be assigned to an axis. |
| global variable | A variable that can be read or written from all POUs (programs, functions, and function blocks). |
| I/O map settings | Settings that assign variables to I/O ports. Assignment information between I/O ports and variables. |
| I/O port | A logical interface that is used by the CPU Unit to exchange data with an external device (slave or Unit). |
| I/O refreshing | Cyclic data exchange with external devices that is performed with predetermined memory addresses. |
| information | One of the event levels for Controller events or user-defined events. These are not errors, but appear in the event log to notify the user of specific information. |
| Initial Value | One of the attributes of a variable. The variable is set to the initial value in the following situations.<br>• When power is turned ON<br>• When the CPU Unit changes to RUN mode<br>• When you specify to initialize the values when the user program is transferred<br>• When a major fault level Controller error occurs |
| inline ST | ST programming that is included within a ladder diagram program. |
| instruction | The smallest unit of the processing elements that are provided by OMRON for use in POU algorithms. There are ladder diagram instructions (program inputs and outputs), function instructions, function block instructions, and ST statements. |
| literal | A constant expression that is used in a user program. |
| local variable | A variable that can be accessed only from inside the POU in which it is defined. “Local variable” is used as opposed to “global variable.”<br>Local variables include internal variables, input variables, output variables, in-out variables, and external variables. |
| main memory | The memory inside the CPU Unit that is used by the CPU Unit to execute the OS and user program. |
| major fault level Controller error | An error for which all NJ-series Controller control operations stop. The CPU Unit immediately stops user program execution and turns OFF the loads for all slaves and Units (including remote I/O). |
| MC Test Run | A function to check motor operation and wiring from the Sysmac Studio. |
| memory used for CJ-series units | One type of I/O memory in an NJ-series CPU Unit. It contains addresses that can be directly specified by the user.<br>It can be accessed only with variables with an AT attribute. This memory is used to access CJ-series Units and CJ-series networks. |

| Term | Description |
|---|---|
| minor fault level Controller error | An error for which part of the control operations for one of the function modules in the NJ-series Controller stop.<br>An NJ-series CPU Unit continues operation even after a minor fault level Controller error occurs. |
| Motion Control Function Module | One of the function modules. The MC Function Module performs motion control based on commands from the motion control instructions that are executed in the user program. |
| motion control instruction | A function block instruction that executes motion control.<br>The Motion Control Function Module supports instructions that are based on function blocks for PLCopen motion control as well as instructions developed specifically for the Motion Control Function Module. |
| Network Publish | One of the attributes of a variable.<br>This attribute allows you to use CIP message communications or tag data links to read/write variables from another Controller or from a host computer. |
| observation | One of the event levels for Controller events or user-defined events.<br>These are minor errors that do not affect control operations, but appear in the event log to notify the user of specific information. |
| partial fault level Controller error | An error for which all of the control operations for one of the function modules in the NJ-series Controller stop.<br>An NJ-series CPU Unit continues operation even after a partial fault level Controller error. |
| PDO communications | An abbreviation for process data communications. Data is exchanged between the master and slaves on a process data communications cycle. (The process data communications cycle is the same as the task period of the primary periodic task.) |
| periodic task | A tasks for which user program execution and I/O refreshing are performed each period. |
| PLC Function Module | One of the function modules. This function module executes the user program, sends commands to the Motion Control Function Module, and provides an interface to the USB and SD Memory Card. |
| POU | An acronym for "program organization unit." A POU is a unit in a program execution model that is defined in IEC 61131-3.<br>A POU contains an algorithm and a local variable table and forms the basic unit used to build a user program.<br>There are three types of POUs: programs, functions, and function blocks. |
| primary periodic task | The task with the highest priority. |
| process data communications | One type of EtherCAT communications in which process data objects (PDOs) are used to exchange information cyclically and in realtime. Process data communications are also called PDO communications. |
| program | Along with functions and function blocks, one of the three types of POUs.<br>Programs are assigned to tasks to execute them. |
| Range Specification | One of the variable specifications. You can specify a range for a variable in advance. The variable can take only values that are in the specified range. |
| Retain | One of the attributes of a variable. The values of variables with a Retain attribute are held at the following times. (Variables without a Retain attribute are set to their initial values.)<br>• When power is turned ON after a power interruption<br>• When the CPU Unit changes to RUN mode<br>• When you specify to not initialize the values when the user program is transferred |
| SDO communications | One type of EtherCAT communications in which service data objects (SDOs) are used to transmit information whenever required. |
| Servo Drive/encoder input slave | Any of the EtherCAT slaves that is assigned to an axis. In the NJ-series System, it would be a Servo Drive or Encoder Input Slave Unit. |
| slave and Unit configurations | A generic term for the EtherCAT configuration and Unit configuration. |
| Special Unit Setup | A generic term for the settings for a Special Unit, including the settings in allocated DM Area words. |
| structure | One of the derivative data types. It consists of multiple data types placed together into a layered structure. |

| Term | Description |
|---|---|
| synchronization | A function that automatically compares the information in the NJ-series Controller with the information in the Sysmac Studio, displays any differences and locations in a hierarchical form, and can be used to synchronize the information. |
| Sysmac Studio | A computer software application for setting, programming, debugging, and trouble-shooting NJ-series Controllers. It also provides operations for motion control and a Simulator. |
| system common processing | System processing that is performed by the CPU Unit to perform I/O refreshing and the user program execution within a task. Exclusive control of variables between tasks, data trace processing, and other processing is performed. |
| system service | Processing that is performed by the CPU Unit in unused time between task pro-cessing. The system service includes communications processing, SD Memory Card access processing, self-diagnosis processing, and other processing. |
| system-defined variable | A variable for which all attributes are defined by the system and cannot be changed by the user. |
| task | An attribute that defines when a program is executed. |
| task period | The interval at which the primary periodic task or a periodic task is executed. |
| union | One of the derivative data types. It allows you to handle the same data as different data types. |
| Unit configuration | The configuration information for the Units that are set on the Sysmac Studio. This information tells what Unit models are connected to the CPU Unit and where they are connected. |
| upload | To transfer data from the Controller to the Sysmac Studio with the synchronization operation of the Sysmac Studio. |
| user program | All of the programs in one project. |
| user-defined event | One of the events in the NJ-series System. These events are defined by the user. “User-defined events” is a generic term for user-defined errors and user-defined information. |
| user-defined variable | A variable for which all of the attributes are defined by the user and can be changed by the user. |
| variable | A representation of data, such as a numeric value or character string, that is used in a user program.<br>You can change the value of a variable by assigned the required value. “Variable” is used as opposed to “constant,” for which the value does not change. |
| variable memory | A memory area that contains the present values of variables that do not have AT specifications. It can be accessed only with variables without an AT attribute. |

# Revision History

A manual revision code appears as a suffix to the catalog number on the front and back covers of the manual.

**Cat. No. W501-E1-01**

Revision code

| Revision code | Date | Revised content |
|---|---|---|
| 01 | July 2011 | Original production |

1

# Introduction

This section provides an introduction to the NJ-series Controllers and their features, and gives the NJ-series Controller specifications.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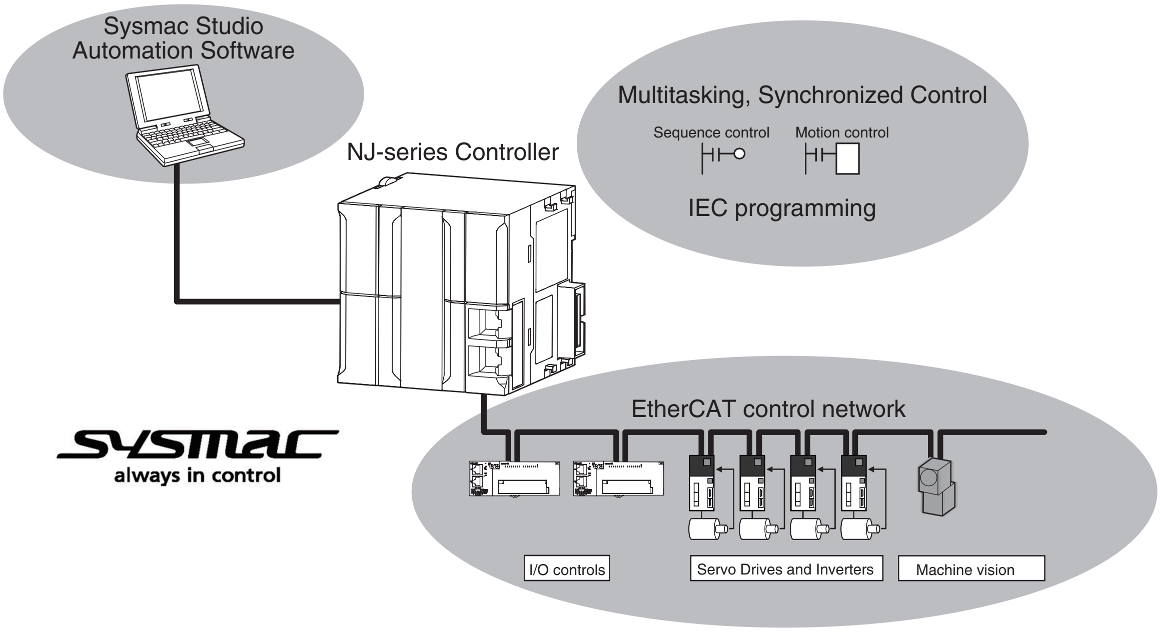
1-3-2 Procedure Details . . . . . . . . . . 1-9

# 1-1 The NJ-series Controllers

The SYSMAC NJ-series Controllers are next-generation machine automation controllers that provide the functionality and high-speed performance that are required for machine control. They provide the safety, reliability, and maintainability that are required of industrial controllers.

The NJ-series Controllers provide the functionality of previous OMRON PLCs, and they also provide the functionality that is required for motion control. Synchronized control of I/O devices on high-speed EtherCAT can be applied to vision systems, motion equipment, discrete I/O, and more.

OMRON offers the new Sysmac Series of control devices designed with unified communications specifications and user interface specifications. The NJ-series Machine Automation Controllers are part of the Sysmac Series. You can use them together with EtherCAT slaves, other Sysmac products, and the Sysmac Studio Automation Software to achieve optimum functionality and ease of operation. With a system that is created from Sysmac products, you can connect components and commission the system through unified concepts and usability.




## 1-1-1 Features

### Hardware Features

#### ● Standard-feature EtherCAT Control Network Support

All CPU Units provide an EtherCAT master port for EtherCAT communications. EtherCAT is an advanced industrial network system that achieves faster, more-efficient communications. It is based on Ethernet. Each node achieves a short fixed communications cycle time by transmitting Ethernet frames at high speed. The standard-feature EtherCAT control network allows you to connect all of the devices required for machine control (e.g., I/O systems, Servo Drives, Inverters, and machine vision) to the same network.

#### ● CJ-series Units

In addition to EtherCAT network slaves, you can also mount CJ-series Basic I/O Units and Special Units on the I/O bus.

### ● Standard-feature EtherNet/IP Communications Port

All CPU Units provide an EtherNet/IP port for EtherNet/IP communications. EtherNet/IP is a multi-vendor industrial network that uses Ethernet. You can use it for networks between Controllers or as a field network. The use of standard Ethernet technology allows you to connect to many different types of general-purpose Ethernet devices.

### ● Standard-feature USB Port

You can connect the computer that runs the Support Software directly to the CPU Unit.

### ● Standard-feature SD Memory Card Slot

You can access an SD Memory Card that is mounted in the CPU Unit from the user program.

### ● Highly Reliable Hardware

The NJ-series Controllers provide the hardware reliability and RAS functions that you expect of a PLC.

## Software Features

### ● Integrated Sequence Control and Motion Control

An NJ-series CPU Unit can perform both sequence control and motion control. You can simultaneously achieve both sequence control and multi-axes synchronized control. Sequence control, motion control, and I/O refreshing are all executed in the same control period. The same control period is also used for the process data communications cycle for EtherCAT. This enables precise sequence and motion control in a fixed period with very little deviation.

### ● Multitasking

You assign I/O refreshing and programs to tasks and then specify execution conditions and execution order for them to flexibly combine controls that suit the application.

### ● Programming Languages Based on the IEC 61131-3 International Standard

The NJ-series Controllers support language specifications that are based on IEC 61131-3. To these, OMRON has added our own improvements. Motion control instructions that are based on PLCopen standards and an instruction set (POUs) that follows IEC rules are provided.

### ● Programming with Variables to Eliminate Worrying about the Memory Map

You access all data through variables in the same way as for the advanced programming languages that are used on computers. Memory in the CPU Unit is automatically assigned to the variables that you create so that you do not have to remember the physical addresses.

### ● A Wealth of Security Features

The many security features of the NJ-series Controllers include operation authority settings and restriction of program execution with IDs.

### ● Complete Controller Monitoring

The CPU Unit monitors events in all parts of the Controller, including mounted Units and EtherCAT slaves. Troubleshooting information for errors is displayed on the Sysmac Studio or on an NS-series PT. Events are also recorded in logs.

- **Sysmac Studio Automation Software**

The Sysmac Studio provides an integrated development environment that covers not only the Controller, but also covers peripheral devices and devices on EtherCAT. You can use consistent procedures for all devices regardless of the differences in the devices. The Sysmac Studio supports all phases of Controller application, from designing through debugging, simulations, commissioning, and changes during operation.

- **A Wealth of Simulation Features**

The many simulation features include execution, debugging, and task execution time estimates on a virtual controller.

## 1-1-2 Introduction to the System Configurations

The NJ Series supports the following system configurations.

- **Basic System Configurations**

The NJ-series basic configurations include the EtherCAT network configuration, CJ-series Unit configuration, and the Support Software.

### EtherCAT Network Configuration

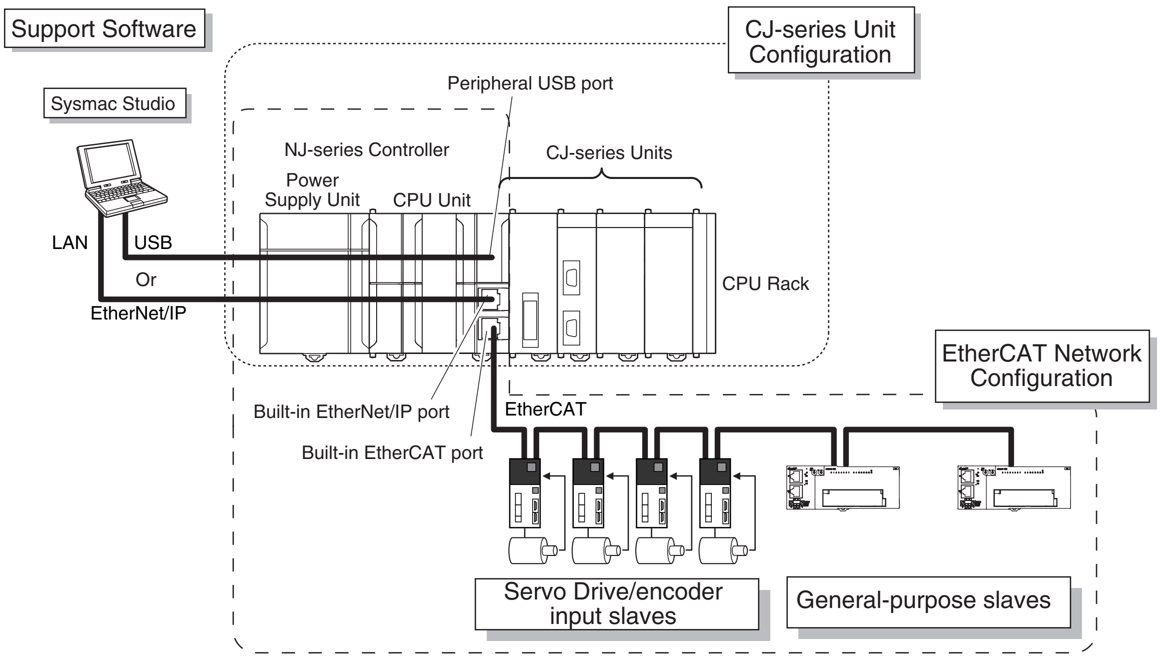
You can use the built-in EtherCAT master port on the CPU Unit to connect to general-purpose terminals for analog and digital I/O and to Servo Drives and encoder input slaves. An EtherCAT network configuration enables precise sequence and motion control in a fixed cycle with very little deviation.

### CJ-series Unit Configuration

In addition to the EtherCAT network, you can mount CJ-series Basic I/O Units and Special Units. CJ-series Units can be mounted both to the CPU Rack where the CPU Unit is mounted and to Expansion Racks.

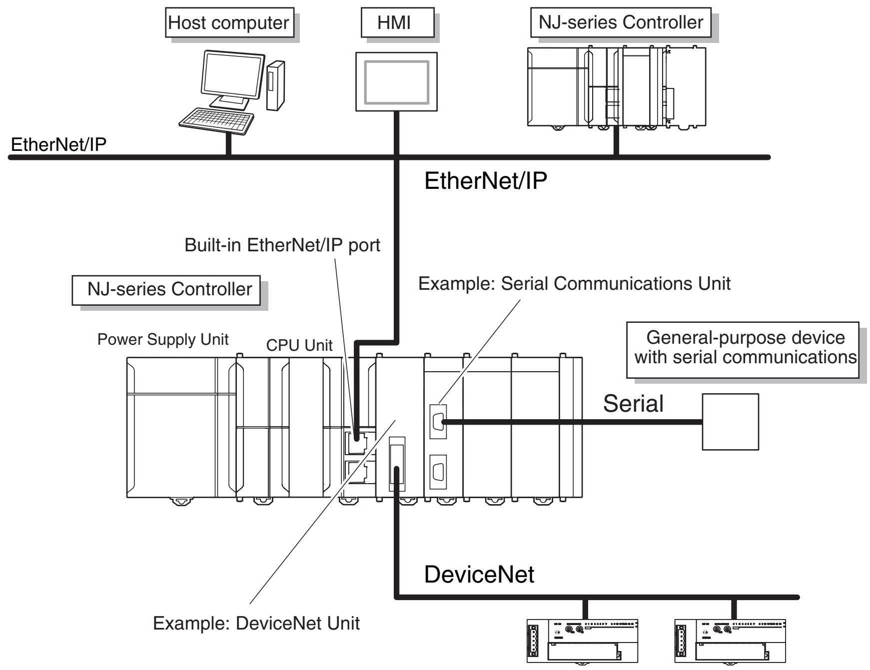
### Support Software

The Support Software is connected to the peripheral USB port on the CPU Unit with a commercially available USB cable. You can also connect it to the built-in EtherNet/IP port on the CPU Unit with Ethernet cable.



## ● Network Configurations

- Host computers, HMIs, and other NJ-series Controllers are connected to the built-in EtherNet/IP port on the CPU Unit.
- A DeviceNet network is connected to a DeviceNet Unit. A serial communications network is connected to a Serial Communications Unit.




## ● Support Software

You can use the following Support Software to set up, monitor, and debug an NJ-series Controller.

### Sysmac Studio

The Sysmac Studio is the main Support Software that you use for an NJ-series Controller. On it, you can set up the Controller configurations, parameters, and programs, and you can debug and simulate operation.

### Other Support Software

The following Support Software is also included in the Sysmac Studio Software Package Standard Edition.

| Configuration software | Application |
|---|---|
| **Sysmac Studio** | The Sysmac Studio is used for sequence control, motion control, and all other operations except those described below. |
| **Network Configurator** | The Network Configurator is used for tag data links on the built-in EtherNet/IP port. |
| **CX-Integrator** | The CX-Integrator is used for remote I/O communications with a DeviceNet Unit. |
| **CX-Protocol** | The CX-Protocol is used for protocol macros with Serial Communications Units. |
| **CX-Designer** | The CX-Designer is used to create screens for NS-series PTs. |

# 1-2 Specifications

This section gives the main specifications of the NJ-series Controllers.

| Item | | | NJ501-1300 | NJ501-1400 | NJ501-1500 |
|---|---|---|---|---|---|
| Program-ming | Program capacity | | 20 MB (execution objects and variable tables (including variable names)) | | |
| | Memory capacity for variables | Variables with Retain attribute (Does not include Holding, DM, and EM Area memory for CJ-series Units.) | 2 MB | | |
| | | Variables without Retain attribute (Does not include CIO and Work Area memory for CJ-series Units.) | 4 MB | | |
| | Memory for CJ-series Units (Can be specified with AT specifications for variables.)*1 | CIO Area | 6,144 words (CIO 0 to CIO 6143) | | |
| | | Work Area | 512 words (W0 to W511) | | |
| | | Holding Area | 1,536 words (H0 to H1535) | | |
| | | DM Area | 32,768 words (D0 to D32767) | | |
| | | EM Area | 32,768 words × 25 banks (E0_00000 to E18_32767) | | |
| Unit configuration | Maximum number of connectable Units | | Maximum per CPU Rack or Expansion Rack: 10 Units<br>Entire Controller: 40 Units | | |
| | Number of Expansion Racks | | 3 max. | | |
| | I/O capacity | | 2,560 points max. plus EtherCAT slave I/O capacity | | |
| | Power Supply Unit for CPU Rack and Expansion Racks | | NJ-P□3001 | | |
| Motion control | Controllable Servo Drives | | OMRON G5-series Servo Drives with Built-in EtherCAT Communications<br>Recommended unit version: Version 2.1 or later | | |
| | Controllable encoder input terminals | | OMRON GX-series GX-EC0211/EC0241 EtherCAT Remote I/O Terminals<br>Recommended unit version: Version 1.1 or later | | |
| | Control method | | Control commands using EtherCAT communications | | |
| | Control modes | | Position control (Cyclic Synchronous Position Control Mode)<br>Velocity control (Cyclic Synchronous Velocity Control Mode)<br>Torque control (Cyclic Synchronous Torque Control Mode) | | |
| | Number of controlled axes | Maximum number of controlled axes | 16 axes | 32 axes | 64 axes |
| | | Single-axis control | 16 axes max. | 32 axes max. | 64 axes max. |
| | | Linear interpolation control | 4 axes max. per axes group | | |
| | | Circular interpolation control | 2 axes per axes group | | |
| | Number of axes groups | | 32 axes groups max. | | |
| | Cams | Number of cam data points | 65,535 points max. per cam table<br>1,048,560 points max. for all cam tables | | |
| | | Number of cam tables | 640 tables max. | | |

| Item | | | | NJ501-1300 | NJ501-1400 | NJ501-1500 |
|---|---|---|---|---|---|---|
| **Communications** | **Peripheral USB port** | **Supported services** | | Sysmac Studio connection | | |
| | | **Physical layer** | | USB 2.0-compliant B-type connector | | |
| | | **Transmission distance** | | 5 m max. | | |
| | **Built-in EtherNet/IP port** | **Communications protocol** | | TCP/IP, UDP/IP, and BOOTP client | | |
| | | **Supported services** | | Sysmac Studio connection, tag data link, CIP message communications, socket service, FTP server, automatic clock adjustment (NTP client), SNMP agent, and DNS client | | |
| | | **Physical layer** | | 10Base-T or 100Base-TX | | |
| | | **Media access method** | | CSMA/CD | | |
| | | **Modulation** | | Baseband | | |
| | | **Topology** | | Star | | |
| | | **Baud rate** | | 100 Mbps (100Base-TX) | | |
| | | **Transmission media** | | STP (shielded, twisted-pair) cable of Ethernet category 5 or higher | | |
| | | **Transmission distance** | | 100 m max. (distance between hub and node) | | |
| | | **Number of cascade connections** | | There are no restrictions if a switching hub is used. | | |
| | | **CIP service: Tag data links (cyclic communications)** | | --- | | |
| | | | **Number of connections** | 32 | | |
| | | | **Permissible communications band** | 1,000 pps[*2] including heartbeat | | |
| | | | **Number of tag sets** | 32 | | |
| | **Built-in EtherCAT port** | **Communications protocol** | | Special protocol for EtherCAT | | |
| | | **Supported services** | | CoE (PDO communications and SDO communications) | | |
| | | **Synchronized communications** | | DC (distributed clock) | | |
| | | **Physical layer** | | 100Base-TX | | |
| | | **Modulation** | | Baseband | | |
| | | **Baud rate** | | 100 Mbps (100Base-TX) | | |
| | | **Duplex mode** | | Auto | | |
| | | **Topology** | | Line, daisy chain, and branching | | |
| | | **Transmission media** | | Use a shielded twisted-pair cable (double shielding with aluminum tape and braiding) of Ethernet category 5 (100Base-TX) or higher. | | |
| | | **Transmission distance** | | Distance between nodes: 100 m max. | | |
| | | **Maximum number of slaves** | | 192 | | |

*1 Timers, counters, index registers, data registers, and Task Flags cannot be specified.

*2 Means packets per second, i.e., the number of communications packets that can be sent or received in one second.

# 1-3 Overall Operating Procedure for the NJ-series Controller

This section gives the overall operating procedure of the NJ-series Controllers and then describes it in more detail.

## 1-3-1 Overall Procedure

The overall procedure to use an NJ-series Controller is given below.

### Step 1. Software Design

Design the overall system configuration, task configuration, programs, and variables.

- Step 1-1 Designing I/O and Processing
- Step 1-2 Designing Tasks
- Step 1-3 Designing Programs

↓

### Step 2. Software Setups and Programming

Create the system configurations that you designed in step 1 on the Support Software and assign the variables. Create the tasks and programs, and debug them, e.g., with simulations.

- Step 2-1 Slave and Unit Configurations
- Step 2-2 Controller Setup
- Step 2-3 Programming
- Step 2-4 Offline Debugging

↓

### Step 3. Mounting and Setting Hardware

Mount the Units and make the required hardware settings.

↓

### Step 4. Wiring

Connect the network cables and wire the I/O.

↓

### Step 5. Confirming Operation and Starting Actual System Operation

Connect the Support Software to the physical system and download the project. Check operation on the physical system and then start actual system operation.

## 1-3-2 Procedure Details

### Step 1. Software Design

| Step | Description | Reference |
|---|---|---|
| Step 1-1 Designing I/O and Processing | • External I/O devices and unit configuration<br>• Refresh periods for external devices<br>• Program contents | *Section 3 Configuration Units* in *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500) |
| Step 1-2 Designing Tasks | • Task configuration<br>• Relationship between tasks and programs<br>• Task periods<br>• Slave and Unit refresh times<br>• Exclusive control methods for variables between tasks | *4-2-3 Task Settings* |
| Step 1-3 Designing Programs | | |
| POU (Program Organization Unit) Design | • Programs<br>• Functions and function blocks<br>• Determining the algorithm languages | *Section 6 Programming* |
| Variable Design | • Defining variables that you can use in more than one POU and variables that you use in only specific POUs<br>• Defining the variables names for the device variables that you use to access slaves and Units<br>• Defining the attributes of variables, such as the Name and Retain attributes<br>• Designing the data types of variables | *6-3 Variables* |

### Step 2. Software Setups and Programming

| Step | Description | Sysmac Studio Operations | Reference |
|---|---|---|---|
| Project Creation | 1. Create a project in the Sysmac Studio.<br>2. Insert a Controller. | **New Project** Button<br>***Insert*** – ***Controller*** | *Sysmac Studio Version 1 Operation Manual* (Cat. No. W504) |

The following *Controller Configurations and Setup* and the *Programming and Task Settings* can be performed in either order.

| | | | |
|---|---|---|---|
| Step 2-1<br>Slave and Unit Configurations | | | |
| 1) Creating the Slave and Unit Configurations | Creating the slave configuration and Unit configuration either offline or online. (For online configuration, make the online connection that is described in step 5.) | EtherCAT Slave Setting Editor<br>Unit Editor | *3-2 Creating the EtherCAT Slave Configuration*<br>*3-3 Creating the Unit Configuration* |

| | | | |
|---|---|---|---|
| 2) Assigning Device Variables to I/O Ports | Registering device variables in variable tables (Variable names are user defined or automatically created.) | I/O Map | *3-4 I/O Ports and Device Variables* |

(The following step is for motion control.)

| | | | |
|---|---|---|---|
| 3) Creating the Axes and Assigning Them to the Servo Drive/Encoder Input Slaves | Creating the axes and setting them as real axes or virtual axes. Creating axes groups to perform interpolated axes control. | **Configurations and Setup – Motion Control Setup** | *3-5 Creating the Axes and Assigning Them to the Servo Drives/Encoder Input Slaves* |

| | | | |
|---|---|---|---|
| Step 2-2<br>Controller Setup | Setting the following parameters from the Sysmac Studio | | *Section 4 Controller Setup* |
| | Setting the initial values for the PLC Function Module | **Configurations and Setup – Controller Setup – Operation Settings** | *4-2 Initial Settings for the PLC Function Module* |
| | Initial settings for Special Units | **Configurations and Setup – CPU/Expansion Racks** | *4-3 Initial Settings for Special Units* |
| | (To use motion control)<br>Setting the initial settings for the Motion Control Function Module | **Configurations and Setup – Motion Control Setup** | *4-4 Initial Settings for the Motion Control Function Module* |
| | Setting the initial values for the EtherCAT Function Module | **Configurations and Setup – EtherCAT** | *4-5 Initial Settings for the EtherCAT Master Function Module* |
| | Setting the initial values for the EtherNet/IP Function Module | **Configurations and Setup – Controller Setup – Built-in EtherNet/IP Port Settings** | *4-6 Initial Settings for the EtherNet/IP Function Module* |

| Step 2-3 Programming | | | |
|---|---|---|---|
| 1) Registering Variables | • Registering the variables used by more than one POU in the global variable table with Sysmac Studio<br>• Registering the local variable table for each program<br>• Registering the local variable table for each function block and function | Global Variable Table Editor<br>Local Variable Table Editor | *Sysmac Studio Version 1 Operation Manual* (Cat. No. W504)<br>*6-3 Variables* |
| 2) Writing Algorithms for POUs | Writing the algorithms for the POUs (programs, function blocks, and functions) in the required languages | Programming Editor | *Section 6 Programming*<br>*NJ-series Instructions Reference Manual* (Cat. No. W502) and *NJ-series Motion Control Instructions Reference Manual* (Cat. No. W508) |
| 3) Setting the Tasks | Making task settings | **Configurations and Setup** – **Task Settings** | *4-2-3 Task Settings* |

| | | | |
|---|---|---|---|
| Step 2-4 Offline Debugging | Checking the algorithms and task execution times on the Simulator (virtual controller) | | *Section 7 Simulation, Transferring Projects to the Physical CPU Unit, and Operation* |

## Step 3. Mounting and Setting Hardware

| Step | Description | Reference |
|---|---|---|
| 1. Mounting | • Connecting adjacent Units<br>• Mounting to DIN Track | *4-3 Mounting Units* in *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500) |
| 2. Setting Hardware | • Setting the node addresses of the EtherCAT slaves<br>• Setting unit numbers on the rotary switches on the front of the Special Units | Operation manuals for the EtherCAT slaves and Special Units |

## Step 4. Wiring

| Step | Description | Reference |
|---|---|---|
| 1. Connecting Ethernet Cable | • Connecting the built-in EtherCAT port<br>• Connecting the built-in EtherNet/IP port | *4-4 Wiring* in *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500) |
| 2. Wiring I/O | • Wiring I/O to EtherCAT slaves<br>• Wiring Basic I/O Units and Special Units | Operation manuals for the EtherCAT slaves and *4-4 Wiring* in *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500) |
| | • Checking wiring | *6-4-2 Performing Online Debugging* in *Sysmac Studio Version 1 Operation Manual* (Cat. No. W504) |
| 3. Connecting the Computer That Runs the Sysmac Studio | • Connecting USB Cable<br>• Connecting the built-in EtherNet/IP port | *Sysmac Studio Version 1 Operation Manual* (Cat. No. W504) |

## Step 5. Confirming Operation and Starting Actual System Operation

| Step | Description | Sysmac Studio Operations | Reference |
|---|---|---|---|
| 1. Online Connection to Controller and Project Download | 1. Make the settings for communications with the Controller, connect online, and download the user program, Controller Configurations, and Controller Setup. (Perform this step before you create the slave configuration or Unit configuration from the mounted Units in step 2-1.)<br>**Note** Use the Synchronize Menu of the Sysmac Studio to download the project.<br>2. Cycle the power supply. | ***Controller – Communications Setup***<br>***Controller – Synchronization*** | *Section 7 Simulation, Transferring Projects to the Physical CPU Unit, and Operation* |

| | | | |
|---|---|---|---|
| 2. Operation Check on Controller | 1. Example: Check the wiring by performing forced-refreshing with user-specified values from the I/O Map or Ladder Editor.<br>2. Example (for motion control): Use the MC Test Run operations in PROGRAM mode to check wiring, motor rotation directions for jogging, travel distances for relative positioning (e.g., for electronic gear settings), and homing operation.<br>3. Perform manual operation in RUN mode.<br>4. Debug the actual control system. | | *Section 7 Simulation, Transferring Projects to the Physical CPU Unit, and Operation* |

| | | | |
|---|---|---|---|
| 3. Actual Controller Operation | Perform automatic operation in RUN mode. | | *Section 7 Simulation, Transferring Projects to the Physical CPU Unit, and Operation* |

2

2

# CPU Unit Operation

This section describes the variables and control systems of the CPU Unit and CPU Unit status.


**2-1 Internal Operation of the CPU Unit . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2-2**

2-1-1 Internal Software Configuration of the CPU Unit . . . . . . . . . . . . . . . . . . . . . . . . 2-2

2-1-2 Overview of Tasks . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2-3

**2-2 Variables and I/O . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2-5**

2-2-1 Types of Variables . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2-5

2-2-2 Variables and I/O Assignments . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2-8

**2-3 Control Systems . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2-12**

**2-4 CPU Unit Status . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2-17**

**2-5 CPU Unit Data and Data Retention . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2-18**

2-5-1 CPU Unit Data . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2-18

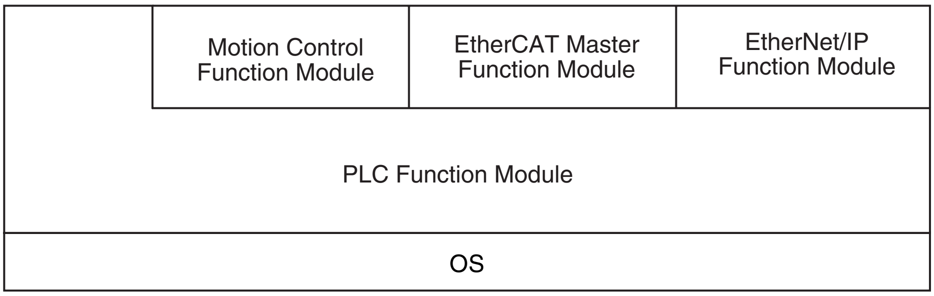
# 2-1 Internal Operation of the CPU Unit

This section describes the internal configuration of an NJ-series CPU Unit.

## 2-1-1 Internal Software Configuration of the CPU Unit

### Software Configuration

The CPU Unit has the following internal software configuration.




The software in the NJ-series CPU Units is divided into modules that are called function modules. The basic function module, which is the PLC Function Module, runs on top of the OS.

The other modules run on top of the PLC Function Module.

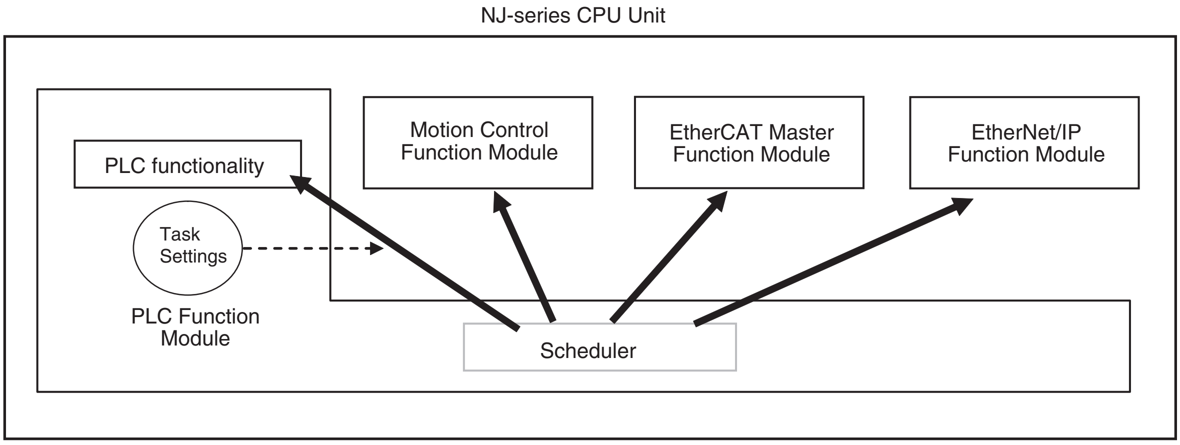
A description of each function module is given in the following table.

| Function module name | Description |
|---|---|
| PLC Function Module | This function module controls overall scheduling, executes the user program, interfaces the CJ-series Units,* sends commands to the other function modules, and interfaces the USB connector and SD Memory Card. |
| Motion Control Function Module | This function module executes motion processing based on target values (such as the position or velocity target value) from the motion control instructions in the user program. It outputs command values, controls status, and obtains information through the EtherCAT Master Function Module.<br>This function module functions as an open-loop controller that outputs command values for Servo Drives. |
| EtherCAT Master Function Module | This function module communicates with the EtherCAT slaves as the EtherCAT master. |
| EtherNet/IP Function Module | This function module performs EtherNet/IP communications. |

* Some CJ-series Units can also be connected to an NJ-series CPU Unit.

## Function Module Execution Relationship

The execution relationship between the function modules is shown below.

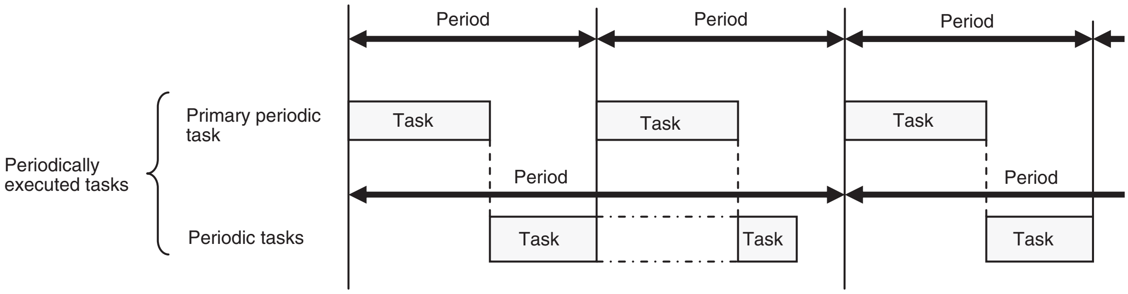



The Scheduler in the PLC Function Module schedules processing according to the task settings in the PLC Function Module. The Scheduler controls the time that is allocated to execution of processing for the PLC functionality and by the other function modules.

# 2-1-2 Overview of Tasks

## Tasks

Tasks are used to specify user program execution and I/O refreshing in the CPU Unit. They are also used to specify execution conditions and execution priorities. (Here, I/O refreshing includes cyclic data exchange with EtherCAT slaves and CJ-series Units.) Some tasks are executed periodically.




### ● Periodically Executed Tasks

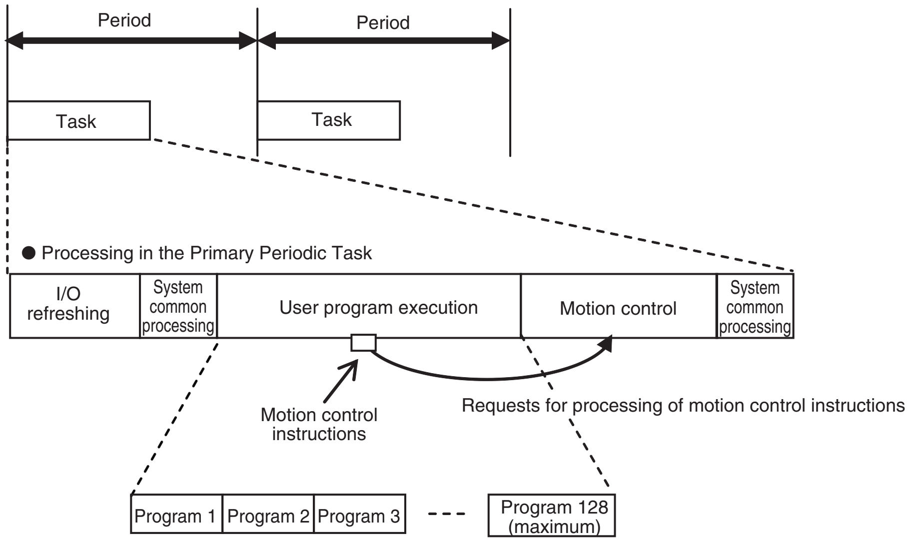
Periodically executed tasks are broadly classified into the following two types based on execution priority.

- Primary periodic task: This task has the highest execution priority. It is always executed in the specified period. There can only be one primary periodic task.
  The EtherCAT process data communications cycle and motion control period are also executed in the same period.
- Periodic tasks: These tasks have a lower execution priority than the primary periodic task. Periodic tasks are executed during the unused time between executions of the primary periodic task. Periodic tasks are executed on periods that are multiples of the primary periodic task period.

Refer to *5-2-3 Basic Operation of Tasks* for details on tasks.

## Overview of Task Processing

The following processing is performed with tasks. This example shows processing for the primary periodic task.




### ● I/O Refreshing

Data I/O is performed for CJ-series Basic I/O Units, CJ-series Special Units, and EtherCAT slaves.

- You can refresh I/O in the primary periodic task or the priority-16 periodic task (the periodic task with the highest execution priority).
- I/O refreshing is assigned by slave or by Unit.
- I/O refreshing is performed in all operating modes (PROGRAM and RUN modes).
- The I/O refresh processing time depends on the type and number of Configuration Units that are used in the Controller. The processing time for each Unit is constant.

### ● User Program Execution

More than one program can be assigned to one task. Programs are executed in the order that they are assigned.

### ● Motion Control

Motion control is executed based on commands from the user program. Motion control instructions are executed only in the primary periodic task.

### ● System Common Processing

System common processing consists of condition evaluation for motion inputs, processing for data tracing, exclusive control of variables, processing for tag data links, and other processing.

Refer to *5-2-3 Basic Operation of Tasks* for details.

# 2-2 Variables and I/O

This section describes the types of variables that are used with an NJ-series CPU Unit and the control systems that are used by an NJ-series CPU Unit.

## 2-2-1 Types of Variables

An NJ-series CPU Unit uses variables to access the memory space from instructions in the user program. A variable is a named data element in memory.

The following table lists the types of variables.

| Major classification | Middle classification | Minor classification | Application |
|---|---|---|---|
| 1. User-defined variables | | | These variables are used internally in the Controller. |
| 2. Semi-user-defined variables | Device variables | Device variables for CJ-series Units | CJ-series Basic I/O Units<br>CJ-series Special Units |
| | | Device variables for EtherCAT slaves | EtherCAT slaves |
| | Cam data variables | | These variables are used for Servo Drives, encoder input slaves, and internally in the Controller. |
| 3. System-defined variables | System-defined variables for PLC Function Module | | These variables are used internally in the Controller. |
| | System-defined variables for motion control | MC Common Variable | These variables are used for Servo Drives, encoder input slaves, and internally in the Controller. |
| | | Axis Variables | |
| | | Axes Group Variables | |
| | System-defined variable for EtherNet/IP | | Built-in EtherNet/IP port |
| | System-defined variables for EtherCAT master | | Built-in EtherCAT master port |

### User-defined Variables

The user defines all of the attributes of a user-defined variable. Refer to *6-3 Variables* for details on user-defined variables.

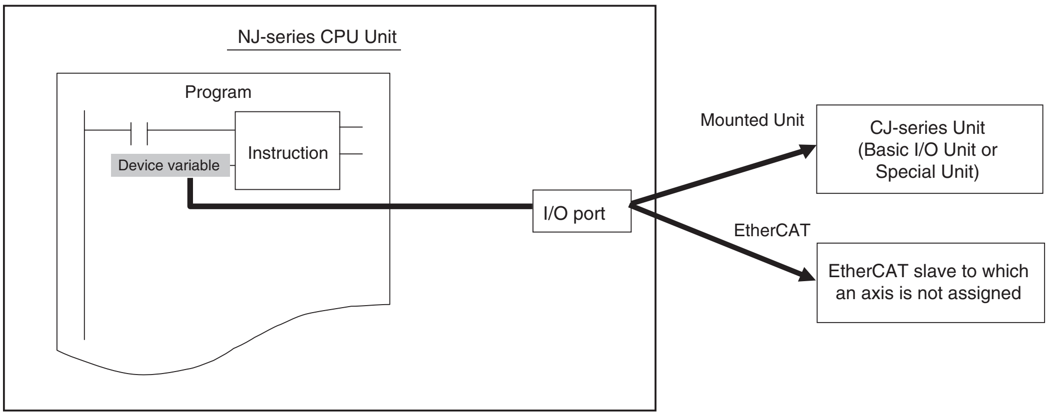
### Semi-user-defined Variables

You use these variables to access specific devices and data. You can change some of the attributes of these variables.

The semi-user-defined variables include the following two types of variables for devices and data.

#### ● Device Variables

Device variables are used to access data in slaves and Units. The data is accessed through logical interface ports that are called I/O ports.




Device variables are assigned to the I/O ports that are automatically created when you create the EtherCAT Slave Configuration or Unit Configuration in the I/O Map of the Sysmac Studio.

You can access the following devices.

| Type of variable | Device to access | Data to access |
|---|---|---|
| Device variables for CJ-series Units | CJ-series Basic I/O Units | Real I/O data in Basic I/O Units |
| | CJ-series Special Units | Operating data (allocated CIO Area words) and setup data (allocated DM Area words) for Special Units |
| Device variables for EtherCAT slaves | EtherCAT slaves to which axes are not assigned | PDO mapping data for EtherCAT slaves (specific objects allocated for PDO communications) |

Refer to *3-4-1 I/O Ports and Device Variables* and *3-4-2 Registering Device Variables* for details.

## ● Cam Data Variables

For information on cam data variables, refer to the *NJ-series CPU Unit Motion Control User's Manual* (Cat. No. W507).

## System-defined Variables

System-defined variables are provided in advance in an NJ-series CPU Unit. The names and all attributes are defined by the system. They have specific functions. You cannot change the name or any other attributes.

The system-defined variables are specific to a function module. There are system-defined variables for each function module.

The following table lists the types of system-defined variables that are available.

| Function module | Type of system-defined variable |
|---|---|
| PLC Function Module | System-defined variables for PLC Function Module |
| Motion Control Function Module | System-defined variables for motion control* |
| EtherNet/IP Function Module | System-defined variables for EtherNet/IP |
| EtherCAT Master Function Module | System-defined variables for EtherCAT master |

Refer to *A-3 System-defined Variables* for details on system-defined variables.

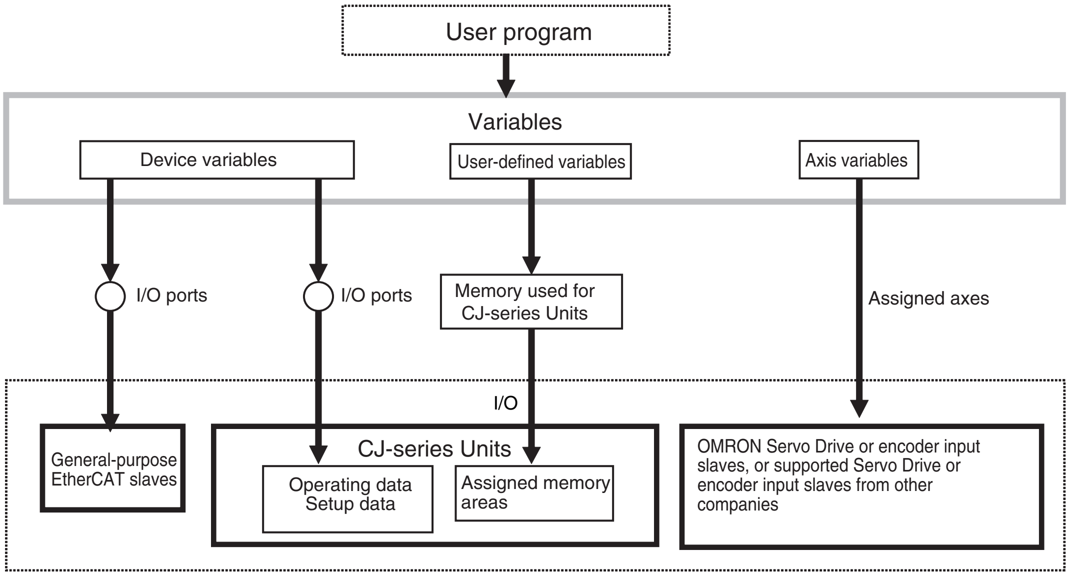
* The following table lists the types of system-defined variables that are provided for motion control.

| System-defined variables for motion control | Description |
|---|---|
| MC Common Variable | This system-defined variable is used to monitor the common status of the Motion Control Function Module. |
| Axis Variables | Each of these system-defined variables is a structure that provides information on an axis (such as physical quantities, status, and error information). They are used to access the EtherCAT slave that is assigned to the axis. These EtherCAT slaves are accessed without the use of I/O ports. |
| Axes Group Variables | Each of these system-defined variables is a structure for an axes group. An axes group contains multiple axes. These variables are used for interpolated motions. |

Refer to *3-5-2 Axis Variables and Axes Group Variables* for details.

## 2-2-2 Variables and I/O Assignments

The NJ-series CPU Unit assigns I/O and variables as shown below.




| Application | | | Type of variable to use |
|---|---|---|---|
| Interfacing EtherCAT slaves | You can access slaves through the objects that are assigned for PDO communications. | | Device variables for EtherCAT slaves |
| | Using motion control instructions | | Axis Variables |
| Interfacing CJ-series Units | Basic I/O Units | | Device variables for CJ-series Units |
| | Special Units | Operating data and setup data | Device variables for CJ-series Units |
| | | Assigned memory area data | User-defined variables with AT specifications in memory used for CJ-series Units |

Refer to *3-4 I/O Ports and Device Variables* for details.

### Interfacing EtherCAT Slaves

The interface method that you use to access an EtherCAT slave depends on the type of slave.

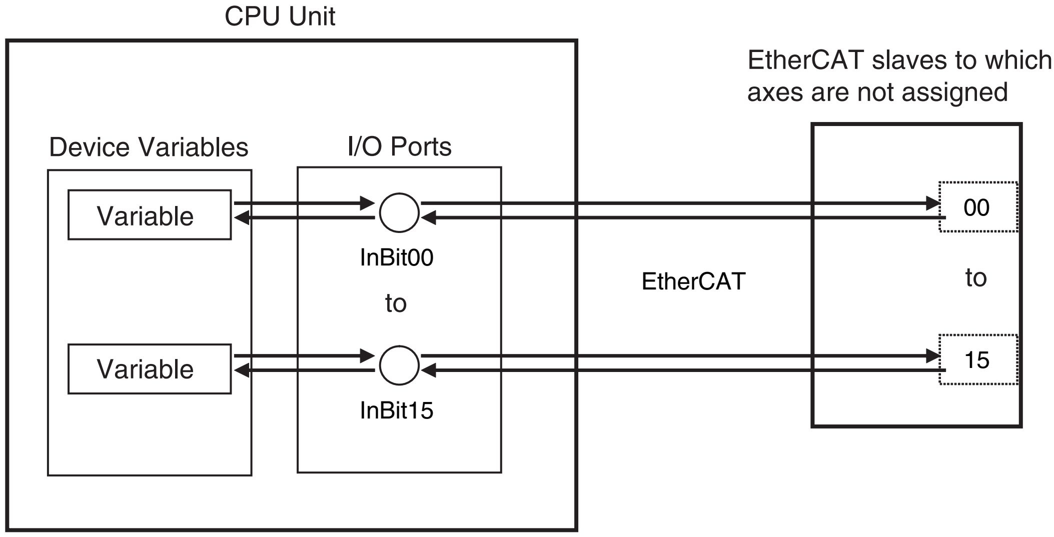
- Accessing Slaves through the Objects That Are Assigned for PDO Communications:
  You can access slaves through the objects that are assigned for PDO communications for Servo Drives/encoder input slaves and general-purpose slaves.*

  * All slaves other than Servo Drives and encoder input slaves are called general-purpose slaves.
- Using Motion Control Instructions:
  You can use motion control instructions to implement motion control for Servo Drives and encoder input slaves. Motion control Instructions cannot be used for slaves from other manufacturers that are not supported.

| Applicable slaves / Access method | General-purpose slaves (all slaves except for Servo Drives and encoder input slaves) | Servo Drive and encoder input slaves | |
|---|---|---|---|
| | | OMRON products or supported products from other manufacturers | Unsupported products from other manufacturers |
| **Accessing slaves through the objects that are assigned for PDO communications** | Supported. | | |
| **Using motion control instructions** | Not supported. | Supported. | Not supported. |

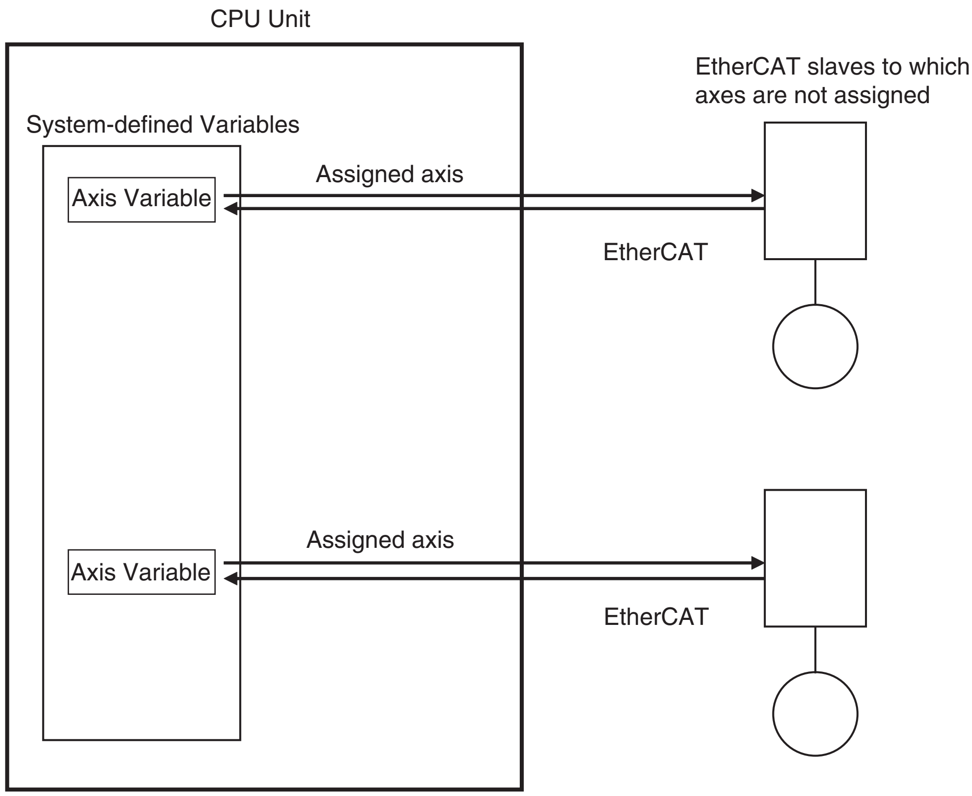
- **Accessing Slaves through the Objects That Are Assigned for PDO Communications**

You use device variables for EtherCAT slaves.




- **Using Motion Control Instructions**

You use the Axis Variables in the system-defined variables.

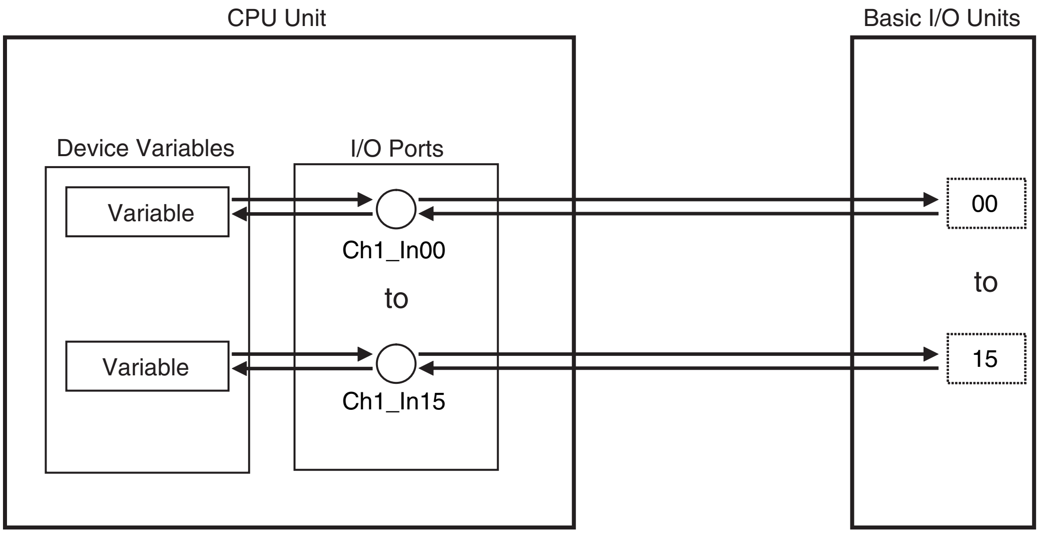



Refer to *3-5-2 Axis Variables and Axes Group Variables* for details.

## Interfacing CJ-series Units

### Accessing Basic I/O Units

You use device variables for CJ-series Units.



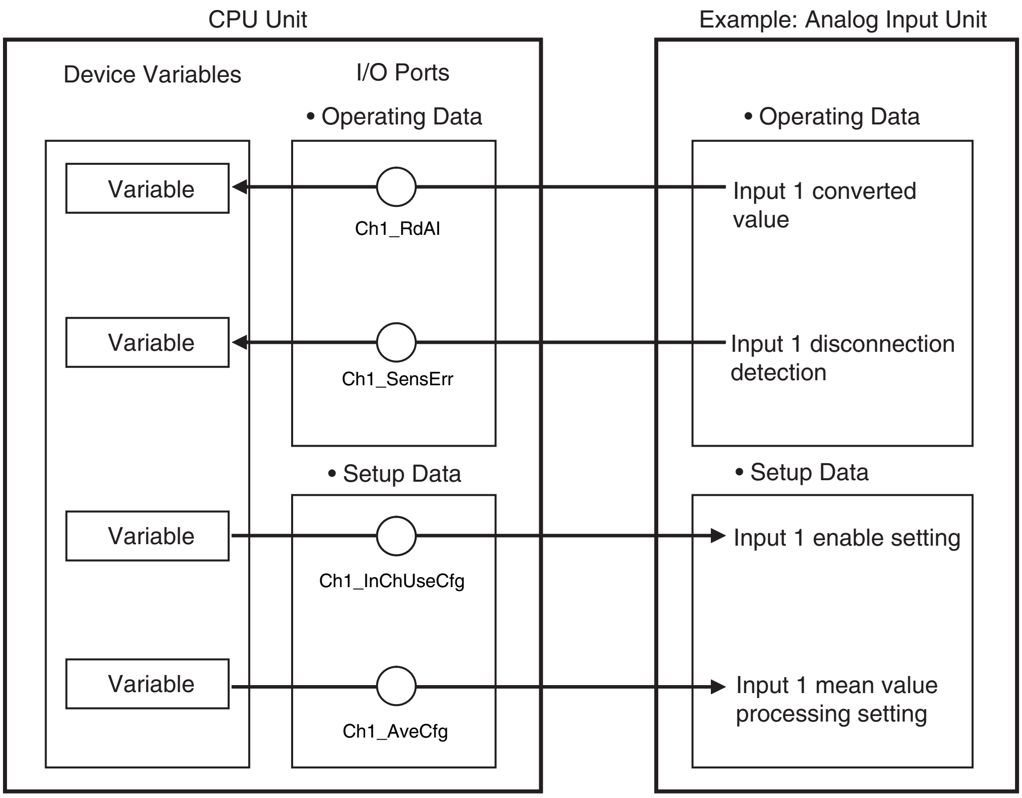

Refer to*3-4-1 I/O Ports and Device Variables* and *3-4-2 Registering Device Variables* for details.

### Accessing Special Units

There are two ways to access Special Units.

#### Using Device Variables to Specify Operating Data and Setup Data

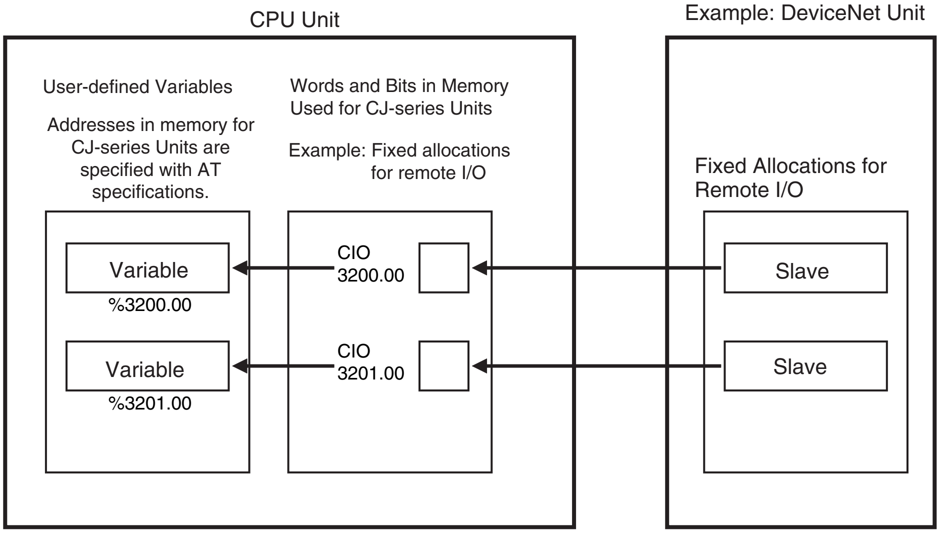
You use device variables for CJ-series Unit to specify operating data (allocated CIO Area words) and setup data (allocated DM Area words) for Special Units.




Refer to *3-4-1 I/O Ports and Device Variables* and *3-4-2 Registering Device Variables* for details.

### Using User-defined Variables to Specify Memory Area Addresses

You use user-defined variables to specify memory area addresses that are assigned to Special Units. The address to access is specified with an AT specification.




You use user-defined variables to specify the memory area addresses for Special Units.

- Addresses in fixed allocations for DeviceNet Units
- Addresses in user-specified allocations for DeviceNet Units from the CX-Integrator
- Addresses in expansion memory for High-speed Counter Units
- Addresses in expansion memory for Analog I/O Units

Refer to *6-3-8 Variable Attributes* for information on the AT Specification attribute.

**Additional Information**

The Network Publish attribute for user-defined variables that are used for tag data links for Ether-Net/IP must be set to Input or Output.
Refer to *6-3-8 Variable Attributes* for information on the Network Publish attribute.

# 2-3 Control Systems

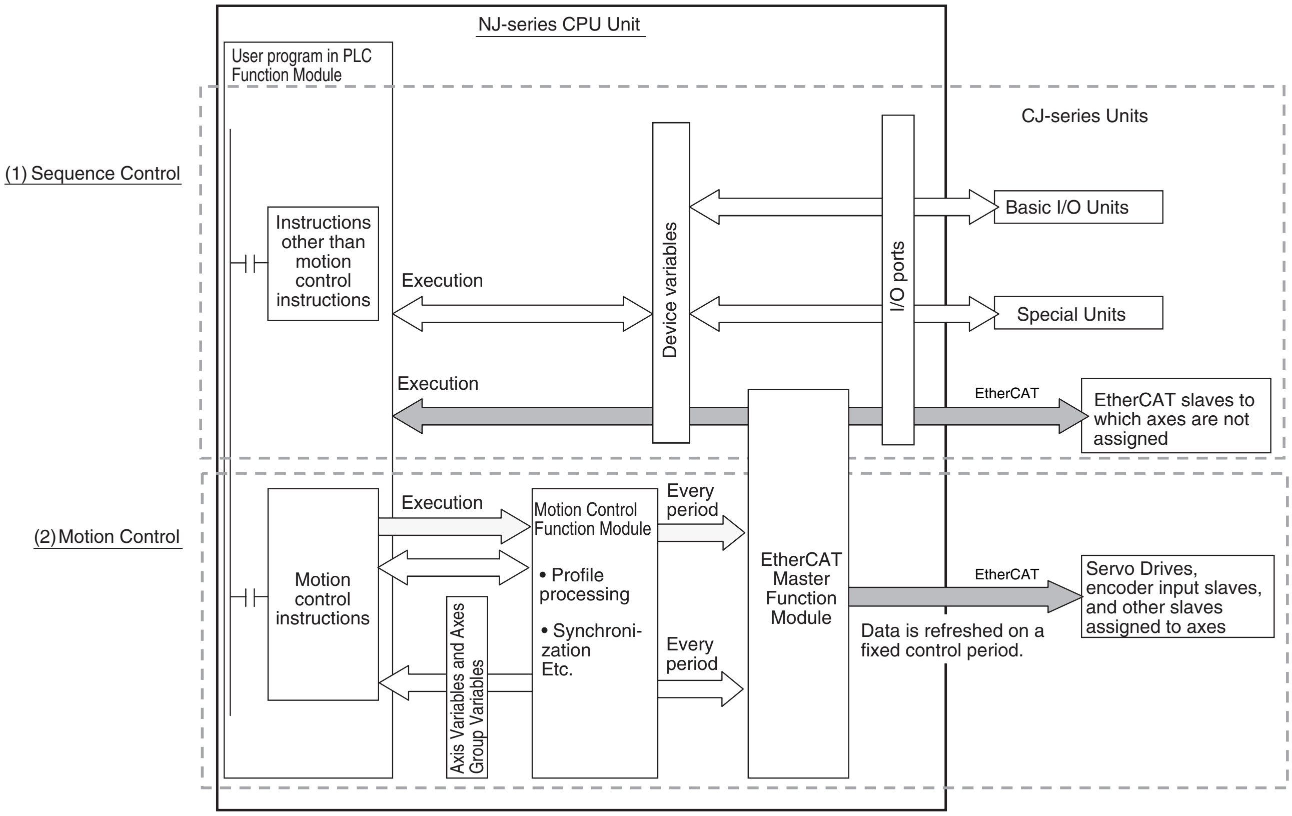
This section describes the control systems that are used by the NJ-series CPU Units.

## Types of Control

An NJ-series CPU Unit can perform two types of control: sequence control and motion control.

(1) You execute sequence control with instructions other than motion control instructions in the user program.

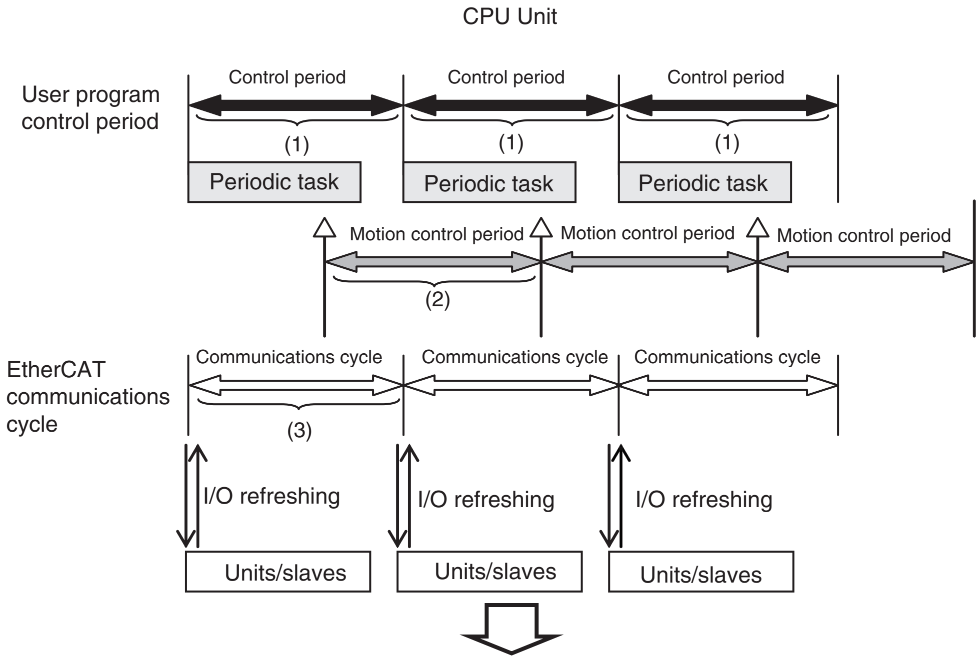
(2) You execute motion control with motion control instructions in the user program for EtherCAT Servo Drives and encoder input slaves that are assigned to axes.



## Relationship between Control Period and Tasks

You assign programs to the periodically executed tasks to execute the user program. Motion control and EtherCAT communications are synchronized with the primary periodic task, which has the highest execution priority of all of the periodically executed tasks.

If you assign the programs to the primary periodic task, user program execution, motion control, and refreshing for EtherCAT slaves are all executed in a constant period.




Processing is performed in a constant period. The following periods all have the same length: (1) user program control period, (2) motion control period, and (3) EtherCAT slave refresh period.

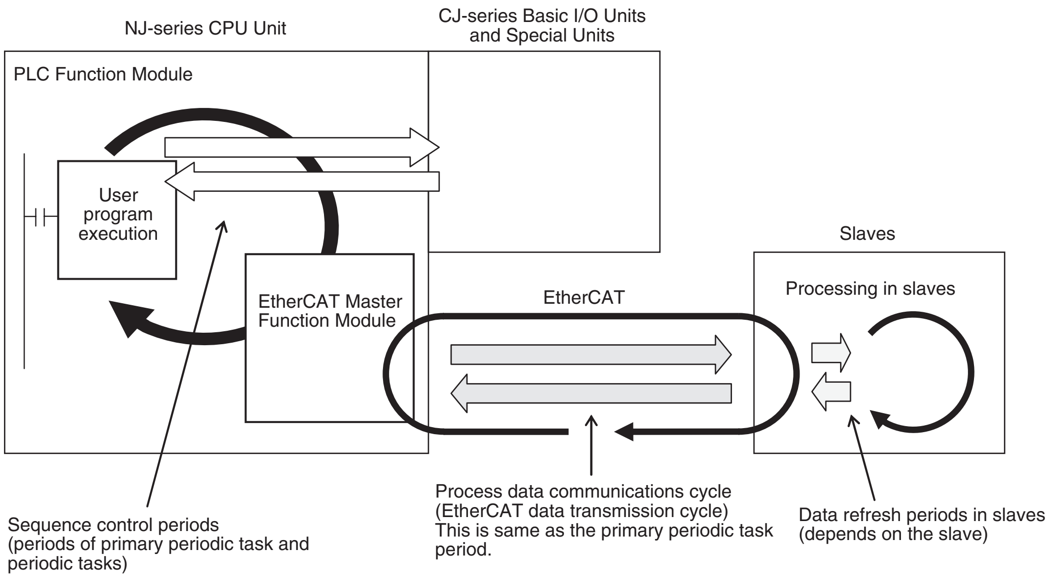
## The Difference between Sequence Control and Motion Control

### ● Sequence Control System

The PLC Function Module executes the instructions in the user program to access the mounted Basic I/O Units, mounted Special Units, and EtherCAT slaves without axis assignments through variables and I/O ports.

The data is exchanged on the same period as shown below.

Task period of the primary periodic task = Process data communications cycle



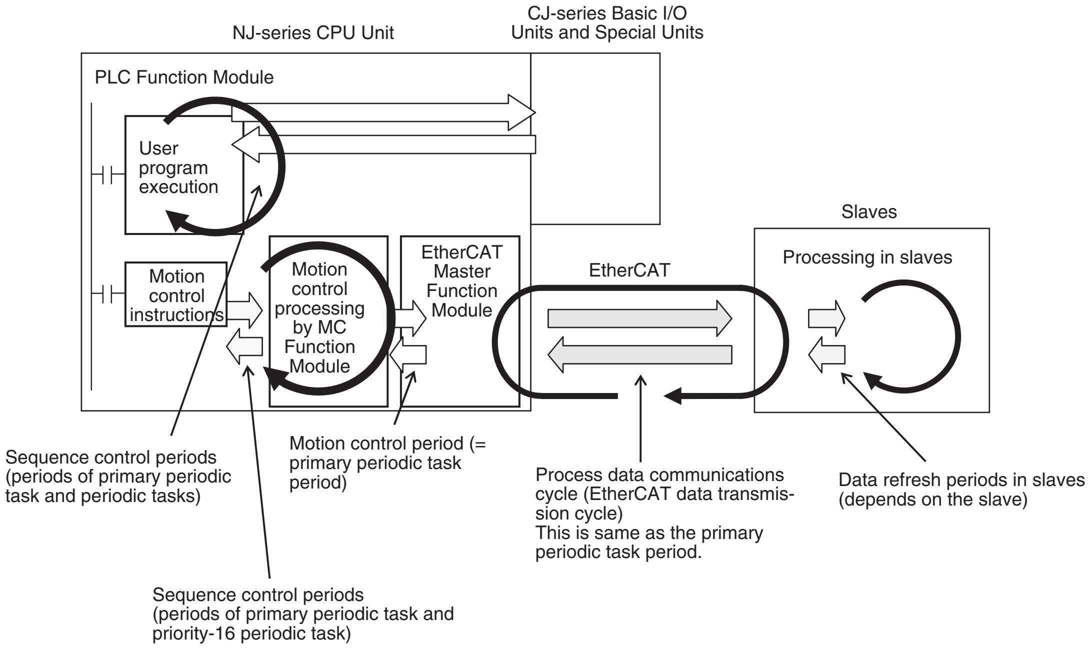
- **Motion Control System**

The PLC Function Module sends motion control commands to the MC Function Module when motion control instructions are executed in the user program.

The MC Function Module then performs motion control processing based on those commands and sends the results of processing as commands to the EtherCAT Servo Drive that is assigned to the axis.*1

The data is exchanged on the same period, as shown below.

Task period of primary periodic task = Motion control period = Process data communications cycle




*1 You must use the Sysmac Studio to assign an axis to an EtherCAT slave to control it from the Motion Control Function Module. This allows you to use motion control instructions in the user program to send commands to the Motion Control Function Module, and to read information from the Motion Control Function Module. You cannot use the Motion Control Function Module to control EtherCAT slaves to which axes are not assigned. You must control these slaves directly from the user program.

*2 The timing of the execution of motion control instructions depends on the task to which the program that contains the instructions is assigned. For details, refer to *5-3-4 System Input and Output Response Times.*

**Additional Information**

**Instruction Types in Terms of Control Systems**

In terms of the control systems, the instructions can be broadly separated into the following two types of instructions.

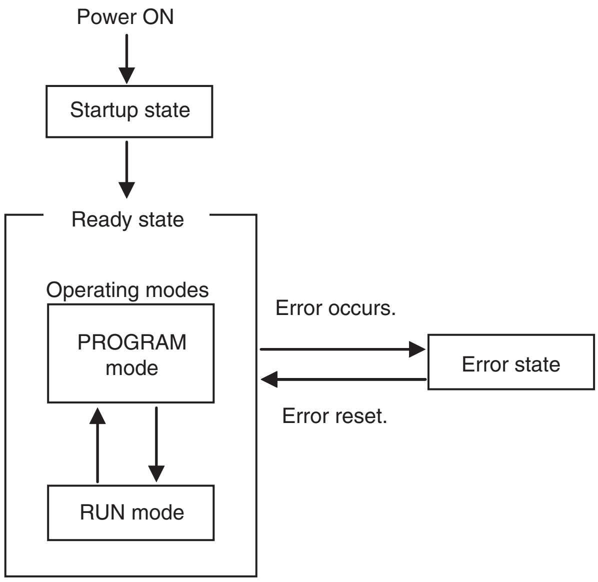
| Type of instruction | Definition |
|---|---|
| All instructions other than motion control instructions (sequence control) | These instructions are executed in the user program in the PLC Function Module and processing for them is completed there. |
| Motion control instructions | These instructions are executed in the user program in the PLC Function Module to send commands to the Motion Control Function Module.<br>MC_Home (Homing), MC_Move (Positioning), MC_CamIn (Start Cam Operation), and instructions for other motion control operations |

For details on motion control instructions, refer to the *NJ-series Motion Control Instructions Reference Manual* (Cat. No. W508). For details on other instructions, refer to the *NJ-series Instructions Reference Manual* (Cat. No. W502).

# 2-4 CPU Unit Status



This section describes the status of an NJ-series CPU Unit.




An NJ-series CPU Unit can be in any of three states: startup state, ready state, or error state

The CPU Unit is ready to operate 10 to 20 seconds after the power supply is turned ON. All outputs from Basic Output Units are OFF during this time. External communications are also not performed. This period is called the startup state.

When the CPU Unit enters the ready state, it will change to the operating mode that you specify in advance, RUN mode or PROGRAM mode (This is called the Startup Mode). In RUN mode, the user program is executed. In PROGRAM mode, the user program is not executed. You use this mode to transfer the project (including the user program) and check I/O wiring.

If an error occurs while the CPU Unit is in ready state, the CPU Unit will change to error state. Depending on the error that occurs, all or part of CPU Unit operation will stop. When the error is reset, the CPU Unit returns to the ready state.

| Item | Controller error | | |
|---|---|---|---|
| | Major fault level | Partial fault level | Minor fault level |
| Definition | Serious errors that prevent all system controls. | Errors that prevent the operation of a function module other than the PLC Function Module. | Errors that prevent a portion of function module control. |
| User program execution in CPU Unit | Stopped. | Continued.<br>Operation of the function module where the error occurred is stopped (Motion Control Function Module, EtherCAT Master Function Module, or EtherNet/IP Function Module). | Continued. |
| Resetting error | Not possible. | Possible | Possible |

Refer to *Section 8 CPU Unit Status*, *Section 12 Troubleshooting*, and the *NJ-series Troubleshooting Manual* (Cat. No. W503) for details on the CPU Unit states.

# 2-5 CPU Unit Data and Data Retention

## 2-5-1 CPU Unit Data

The data in the CPU Unit are listed below.

| Type of data | | | Description | Retention |
|---|---|---|---|---|
| **User Program** | | | The user program contains all of the programs that are assigned to tasks. | Always retained. |
| | **POUs (program organization units)** | | These are the definitions of the programs, functions, and function blocks. Each algorithm is written as a ladder diagram or in structured text. The local variable table for each POU is also included. The local variable tables include the initial values of the variables. | |
| **Global Variable Table** | | | The global variable table lists attribute information for the variables that are shared by all POUs. The global variable table includes the initial values of the variables. | |
| **Controller Configurations and Setup** | **Unit Configuration and Unit Setup** | | • The Unit Configuration and Unit Setup contain information on the Unit configuration that enables the CPU Unit to recognize the Units. This information is used to automatically create I/O ports.<br>• Initial settings for Special Units | |
| | **EtherCAT Configuration** | **EtherCAT Slave Configuration** | This is the EtherCAT slave configuration. | Network configuration information |
| | | **EtherCAT Master Settings** | The EtherCAT Master Settings contain parameter settings for the EtherCAT Master Function Module, such as the communications cycle. | |
| | | **Process Data Table** | The process data table contains the device variables, axis variables, and process data. | |
| | **I/O Map** | | The I/O Map contains assignment information between the variables and the I/O ports that are automatically created based on the Unit Configuration. | |
| | **Controller Setup** | **Operation Settings** | The Operation Settings contain information that is used to change the software operation of the CPU Unit. | |
| | | **Built-in EtherNet/IP Port Settings** | The Built-in EtherNet/IP Port Settings contain the following settings:<br>TCP/IP settings, Ethernet settings, DHCP settings, DNS settings, FTP settings, NTP settings, and SNMP settings | |
| | **Task Settings** | | The Task Settings contain settings for the task types, number of tasks, task execution conditions, task names, programs executed in the task, and other task settings. | |
| | **Motion Control Setup** | **Axes** | The Motion Control Setup contains data for the axes and axes groups. The axes are assigned to Servo Drive and encoder EtherCAT slaves. The settings consist of Axis Variables, Axes Group Variables, and motion control parameter settings. The Axis Variables and Axes Group Variables are structure array variables. | |
| | | **Axes Groups** | | |
| | **Cam Data** | | The cam data includes cam tables that consist of phase/displacement data for use in cam operation for motion control instructions. This data can be read and saved as cam data variables, which are structure array variables. | |
| | **Event Setting Tables** | | The Event Setting Tables are set to create user-defined errors and user-defined information. | |
| | **Data Trace Settings** | | The Data Trace Settings include settings for trigger conditions. | |
| **Tag Data Link Tables** | | | The Tag Data Link Tables contain the tag data link settings for EtherNet/IP (tags, tag sets, and connection information). | |

| Type of data | | Description | Retention |
|---|---|---|---|
| Variable memory | Variables without a Retain attribute | The Variable Memory contains the present values of variables that do not have AT specifications. There are variables with and without the Retain attribute. | Not retained. |
| | Variables with a Retain attribute | | Retained if a Battery is connected. |
| Memory Used for CJ-series Units | | This is the CIO and Work Areas for CJ-series Units. | Not retained. |
| | | This is the Holding, DM, and EM Areas for CJ-series Units. | Retained if a Battery is connected. |
| System Time | | This is the time information that is used inside the CPU Unit. | Retained if a Battery is connected. |
| Event Log Data | | The event logs include the error log for the CPU Unit and Special Units and logs of events other than errors, such as when the power supply was turned ON and OFF and when operation started. | |
| Absolute Encoder Home Offset Data | | This data is used to restore the actual position of a Servo Drive with an absolute encoder in motion control. The offset is the difference between the command position after homing and the absolute data that is read from the absolute encoder. | |

3

# I/O Ports, Slave Configuration, and Unit Configuration



This section describes how to use I/O ports, how to create the slave configuration and unit configuration, and how to assign functions.


**3-1 Overview of Procedures for the Slave and Unit Configurations . . . . . . . . 3-2**

**3-2 Creating the EtherCAT Slave Configuration . . . . . . . . . . . . . . . . . . . . . . . . 3-5**

3-2-1 Introduction . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3-5

3-2-2 Creating the EtherCAT Slave Configuration . . . . . . . . . . . . . . . . . . . . . . . . . . . 3-5

**3-3 Creating the Unit Configuration . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3-7**

3-3-1 Introduction . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3-7

3-3-2 Creating the Unit Configuration . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3-7

3-3-3 Verifying the Unit Configuration . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3-10

**3-4 I/O Ports and Device Variables . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3-11**

3-4-1 I/O Ports and Device Variables . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3-11

3-4-2 Registering Device Variables . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3-15

**3-5 Creating the Axes and Assigning Them to the Servo Drives/Encoder Input Slaves . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3-17**

3-5-1 Introduction . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3-17

3-5-2 Axis Variables and Axes Group Variables . . . . . . . . . . . . . . . . . . . . . . . . . . . 3-18

3-5-3 Creating and Using Axes and Axis Variables . . . . . . . . . . . . . . . . . . . . . . . . 3-19

# 3-1 Overview of Procedures for the Slave and Unit Configurations

This section provides an overview of the procedures for the Slave and Unit Configurations.

The shaded steps in the overall procedure that is shown below are related to the Slave and Unit Configurations.

**Step 1. Software Design**

- Step 1-1 Designing I/O and Processing
- Step 1-2 Designing Tasks
- Step 1-3 Designing Programs

**Step 2. Software Setups and Programming**

- Step 2-1 Slave and Unit Configurations
- Step 2-2 Controller Setup
- Step 2-3 Programming
- Step 2-4 Offline Debugging

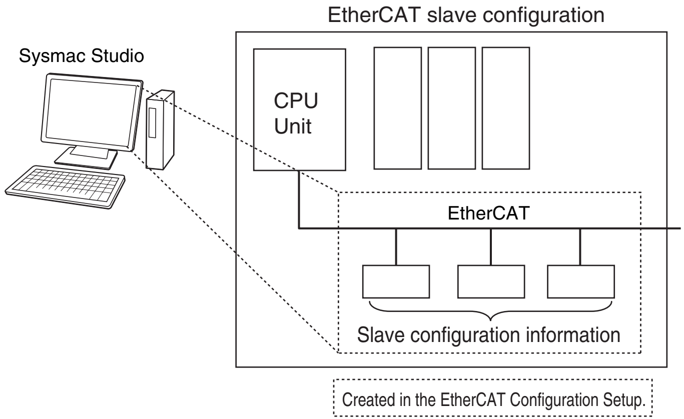
**Step 3. Mounting and Setting Hardware**

**Step 4. Wiring**

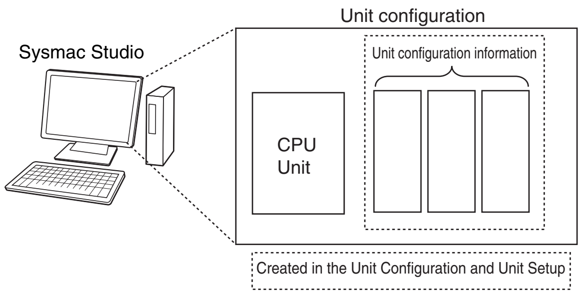
**Step 5. Confirming Operation and Starting Actual System Operation**

Refer to *1-3 Overall Operating Procedure for the NJ-series Controller* for details.

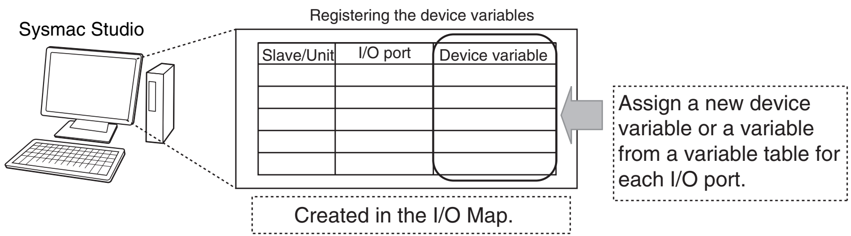
| **Step 1** Create the EtherCAT Slave Configuration (if EtherCAT is used) and the Unit Configuration (if CJ-series Units are used). | Reference |
|---|---|
| • Create the EtherCAT Configuration. | *3-2 Creating the EtherCAT Slave Configuration*<br>*3-3 Creating the Unit Configuration* |

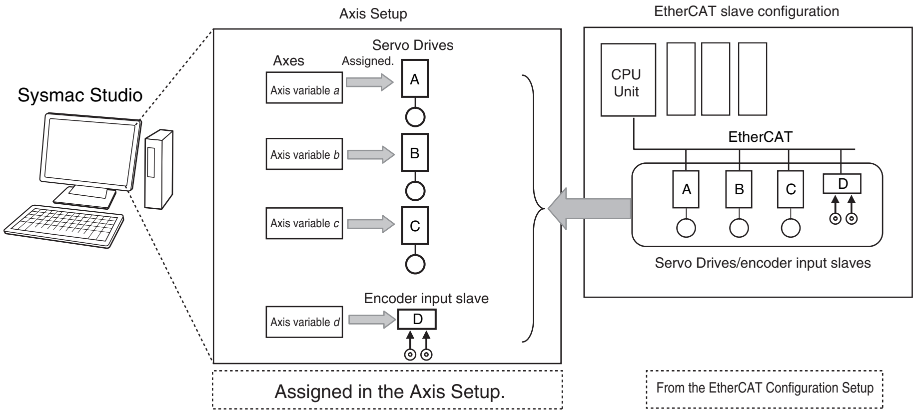



• Create the Unit Configuration.




| **Step 2** Assign device variables to I/O ports. | Reference |
|---|---|
| • Register the device variables. | *2-2-1 Types of Variables*<br>*3-4 I/O Ports and Device Variables* |



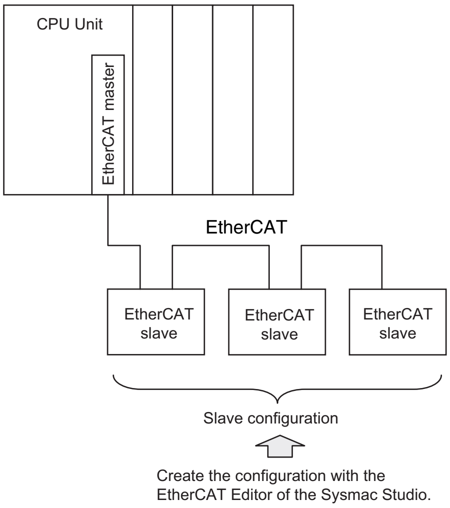
| **Step 3** Create the axes and assigning them to the Servo Drives and encoder input slaves (if motion control is used). | Reference |
| --- | --- |
| 1. Create the axes.<br>2. Assign the axes to the Servo Drives and encoder input slaves in the EtherCAT configuration.<br> | *3-5 Creating the Axes and Assigning Them to the Servo Drives/Encoder Input Slaves* |

# 3-2 Creating the EtherCAT Slave Configuration

This section describes how to create the EtherCAT Slave Configuration of an NJ-series CPU Unit.

## 3-2-1 Introduction

Use the Sysmac Studio EtherCAT Editor to create the EtherCAT slave configuration that is detected as “correct” by the CPU Unit.




The I/O ports are automatically registered for the slaves in the configuration. Assign device variables to the I/O ports. You can specify device variables in the programs to access the slaves.

## 3-2-2 Creating the EtherCAT Slave Configuration

You can use either of the following two methods to create the EtherCAT slave configuration.

### Method 1 Creating the Slave Configuration Offline

#### ● Procedure to Open the EtherCAT Editor Tab Page

**1** Double-click **EtherCAT** under **Configurations and Setup** in the Multiview Explorer. Or, right-click **EtherCAT** under **Configurations and Setup** and select ***Edit*** from the menu.

The EtherCAT Editor Tab Page appears in the Configurations and Setup Layer.

#### ● Registering Slaves

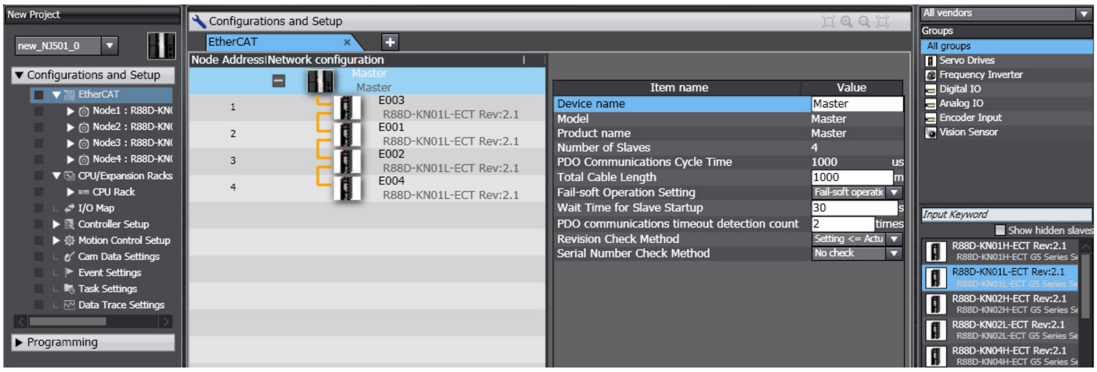
#### Procedure to Register Slaves in the Topology Display

**1** Drag a slave from the Toolbox to the master in the Topology Display.

The slave is added under the master.

**2** In the same as in step 1, drag a slave from the Toolbox to the slave to connect it to in the Topology Display.

The slave is added under the previous slave.




### Procedure to Delete Slaves in the Topology Display

**1** Right-click the slave to delete and select ***Delete*** from the menu.

The slave is deleted.

### Procedure to Copy and Paste Slaves in the Topology Display

**1** Right-click the slave to copy and select ***Copy*** from the menu.

**2** Right-click the slave to connect it to and select ***Paste*** from the menu.

The slave is pasted.

## Method 2 Reading the Actual Slave Configuration Online

Connect the Sysmac Studio online to the actual network to read the slave configuration.

#### Additional Information

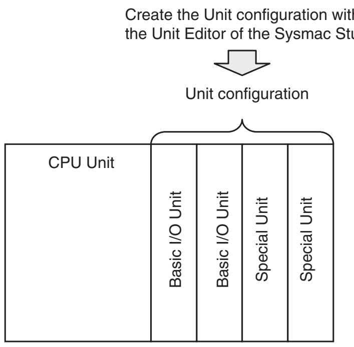
After the EtherCAT Slave Configuration is registered for the Servo Drives and encoder input slaves, Axis Variables are automatically created when you create the axes. Refer to *3-5 Creating the Axes and Assigning Them to the Servo Drives/Encoder Input Slaves.*

# 3-3 Creating the Unit Configuration

This section describes how to create the Unit Configuration of an NJ-series CPU Unit.

## 3-3-1 Introduction

Use the Unit Editor in the CPU/Expansion Racks Tab Page of the Sysmac Studio to create the Unit Configuration that is recognized as correct by the CPU Unit.




When the power is turned ON, an automatic check is performed to determine whether the “correct” Unit Configuration matches the physical Unit configuration. The I/O ports are automatically registered for Units that are specified in the Unit Configuration. Assign device variables to the I/O ports. The device variables are used in the programs to access the Units in the Unit configuration.

**Additional Information**

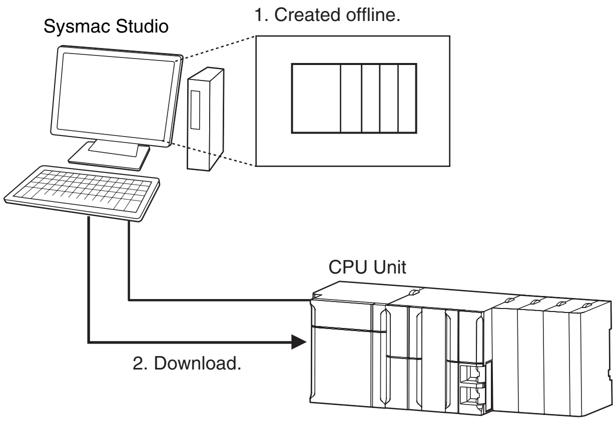
You can start an NJ-series Controller with mounted Units without creating or transferring a Unit Configuration to the Controller, but I/O ports and device variables are not created automatically, so you will not be able to access the Units from the programs.

## 3-3-2 Creating the Unit Configuration

You can use either of the following two methods to create the Unit Configuration.

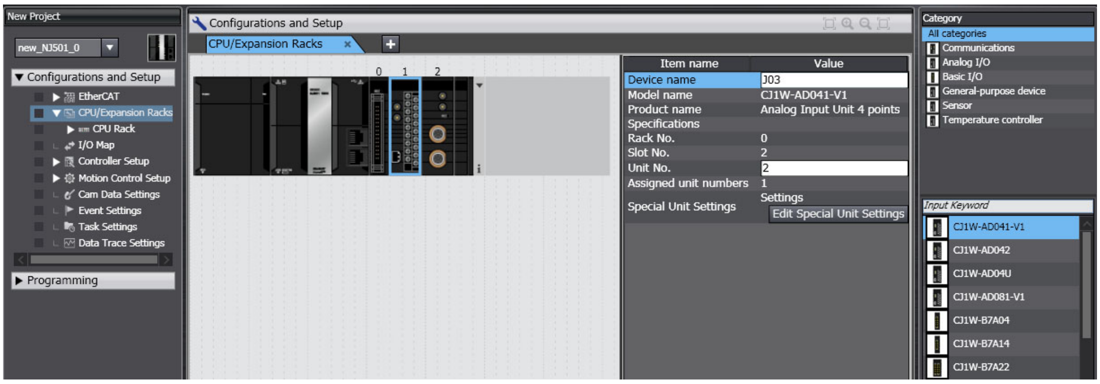
### Method 1 Creating the Unit Configuration Offline and Transferring It

Create the Unit Configuration that is to be considered as “correct” with the Unit Editor of the Sysmac Studio. After you create Unit Configuration with the Unit Editor, you download it along with the user program to the CPU Unit.



Create the Unit configuration with the Unit Editor. Use one of the following procedures to display the Unit Editor.

- Double-click **CPU/Expansion Racks** under **Configurations and Setup** in the Multiview Explorer.
- Or, right-click **CPU/Expansion Racks** under **Configurations and Setup** and select ***Edit*** from the menu.




| | |
|---|---|
| Model information | Displays the model number, product name, vendor name, and specifications information for the selected Unit. |
| Unit information | Displays device information for the selected Unit, such as the rack number, slot number, unit number, device name, number of unit numbers assigned, response time, and error information. |
| Rack information | Click the tab to the right of a rack to view its power consumption and size. |

## ● Registering Units

### Procedure to Change the Power Supply Unit Model

**1** Right-click the Power Supply Unit and select ***Change Model*** from the menu.

The Change Model Dialog Box is displayed.

**2** Select the Power Supply Unit, and then click the **OK** Button.

### Procedure to Insert Units

**1** Drag the selected Unit from the Model Selection Pane to the Unit Editor. The Unit is inserted.

### Procedure to Change the Unit Model

**1** Right-click the Unit and select ***Change Model*** from the menu. The Changing Unit Model Dialog Box is displayed.

**2** Select the Unit and then click the **OK** Button. The Unit is changed to the selected model.

### Procedure to Delete Units

**1** Right-click the Unit to delete and select ***Delete*** from the menu. The Unit is deleted.

### Procedure to Copy and Paste Units

**1** Right-click the Unit to copy and select ***Copy*** from the menu.

**2** Right-click at the location where you want to insert the Unit and select ***Paste*** from the menu. The Unit is pasted.

### ● Creating Expansion Racks

#### Procedure to Add Expansion Racks

**1** Right-click at any location where there are no Units and select ***Add Rack*** from the menu. The Rack is added.

#### Procedure to Delete Expansion Racks

**1** Select a Unit of the Rack to delete.

**2** Right-click at any location where there are no Units and select ***Delete Rack*** from the menu.

The Rack is deleted.

#### Procedure to Delete All Racks and Units

**1** Right-click at any location where there are no Units and select ***Clear All*** from the menu. All Racks and Units are deleted.

### ● Configuration Unit Settings

Make the following settings for the Configuration Units in the Unit Editor.

#### Device Names

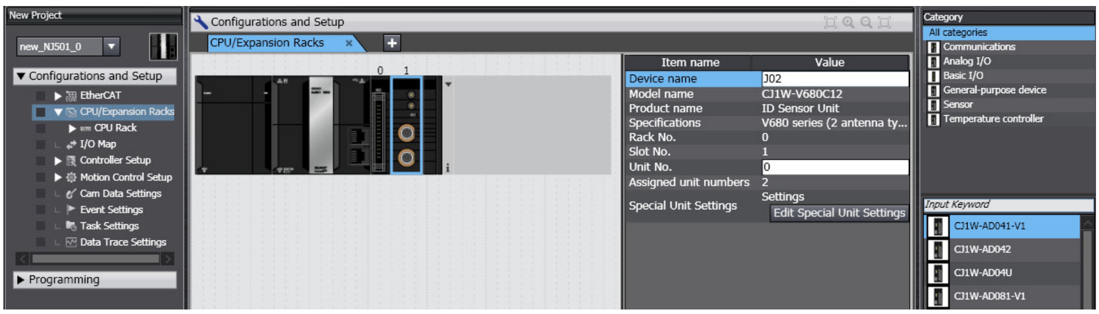
Enter names for the Configuration Units. The device names that you set are used in the device variables that you use to access the Configuration Units.

#### Input Response Times

Set the input response times of the Basic I/O Units for the slots on each rack.

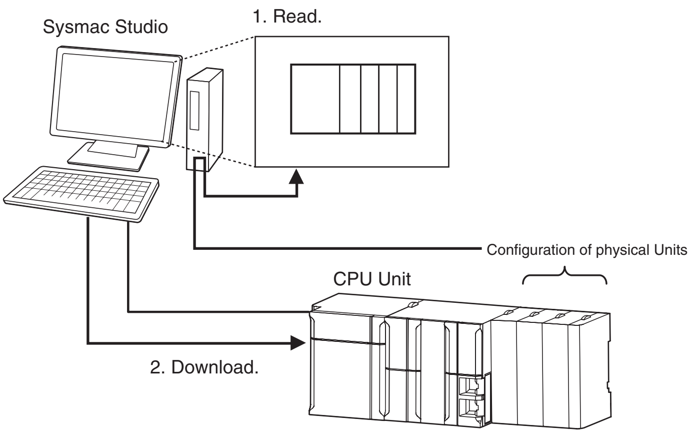
#### Unit Numbers

Set the unit numbers for the CPU Bus Units and Special I/O Units that are mounted.




## Method 2 Reading the Unit Configuration Online from the Actual Mounted Units and Transferring It

This method can be used to treat the current physical Unit configuration as the “correct” configuration. The Sysmac Studio is connected online to the physical Units to read the Unit configuration. The user program is then created accordingly. Then you download the Unit Configuration and user program to the CPU Unit.

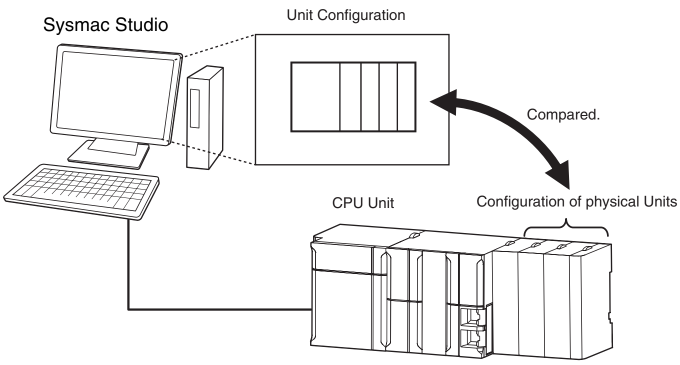



## 3-3-3 Verifying the Unit Configuration

You can perform the following Unit configurations comparison with the Sysmac Studio.

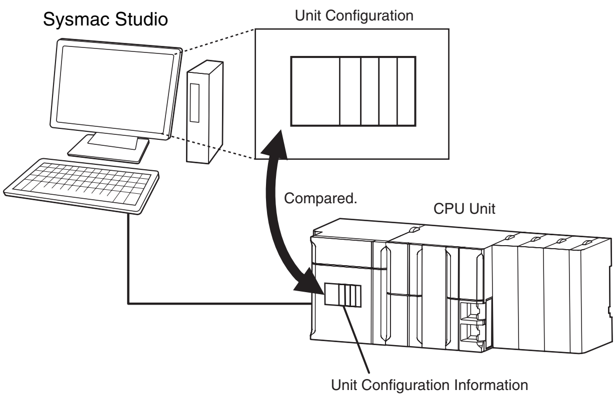
### ● Comparison between the Unit Configuration on the Sysmac Studio (Computer) and the Physical Unit Configuration

You can compare the Unit Configuration on the Sysmac Studio with the physical Unit configuration to see if they match before the first time you download the Unit Configuration to the CPU Unit from the Sysmac Studio.




### ● Comparison between the Unit Configuration on the Sysmac Studio (Computer) and the Unit Configuration in the Physical CPU Unit

You can compare the Unit Configuration on the Sysmac Studio with the Unit Configuration Information that is stored in the CPU Unit to see if they match before you download the Unit Configuration to the CPU Unit from the Sysmac Studio.



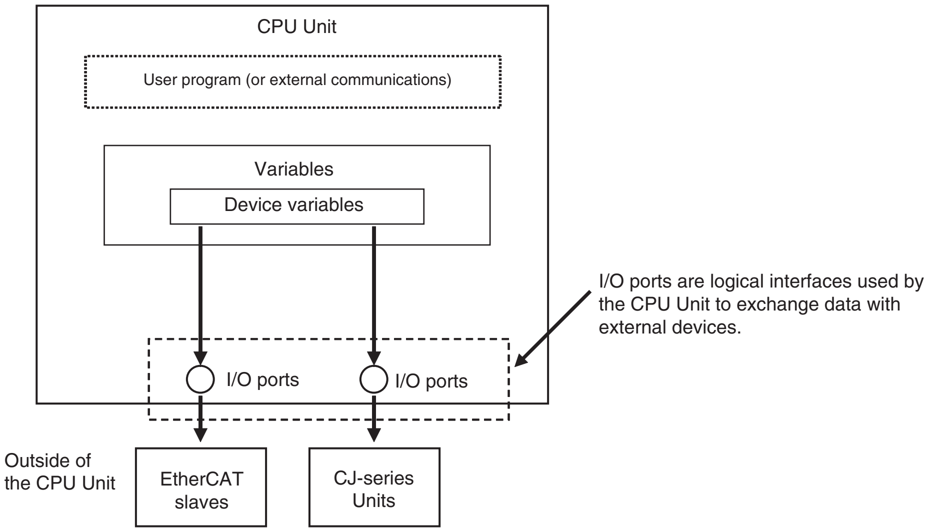
# 3-4 I/O Ports and Device Variables

This section describes the I/O ports and device variables that you use to access the EtherCAT slaves and CJ-series Units of an NJ-series Controller.

## 3-4-1 I/O Ports and Device Variables

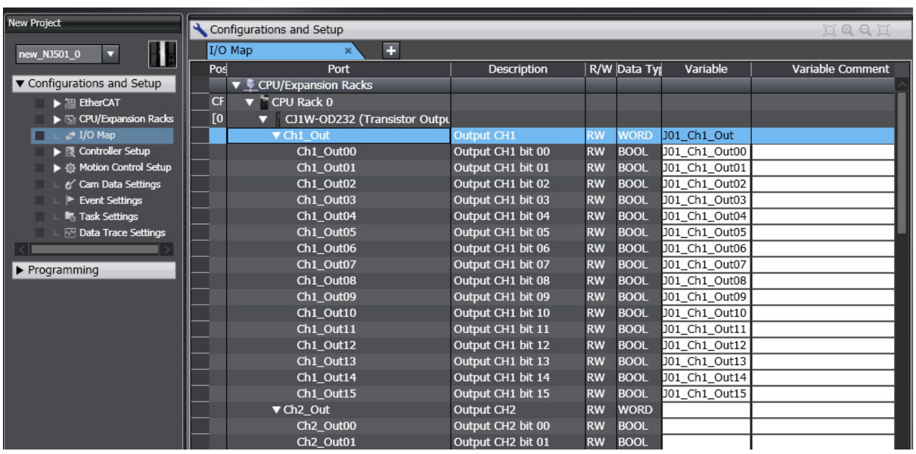
### I/O Ports

An I/O port is a logical interface that is used by the CPU Unit to exchange data with external devices (slaves and Units). I/O ports are automatically created when you create the slave and Unit configurations on the Sysmac Studio. You assign device variables to I/O ports to enable accessing the slaves and Units from the user program.




I/O ports are automatically registered in the I/O Map when you create the EtherCAT Slave Configuration or Unit Configuration in the Sysmac Studio, or when you read either of these configurations from the physical Controller from the Sysmac Studio. You can check the I/O ports that were registered in the I/O Map of the Sysmac Studio.

I/O Map



## I/O Port Names

### ● EtherCAT Slaves

The following I/O port names are used for Remote I/O Terminals.

Example for a 16-point Remote I/O Terminal: Bit00 to Bit15

For other slaves, all or part of the object names that are defined in the EtherCAT object dictionary are used.

Example for Analog Input Unit: CH0_input16-bit

Examples for the R88D-KN50H-ECT: Position actual value and Digital inputs

### ● CJ-series Basic I/O Units

I/O port names are created according to the following rules.

#### Rules for I/O Port Names for Basic I/O Units

| Inputs | Outputs |
|---|---|
| Ch□_In□□<br>Terminal number: 00 to 15<br>16-bit words: 1 to 4 | Ch□_Out□□<br>Terminal number: 00 to 15<br>16-bit words: 1 to 4 |

#### I/O Port Names for Specific Numbers of I/O Points

| Number of input points Number of output points | I/O port names | | | |
|---|---|---|---|---|
| | Inputs | Data type | Outputs | Data type |
| 8 points | Ch1_In | WORD | Ch1_Out | WORD |
| | Ch1_In00 to Ch1_In07 | BOOL | Ch1_Out00 to Ch1_Out07 | BOOL |
| 16 points | Ch1_In | WORD | Ch1_Out | WORD |
| | Ch1_In00 to Ch1_In15 | BOOL | Ch1_Out00 to Ch1_Out15 | BOOL |
| 32 points | Ch1_In | WORD | Ch1_Out | WORD |
| | Ch1_In00 to Ch1_In15 | BOOL | Ch1_Out00 to Ch1_Out15 | BOOL |
| | Ch2_In | WORD | Ch2_Out | WORD |
| | Ch2_In00 to Ch2_In15 | BOOL | Ch2_Out00 to Ch2_Out15 | BOOL |
| 64 points | Ch1_In | WORD | Ch1_Out | WORD |
| | Ch1_In00 to Ch1_In15 | BOOL | Ch1_Out00 to Ch1_Out15 | BOOL |
| | Ch2_In | WORD | Ch2_Out | WORD |
| | Ch2_In00 to Ch2_In15 | BOOL | Ch2_Out00 to Ch2_Out15 | BOOL |
| | Ch3_In | WORD | Ch3_Out | WORD |
| | Ch3_In00 to Ch3_In15 | BOOL | Ch3_Out00 to Ch3_Out15 | BOOL |
| | Ch4_In | WORD | Ch4_Out | WORD |
| | Ch4_In00 to Ch4_In15 | BOOL | Ch4_Out00 to Ch4_Out15 | BOOL |

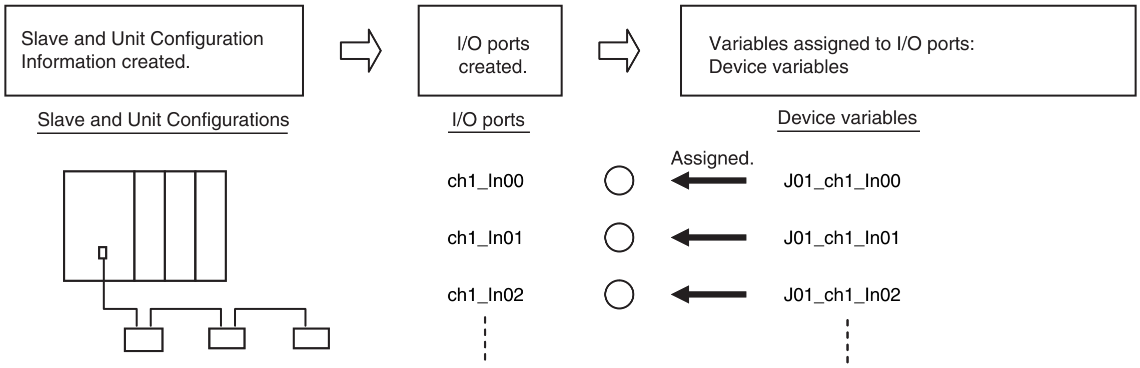
### ● CJ-series Special Units

I/O port names are determined by the model number of the Unit and the functionality.

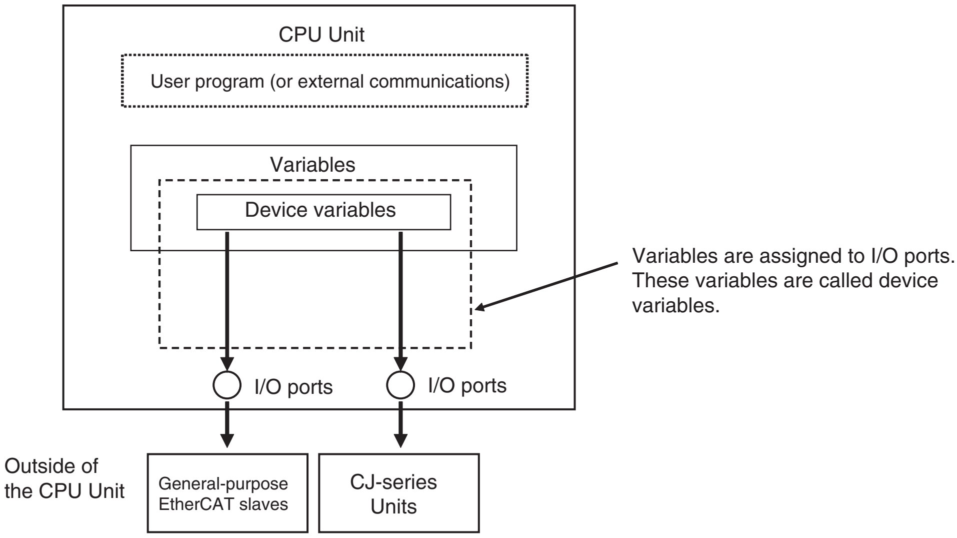
Examples for a CJ1W-AD041-V1 Analog Input Unit:
*Ch1_PkHdCmd*, *Ch1_AveCfg*, etc.

## Device Variables

In an NJ-series Controller, external devices (slaves and Units) are not assigned to specific memory addresses in the CPU Unit. Rather, variables are assigned to the I/O ports. These variables are called device variables.




You can specify device variables in the user program or in external communications to access the devices (slaves or Units).




Refer to *2-2-1 Types of Variables* for the relationship of device variables to other variables.

### ● Device Variable Attributes

Device variables are registered in the variable table specified in the *Variable Type* Column under the following conditions.

| Attribute | Setting | Changes to settings |
|---|---|---|
| Variable Name | Automatically generated variables: [*device_name*] + [*I/O_port_name*]<br>The default device names are as follows:<br>• For EtherCAT slaves, an E followed by a sequential number starting from 001.<br>• For CJ-series Units, the device names start with a J followed by a sequential number starting from 01.<br>Refer to *3-4-1 I/O Ports and Device Variables* for more information on *I/O Port Names*.<br>If entered manually, the variable name is the string you enter. | Allowed. |
| Data Type | According to the data type of the I/O port. | Allowed. |
| AT Specification | • Device variables for EtherCAT slaves: ECAT://node#[*node_number*]/[*I/O_port_name*]<br>• Device variables for CJ-series Units: IOBus://rack#[*rack_number*]/slot#[*slot_number*]/[*I/O_port_name*] | Not allowed. |
| Retain | • Device variables for EtherCAT slaves: Not retained.<br>• Device variables for CJ-series Units assigned to the Operating Data (CIO Area): Not retained<br>Device variables for CJ-series Units assigned to the Setup Data (DM Area): Retained | Not allowed. |
| Initial Value | None | Allowed. |
| Constant | None | Allowed. |
| Network Publish | Do not publish. | Allowed. |
| Edge | None | Not allowed. |

Refer to *6-3-4 Attributes of Variables* for the meanings of the attributes.

**Additional Information**

- You can specify forced refreshing for I/O ports in the I/O Map. You can force real I/O to turn ON or OFF to check the wiring.
- You can choose the variable table (global variable table or local variable table for one POU) in which to register a device variable in the I/O Map.

## 3-4-2 Registering Device Variables

You assign device variables to I/O ports in the I/O Map of the Sysmac Studio. As a result, the device variables are registered in the variable table.

There are three ways to assign a device variable.

- Manually enter a new device variable name.
- Automatically create device variable names.
- Select variables from the variable table.

### Manually Entering Device Variable Names

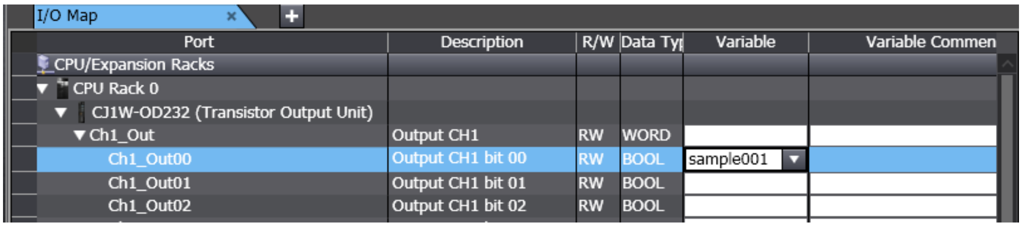
You can enter a device variable name manually. You assign device variables using this method in the following case.

- To assign your own name for a slave I/O terminal or a Basic I/O Unit.

Use the following procedure.

**1** Create the slave configuration information or Unit configuration information.

**2** Select an I/O port in the I/O Map and enter a variable name in the *Variable* Column.




Device variables are automatically assigned to the I/O ports for each slave or Unit. These device variables are also automatically registered in the variable table specified in the *Variable Type* Column.

### Automatically Creating New Device Variable Names

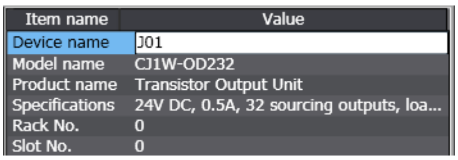
The device variables are named automatically from a combination of the device name and the I/O port names. You assign device variables using this method in the following cases.

- When you do not want to spend time manually entering device variable names.
- To automatically create device variable names to use to access operating data and setup data for Special Units.

Use the following procedure.

**1** Create the slave configuration information or Unit configuration information.

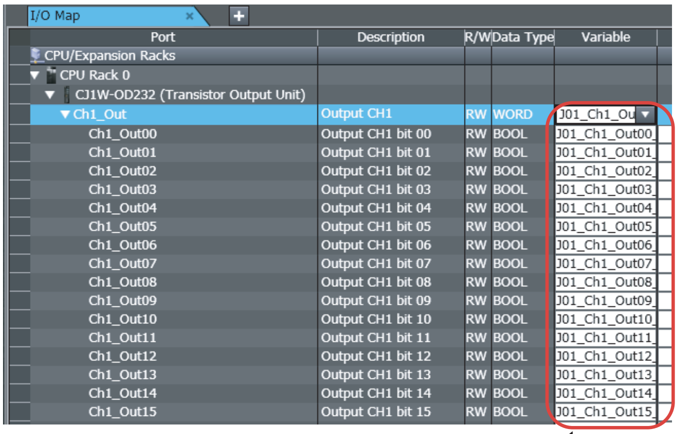
**2** Set a device name in the EtherCAT Editor or the Unit Editor.




The possible default device names are as follows:

- For slaves, the device names start with an E followed by a sequential number starting from 001.
- For Units, the device names start with a J followed by a sequential number starting from 01.

**3** Right-click a slave, Unit, or one or more I/O ports in the I/O Map, and then select ***Create Device Variable*** from the menu.




Automatically created Device Variables

Device variables are automatically assigned to the I/O ports for each slave or Unit. These device variables are also automatically registered in the variable table specified in the *Variable Type* Column.

### Additional Information

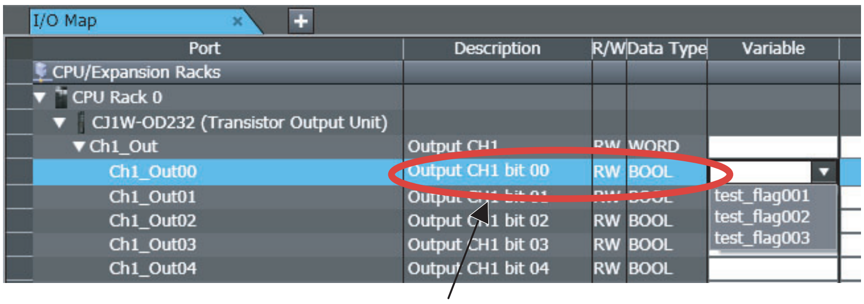
We recommend that you set the device names.

## Selecting from the Registered Variables

Select a registered variable in the I/O Map. You assign device variables using this method in the following cases.

- To create slave configuration information or Unit configuration information after you start programming.
- To reuse programs from another project.

1. Enter the programs.
2. Create the slave configuration information or Unit configuration information.
3. Select a variable that was created in a program from the list in the I/O Map to assign it to an I/O port.




Select a user-defined variable that has already been registered in the global variable table.

### Additional Information

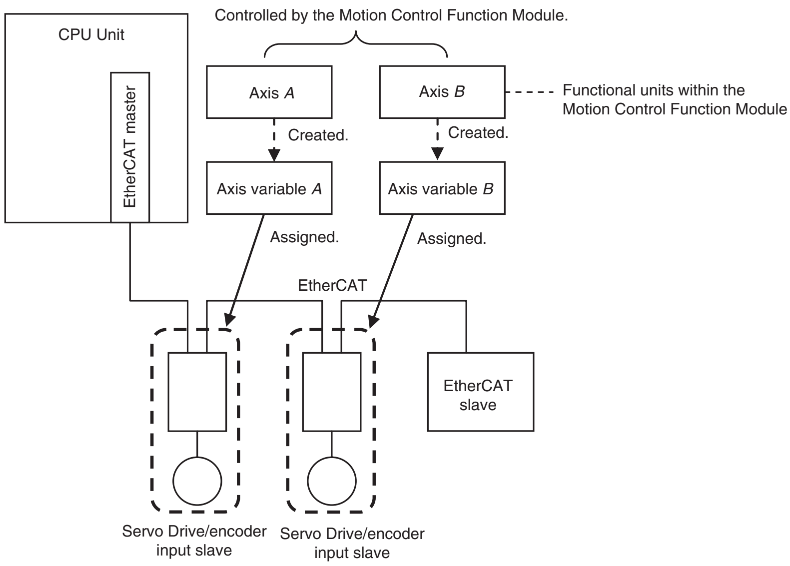
To remove the variable assigned to an I/O port, clear the *Variable* Column or right-click the variable and select ***Reset Assignment*** from the menu. The device variable assignment is removed. However, removing the assignment does not delete the variable from the variable table where it is registered.

# 3-5 Creating the Axes and Assigning Them to the Servo Drives/Encoder Input Slaves

This section describes how to create axes in the NJ-series Controller and how to assign the axes to the Servo Drives and encoder input slaves.

## 3-5-1 Introduction

When you use the Motion Control Function Module for operation with EtherCAT Servo Drive or encoder input slaves, create axes in the Sysmac Studio and define them as EtherCAT servo axes or encoder axes. At a result, Axis Variables are automatically created as system-defined variables.




You can specify an Axis Variable in a motion control instruction in the user program to easily access and perform operations with Servo Drives and encoder input slaves.

## 3-5-2 Axis Variables and Axes Group Variables

The following table lists the types of Axis Variables and Axes Group Variables.

| Type of variable | | Application | Device to access | Creation method |
|---|---|---|---|---|
| Axis Variables | System-defined axis variables | An Axis Variable is used to control a single axis. | The EtherCAT slave (Servo Drive or encoder input slave) that is assigned to the axis | Provided by the system. |
| | Axis Variables automatically created when axes are created with the Sysmac Studio | | | You must create an axis with Sysmac Studio and assign the device to the axis. |
| Axes Group Variables | System-defined axes group variables | An Axes Group Variable is used for multi-axes coordinated control. | The EtherCAT slaves (Servo Drive or encoder input slaves) that are assigned to the axes group | Provided by the system. |
| | Axes Group Variables automatically created when axes groups are created with the Sysmac Studio | | | You must create an axes group with the Sysmac Studio. |

Refer to the *NJ-series Motion Control Instructions Reference Manual* (Cat. No. W508) for details on Axis Variables and Axes Group Variables.

### Specifying Axis and Axes Group Variables

The variables can be specified with variable names that are created with the Sysmac Studio or with system-defined variable names.

| Type | Names | |
|---|---|---|
| | Axis Variables | Axes Group Variables |
| Variable names created with the Sysmac Studio | MC_Axis***<br>("***" is assigned in ascending order from 000 in the order the variables are created.) You can change the names as required. | MC_Group***<br>("***" is assigned in ascending order from 000 in the order the variables are created.) You can change the names as required. |
| System-defined variable names | _MC_AX[0..63]<br>(The array element numbers are assigned in ascending order from 0 in the order the variables are created.) | _MC_GRP[0..31]<br>(The array element numbers are assigned in ascending order from 0 in the order the variables are created.) |

### Application

There are two ways to use Axis Variables and Axes Group Variables.

1) Specifying Axes and Axes Groups in Motion Control Instructions:
If you specify an axis or axes group for an I/O variable for a motion control instruction, you can perform operations for the OMRON Servo Drive or encoder input slave.

2) Monitoring Axis Variable Members:
You can use instructions to monitor the actual position, error information, or other information on the Servo Drives and encoder input slaves.

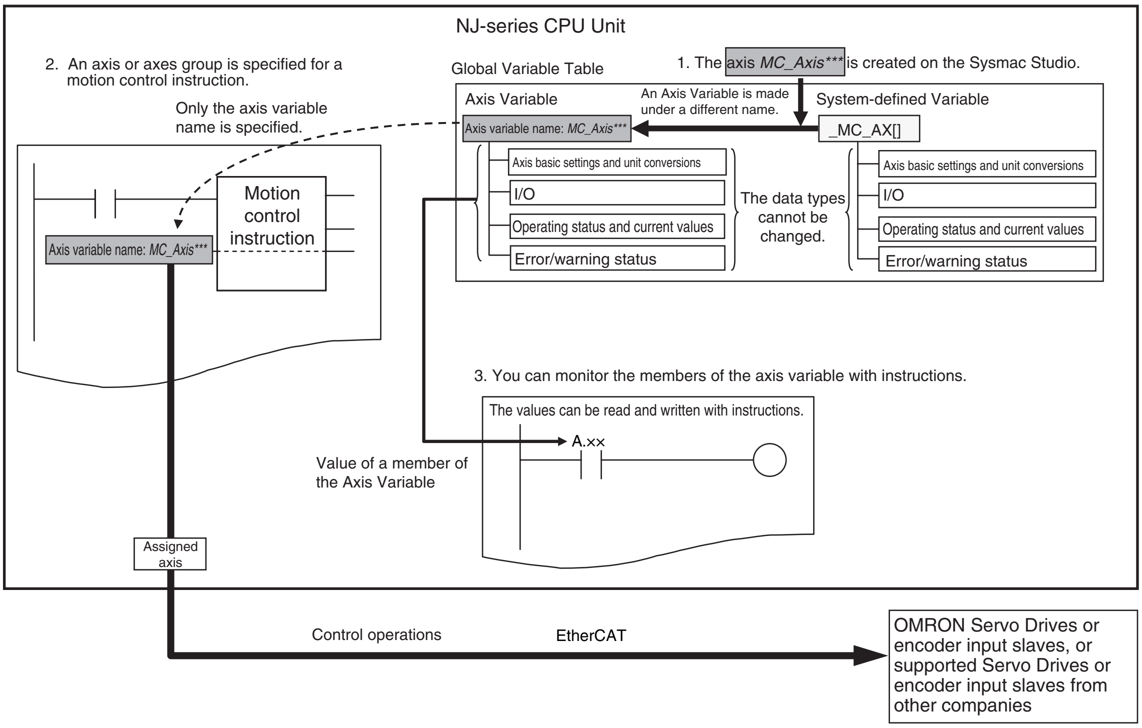
**Additional Information**

**Details on Axis Variables**

1. Assume that you create an axis with an axis name of A on the Sysmac Studio. An Axis Variable with a variable name of *A* is created automatically based on the system-defined axis variable. The Axis Variable consists of Axis Basic Settings, Unit Conversion Settings, I/O, operating status, current values, error status, and warning status.

2. You specify the axis variable name *A* for the in-out variable of a motion control instruction. With the axis variable name, you can access the OMRON Servo Drive or encoder input slave, or supported Servo Drive or encoder input slave from another company and perform operations for it.

3. You can specify the Axis Variable to use instructions as required to monitor the actual position, error information, or other information on the Servo Drive or encoder input slave.




## 3-5-3 Creating and Using Axes and Axis Variables

You can create and use axes and Axis Variables as described below.

**1** Right-click **Axis Settings** under **Configurations and Setup** – **Motion Control Setup** in the Multiview Explorer and select ***Add*** – ***Axis Settings*** from the menu.

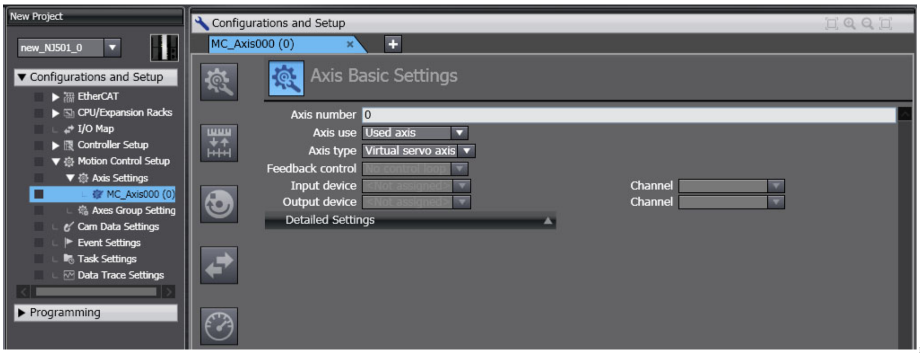
If necessary, you can change the axis variable names from the default names of *MC_Axis****. ("***" is incremented from 000 in the order that the axis variables are created.)

**2** Assign the axes that you created to Servo Drives or encoder input slaves in the EtherCAT Slave Configuration of the Sysmac Studio.

Set the Axis Basic Settings from the Sysmac Studio.

| Classification | Parameter name | Setting |
|---|---|---|
| Axis Basic Settings | Axis Number | Axis numbers are automatically set in the order that the axes are created. |
| | Axis Use | Select *Used Axis*. |
| | Axis Type | Select a servo axis or encoder axis. |
| | Input Device/ Output Device | Specify the node address of the EtherCAT slave that is assigned to the axis. |

**3** Use the Sysmac Studio to specify the settings required for Test Mode operation (Unit Conversion, Count Mode, Limits, etc.) and the settings required for actual system operation. Then transfer the settings to the CPU Unit with the project.

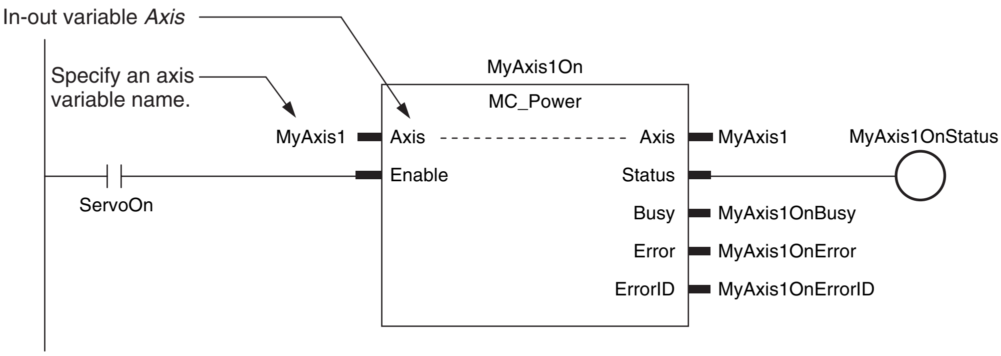



**4** In the user program, an axis variable name is specified for the in-out variable *Axis* in motion control instructions.

For the axis variable name, specify the axis name (axis variable name) that was specified in the Motion Control Setup or the system-defined variable *_MC_AX[0..63].*

You can execute motion control for the assigned Servo Drive or encoder input slave. An example that specifies the axis variable name *MyAxis1* is shown below.

Example:




Refer to *3-5-2 Axis Variables and Axes Group Variables* for information on Axis Variables.

4

# Controller Setup

This section describes the initial settings of the function modules.


**4-1 Overview of the Controller Setup . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4-2**

**4-2 Initial Settings for the PLC Function Module . . . . . . . . . . . . . . . . . . . . . . . 4-4**

4-2-1 Introduction . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4-4
4-2-2 Controller Setup . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4-4
4-2-3 Task Settings . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4-5
4-2-4 Unit Configuration and Unit Setup . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4-9

**4-3 Initial Settings for Special Units . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4-11**

**4-4 Initial Settings for the Motion Control Function Module . . . . . . . . . . . . . 4-13**

4-4-1 Introduction . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4-13
4-4-2 Setting Methods . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4-14

**4-5 Initial Settings for the EtherCAT Master Function Module . . . . . . . . . . . . 4-15**

**4-6 Initial Settings for the EtherNet/IP Function Module . . . . . . . . . . . . . . . . 4-16**

# 4-1 Overview of the Controller Setup

This section provides an overview of the Controller Setup.

The shaded steps in the overall procedure that is shown below are related to the Controller Setup.

**Step 1. Software Design**

- Step 1-1 Designing I/O and Processing
- Step 1-2 Designing Tasks
- Step 1-3 Designing Programs

↓

**Step 2. Software Setups and Programming**

- Step 2-1 Slave and Unit Configurations
- Step 2-2 Controller Setup
- Step 2-3 Programming
- Step 2-4 Offline Debugging

↓

**Step 3. Mounting and Setting Hardware**

↓

**Step 4. Wiring**

↓

**Step 5. Confirming Operation and Starting Actual System Operation**

Refer to *1-3 Overall Operating Procedure for the NJ-series Controller* for details.

| Controller Setup | Reference |
|---|---|
| ● **Initial Settings Related to the PLC Function Module:**<br>Controller Setup: Startup Mode, Write Protection, System Service Monitoring Settings, and other settings | *4-2 Initial Settings for the PLC Function Module* |
| ● **Initial Settings for Special Units:**<br>Unit Configuration and Setup: Initial settings for the Special Units | *4-3 Initial Settings for Special Units* |
| ● **Initial Settings for the Motion Control Function Module:**<br>• Axis Parameters: Motion control parameters for single-axis operation<br>• Axes Group Parameters: Motion control parameters for multi-axes coordinated operation<br>• Cam data: Phase and displacement setting tables for cam motions | *4-4 Initial Settings for the Motion Control Function Module* |
| ● **Initial Settings for the EtherCAT Master Function Module:**<br>EtherCAT Master Parameters in the EtherCAT Configuration:<br>Parameter settings for the EtherCAT master process data communications cycle, and other settings | *4-5 Initial Settings for the EtherCAT Master Function Module* |
| ● **Initial Settings for the EtherNet/IP Function Module:**<br>Ethernet Port Setup: EtherNet/IP Port TCP/IP Settings, Ethernet Settings, and other settings | *4-6 Initial Settings for the EtherNet/IP Function Module* |

# 4-2 Initial Settings for the PLC Function Module

This section describes the initial settings that are required for the PLC Function Module.

## 4-2-1 Introduction

The initial settings for the PLC Function Module are listed below.

- Controller Setup
- Task Settings

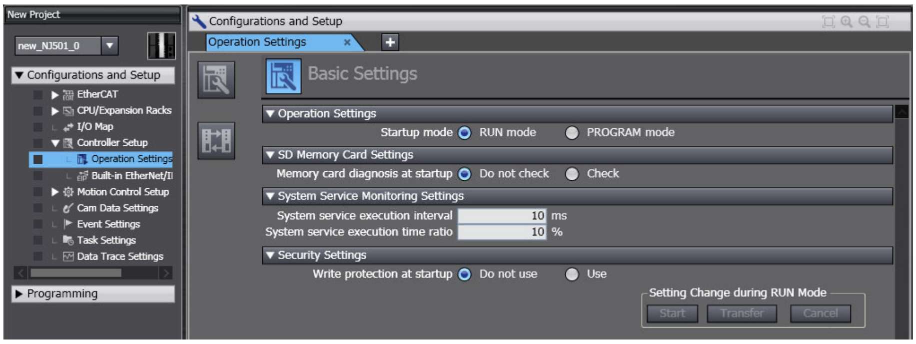
Select **Configurations and Setup** – **Controller Setup** and **Configurations and Setup** – **Task Settings** on the Sysmac Studio to make these settings

## 4-2-2 Controller Setup

### Operation Settings Tab Page

#### ● Basic Settings

The Operation Settings are for functions supported by the CPU Unit, such as the definitions of operations when the power is turned ON or when the operating mode changes.



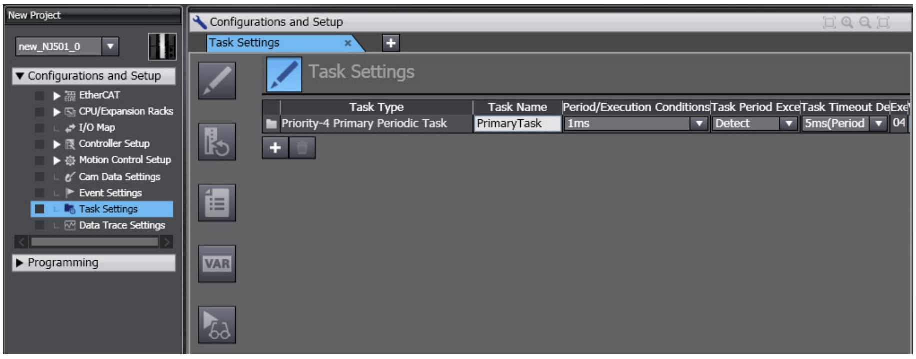

| Parameter | Setting group | Description | Set value | Default | Update timing | Changes in RUN mode |
|---|---|---|---|---|---|---|
| Operation Settings | Startup Mode | Sets the CPU Unit's operating mode at startup. | RUN or PROGRAM mode | RUN mode | When downloaded to CPU Unit | Not allowed. |
| SD Memory Card Setting | Memory Card Diagnosis at Startup | Sets whether to execute self-diagnosis (file system check and recovery) on the inserted SD Memory Card when the power is turned ON. | Do not check.<br>Check. | Do not check. | When downloaded to CPU Unit | Not allowed. |

| Parameter | Setting group | Description | Set value | Default | Update timing | Changes in RUN mode |
|---|---|---|---|---|---|---|
| System Service Monitoring Settings | System Service Execution Interval [ms] | Sets the interval of system service execution. | 10 ms to 1 s | 10 ms | When downloaded to CPU Unit | Not allowed. |
| | System Service Execution Time Ratio [%] | Sets the ratio of execution for monitoring system services in relation to overall processing of the CPU Unit. | 5% to 50% | 10% | When downloaded to CPU Unit | Not allowed. |
| Security Setting | Write Protection at Startup | Automatically enables write protection when you turn ON the power supply to the Controller. | Do not use.<br>Use. | Do not use. | When power is turned ON | Supported. |

## 4-2-3 Task Settings

### ● Task Settings

The Task Settings are used to add and set up tasks.

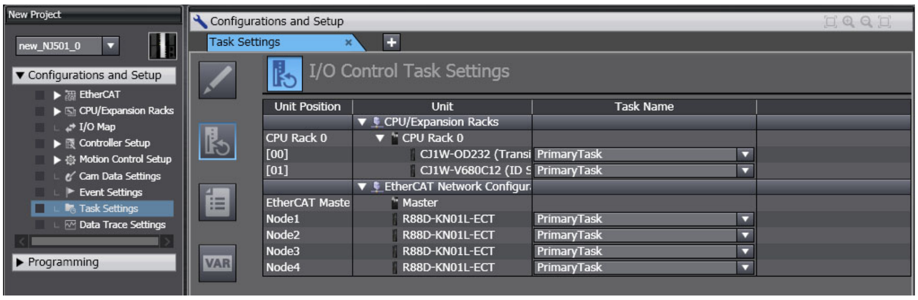



| Parameter | Setting group | Description | Set value | Default | Update timing | Changes in RUN mode |
|---|---|---|---|---|---|---|
| Task Type | | Sets the task type. | Priority-4 primary periodic task<br>Priority-16 periodic task<br>Priority-17 periodic task<br>Priority-18 periodic task | Priority-4 primary periodic task | When downloaded to CPU Unit | Not allowed. |
| | Execution Priority | Sets the task execution priority. | Automatically set according to the task type. | Primary periodic task: 4 | When downloaded to CPU Unit | Not allowed. |
| Task Name | | Sets the task name. | Text string | PrimaryTask | When downloaded to CPU Unit | Not allowed. |

| Parameter | Setting group | Description | Set value | Default | Update timing | Changes in RUN mode |
|---|---|---|---|---|---|---|
| Period/Execution Conditions | | Sets the task period. | Primary periodic task: 500 µs, 1 ms, 2 ms, or 4 ms<br>Periodic tasks: 1 ms, 2 ms, 3 ms, 4 ms, 5 ms, 8 ms, 10 ms, 15 ms, 20 ms, 25 ms, 30 ms, 40 ms, 50 ms, 60 ms, 75 ms, or 100 ms | Primary periodic task: 1 ms<br>Periodic tasks: 10 ms | When downloaded to CPU Unit | Not allowed. |
| Task Period Exceeded Detection | | Sets whether to detect an error when the task period is exceeded. | • Detect. (Minor fault level Controller error generated.)<br>• Do not detect. (Store an observation level log record.) | Detect | When downloaded to CPU Unit | Not allowed. |
| Task Timeout Detection Time | | Sets the task execution timeout time. A Task Execution Timeout Error occurs when the timeout time is exceeded. | Primary periodic task and periodic tasks: Task period × 1 to Task period × 5 | Primary periodic task and periodic tasks: 5 periods | When downloaded to CPU Unit | Not allowed. |
| Variable Access Time [%] | | Sets the percentage of the task period to assign to variable access from outside the Controller. | 1% to 50% | 3% | When downloaded to CPU Unit | Not allowed. |

## ● I/O Control Task Settings

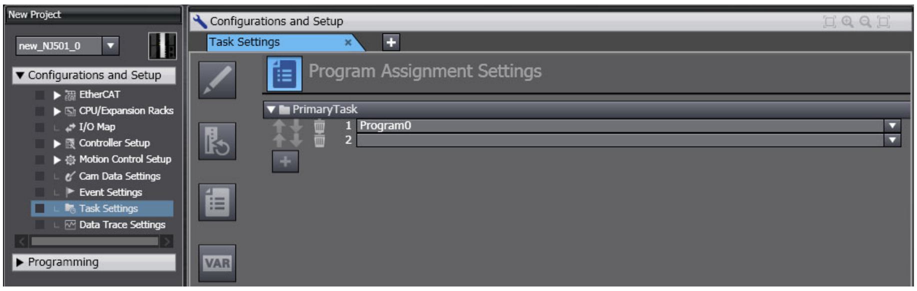
The I/O Control Task Settings are used to set the timing of refresh execution of inputs and outputs.



| Parameter | Description | Set value | Default | Update timing | Changes in RUN mode |
|---|---|---|---|---|---|
| Task Name | Sets the task to use to refresh the specified Units or slaves. | PrimaryTask or PeriodicTask | PrimaryTask | When downloaded to CPU Unit | Not allowed. |

## ● Program Assignment Settings

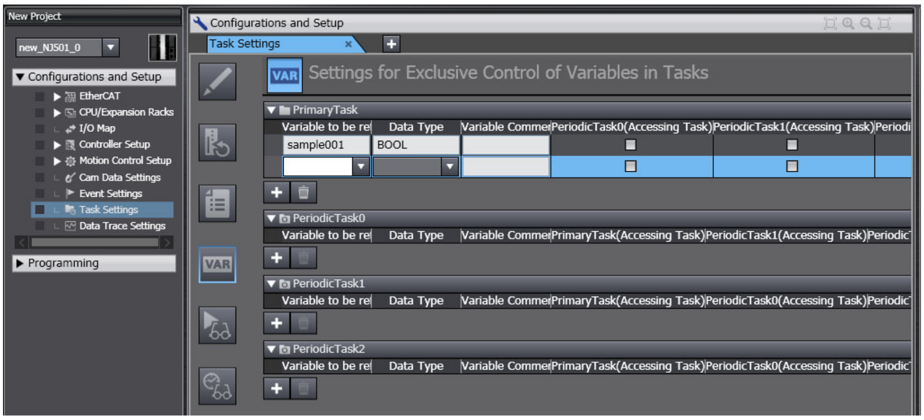
The Program Assignment Settings are used to assign the programs to tasks and set the program execution order.




| Parameter | Description | Set value | Default | Update timing | Changes in RUN mode |
|---|---|---|---|---|---|
| Program Execution Order | Assigns the programs to the specified tasks and sets the order of program execution within the tasks. | Assign the programs in the order to execute them from top to bottom. | Program0 | When downloaded to CPU Unit | Not allowed. |

## ● Settings for Exclusive Control of Variables in Tasks

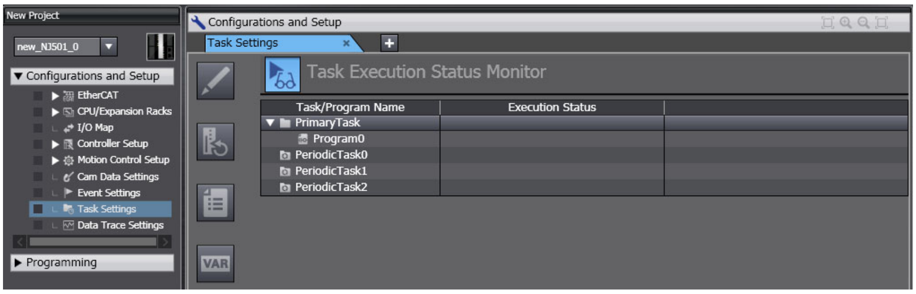
The Settings for Exclusive Control of Variables in Tasks are used to set the tasks that refresh specified global variables and the tasks that access specified global variables.




| Item | Parameter | Description | Set value | Default | Update timing | Changes in RUN mode |
|---|---|---|---|---|---|---|
| Each Task | Variables to be refreshed | Sets the variables to refresh in the primary periodic task or periodic task. | | None | When downloaded to CPU Unit | Not allowed. |
| | Data Type | Sets the data type of variable. | None | | | |
| | Variable Comment | Sets a comment for the variable. | None | | | |
| | Accessing Task | Sets the tasks that access the variable. | | | | |

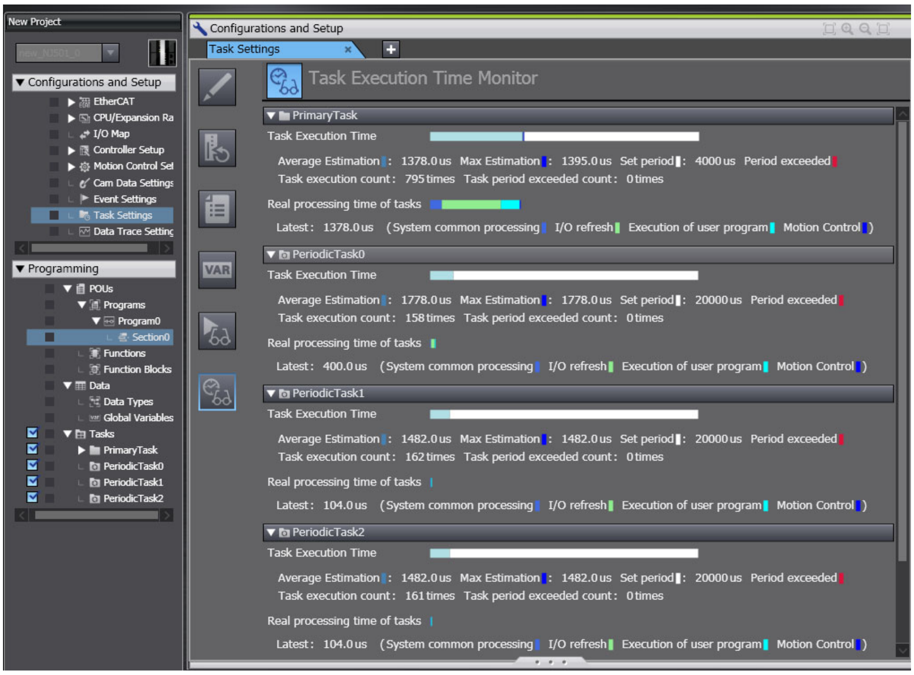
## ● Task Execution Status Monitor

The Task Execution Status Monitor displays the execution status of the programs.



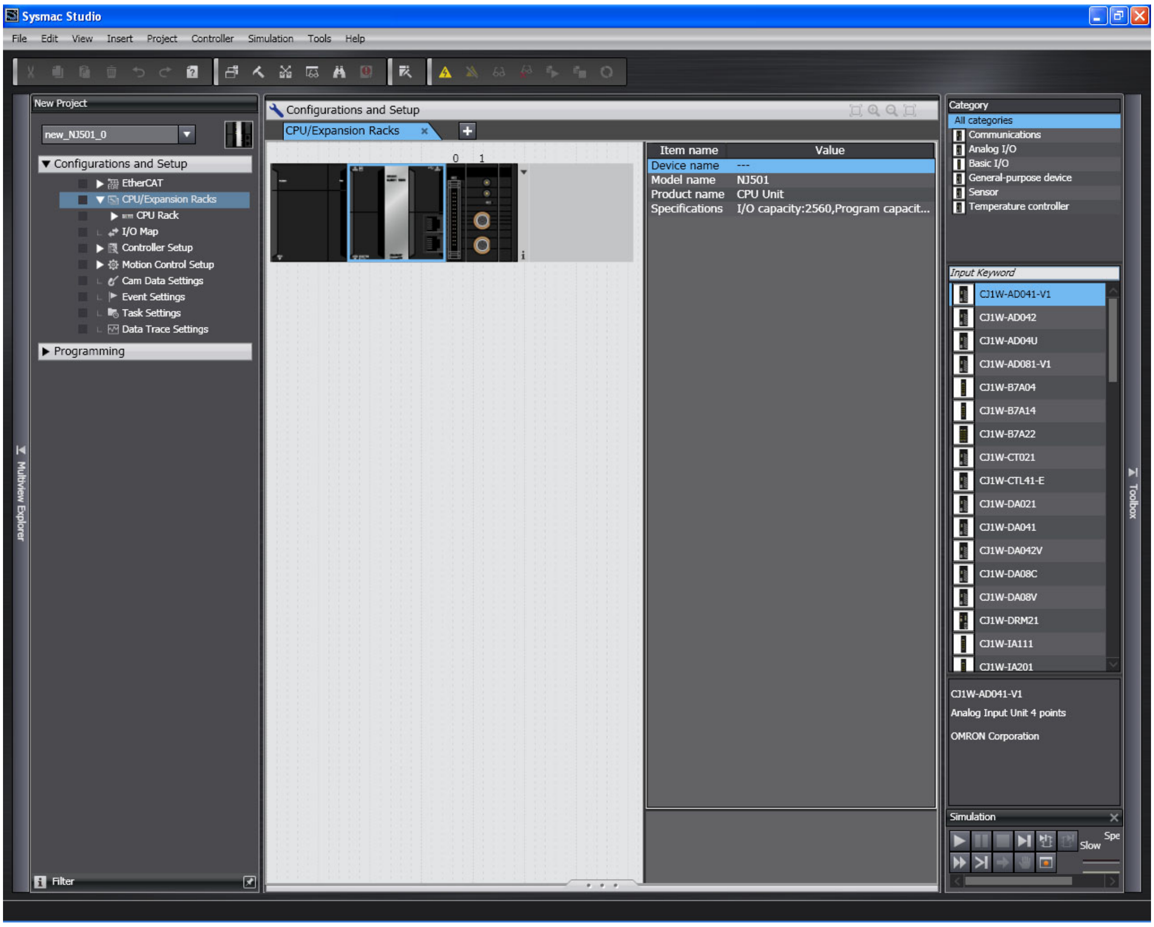

## ● Task Execution Time Monitor

The Task Execution Time Monitor displays the execution times of the tasks.



## 4-2-4 Unit Configuration and Unit Setup

### ● Unit Information




### ● Settings for All Units

Set the device names.

Device names are automatically created when Units are added in the Unit Editor.

Default names: “J” followed by serial numbers that start from 01

We recommend that you change the name to one that is suitable to the device.

**Additional Information**

The device names that are set here are placed before the I/O port name when device variables are automatically created.

### ● Special Units

Set the unit numbers of the Special Units.

**Precautions for Correct Use**

Make sure you set the same unit numbers as the unit numbers that are set on the rotary switches on the front of the Special Units. If they are not the same, operation will be according to the unit numbers that are set on the front-panel rotary switches.

## Basic I/O Units

The following settings are made in the Unit Information of the Basic I/O Units.

| Access point | Setting group | Description | Set values | Default | Update timing | Changes in RUN mode |
|---|---|---|---|---|---|---|
| Unit Information<br>**Note** Set the information for each slot. | Basic Input Unit Input Response Time | Sets the input response time (ON response time = OFF response time) of the Basic Input Unit. You can set this value in increments from 0 to 32 ms. You can increase the value to reduce chattering and the effects of external noise. If you decrease the value, shorter input pulses are received (but the pulses must be longer than the task period). | No filter<br>0.5 ms,<br>1 ms,<br>2 ms,<br>4 ms,<br>8 ms,<br>16 ms,<br>or<br>32 ms | 8 ms | When power is turned ON or the CPU Unit is reset | Not allowed. |

# 4-3 Initial Settings for Special Units

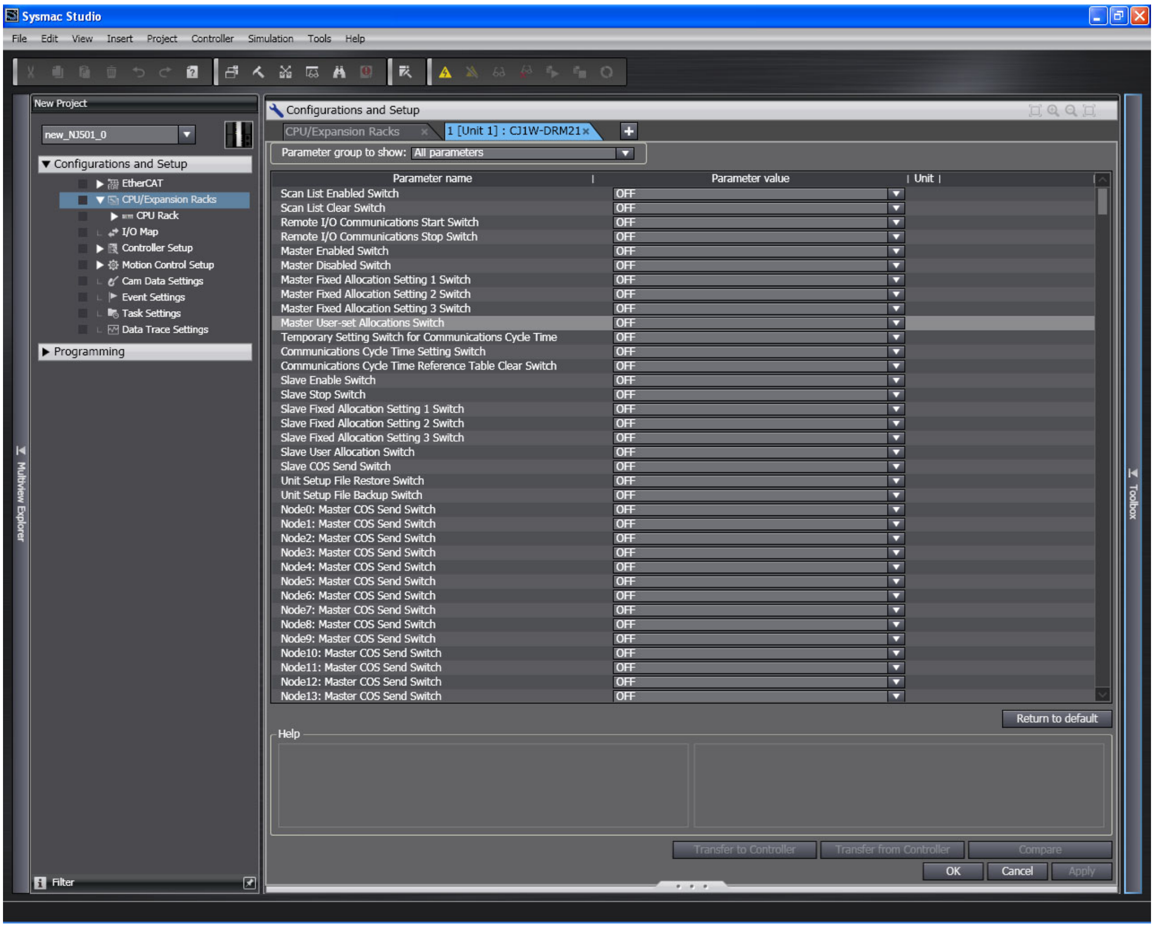
This section describes the initial settings that are required for the Special Units.

You can use any of the following methods to set the initial settings of the Special Units.

## Method 1: Setting from the Unit Setting Pane of the Sysmac Studio

**1** Select the Unit in the Unit Configuration and Setup.

**2** Specify the settings in the Unit Settings Tab Page shown below.



**3** Connect the CPU Unit online and transfer the settings to the CPU Unit.

## Method 2: Using the Sysmac Studio to Specify Initial Settings for the I/O Ports in the I/O Map

**1** Use the I/O Map in the Sysmac Studio to set values for the I/O ports.

**2** Restart the Unit, reset the Controller, or cycle the power supply to the Controller.

## Method 3: Using the Sysmac Studio to Specify Initial Settings for the Device Variables of the CJ-series Units

**1** Use the Sysmac Studio to specify the initial values for the device variables of the CJ-series Units.

**2** Download the variable table from the Sysmac Studio to the CPU Unit.

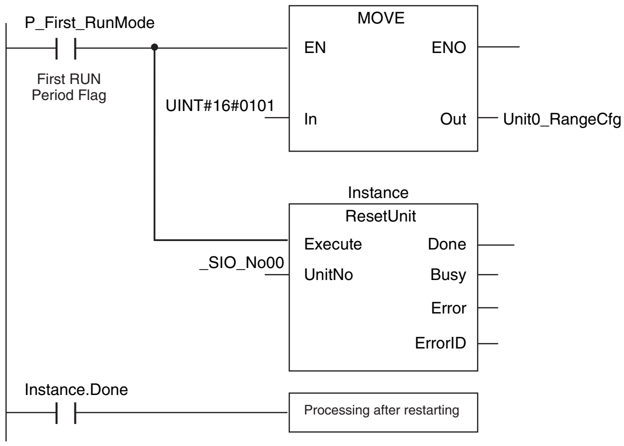
Select the *Clear the present values of variables with Retain attribute* Check Box.

**3** Restart the Unit, reset the Controller, or cycle the power supply to the Controller.

## Method 4: Using Instructions to Set the Device Variables for the CJ-series Units

**1** Set the values for the device variables for the CJ-series Unit at the start of operation from the user program (e.g., use the MOVE instruction) and then restart the Unit.

Example:




### Precautions for Safe Use

When you restart a Special Unit after you change the settings, confirm the safety of the devices at the connection target before you restart the Unit.

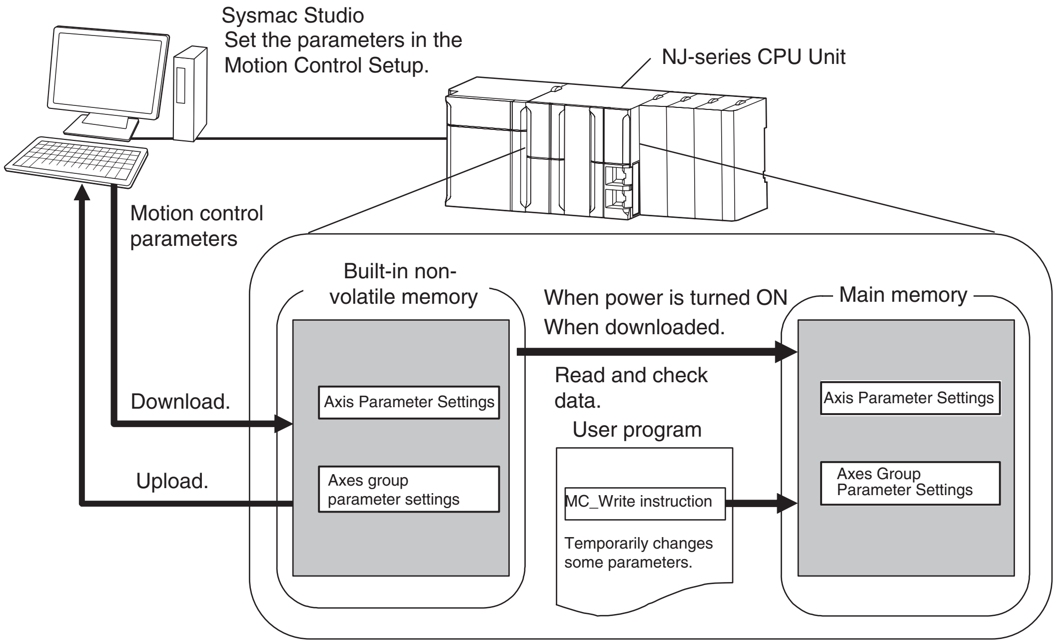
# 4-4 Initial Settings for the Motion Control Function Module

This section describes the initial settings that are required for the MC Function Module.

## 4-4-1 Introduction

The initial settings for the Motion Control Function Module are called motion control parameters. Motion control parameters include the following parameters.

- Axis Parameters: Settings for single-axis control
- Axes Group Parameters: Settings for multi-axes coordinated control

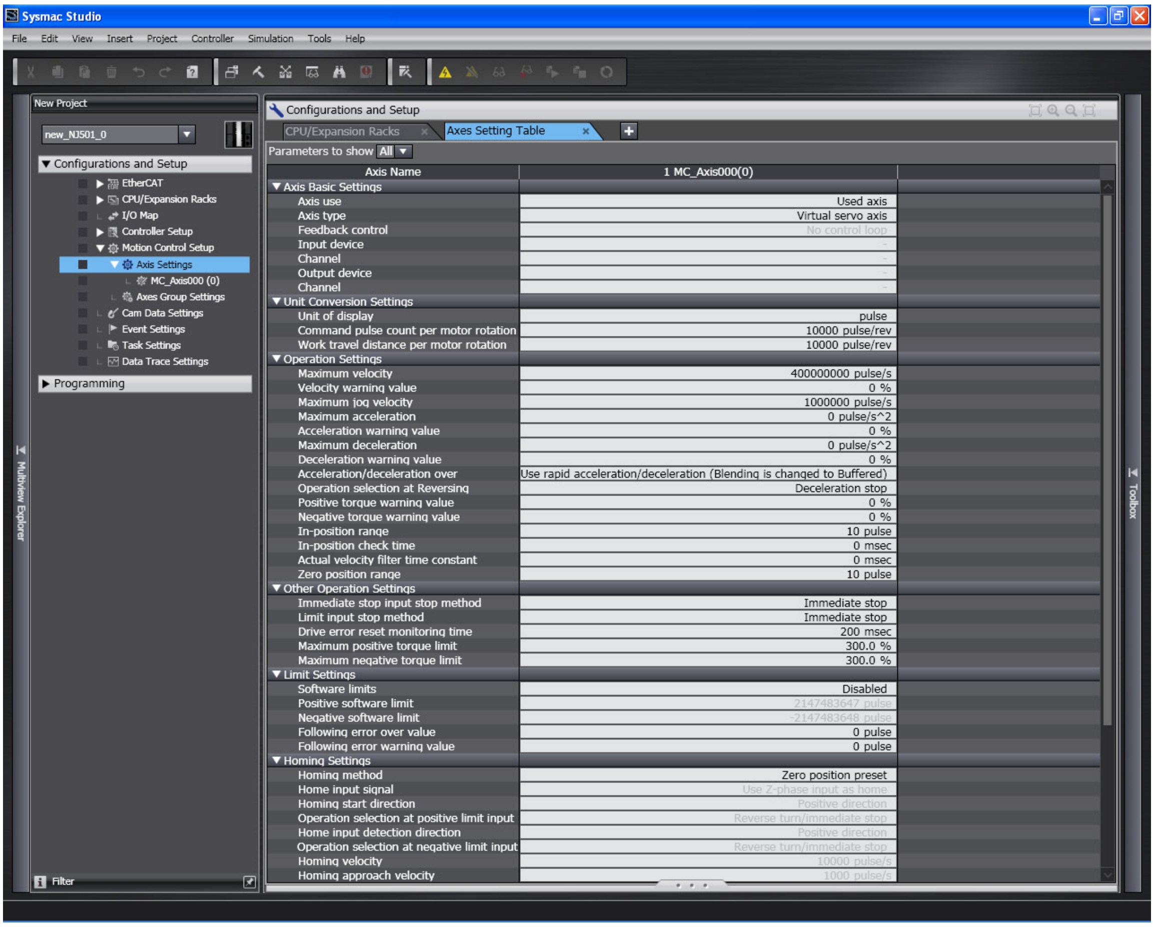


## 4-4-2 Setting Methods

You can use either of the following methods to set motion control parameters.

### Method 1: Setting the Motion Control Setup in the Sysmac Studio

Right-click ***Axis Settings*** from under **Configurations and Setup - Motion Control Setup** in the Sysmac Studio and make the settings in the Axis Setting Table.




Download the motion control parameters to the CPU Unit to save them in the non-volatile memory in the CPU Unit. The downloaded settings are enabled when the power is turned ON or a download is performed.

### Method 2: Setting with the MC_Write Instruction

You can temporarily overwrite some motion control parameters with the MC_Write instruction.

For details, refer to the *NJ-series Instructions Reference Manual* (Cat. No. W502).

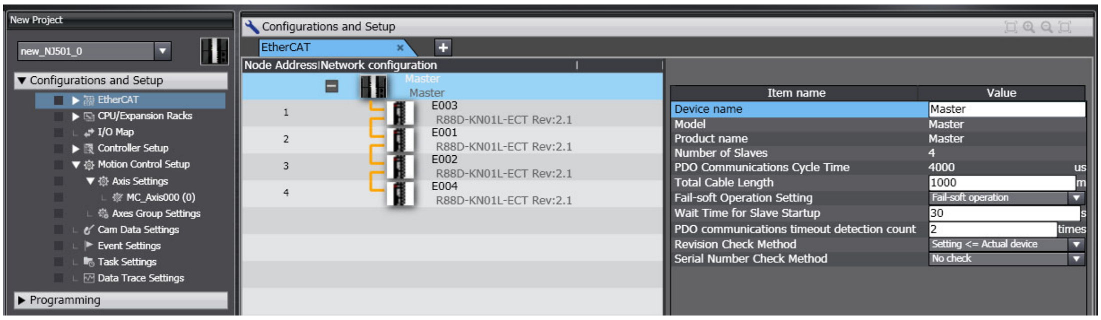
# 4-5 Initial Settings for the EtherCAT Master Function Module

This section describes the initial settings that are required for the EtherCAT Master Function Module.

The initial settings for the EtherCAT Master Function Module are listed below.

- Device names
- Total Cable Length
- Fail-soft Operation Settings
- Wait Time for Slave Startup
- PDO Communications Timeout Detection Count
- Revision Check Method
- Serial Number Check Method

Double-click **EtherCAT** under **Configurations and Setup** and then select the master on the Sysmac Studio. The Initial Setting Tab Page for the EtherCAT Master Function Module is displayed.



Refer to the *NJ-series CPU Unit Built-in EtherCAT Port User's Manual* (Cat. No. W505) for details.

# 4-6 Initial Settings for the EtherNet/IP Function Module

This section describes the initial settings that are required for the EtherNet/IP Function Module.

The initial settings for the EtherNet/IP Function Module are listed below.

- TCP/IP Settings
- Link Settings
- FTP Settings
- NTP Settings
- SNMP Settings
- SNMP Trap Settings
- FINS Settings

Select **Configurations and Setup** – **Controller Setup** – **Built-in EtherNet/IP Port Settings** on the Sysmac Studio to make these settings

Refer to the *NJ-series CPU Unit Built-in EtherNet/IP User's Manual* (Cat. No. W506) for details.

# 5

# Designing Tasks

This section describes the task system and types of tasks.


**5-1 Overview of Task Designing Procedure . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5-2**

**5-2 Task System . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5-5**

5-2-1 Introduction . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5-5
5-2-2 Specifications . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5-6
5-2-3 Basic Operation of Tasks . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5-6
5-2-4 Assigning I/O Refreshing to Tasks . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5-12
5-2-5 Assigning Tasks to Programs . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5-13
5-2-6 Parameters for Primary Periodic Task and Periodic Tasks . . . . . . . . . . . . . . 5-13
5-2-7 Ensuring Concurrency of Variable Values between Tasks . . . . . . . . . . . . . . . 5-15
5-2-8 Synchronizing Variable Access from Outside the Controller with Task Execution . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5-18
5-2-9 Instructions Related to Tasks . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5-19
5-2-10 System-defined Variables Related to Tasks . . . . . . . . . . . . . . . . . . . . . . . . . 5-19
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**5-3 Task Design Example and I/O Response Times . . . . . . . . . . . . . . . . . . . 5-26**

5-3-1 Checking the Task Execution Time . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5-26
5-3-2 Checking the System Service Monitoring Settings . . . . . . . . . . . . . . . . . . . . 5-27
5-3-3 Examples of Task Design . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5-28
5-3-4 System Input and Output Response Times . . . . . . . . . . . . . . . . . . . . . . . . . 5-29

# 5-1 Overview of Task Designing Procedure

This section provides an overview of the task designing procedure.

The shaded steps in the overall procedure that is shown below are related to the task designing procedure.

| Step 1. Software Design | |
|---|---|
| | Step 1-1 I/O Processing Design |
| | Step 1-2 Designing Tasks |
| | Step 1-3 Designing Programs |

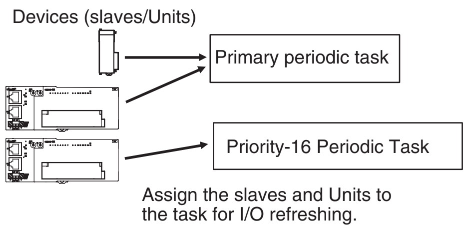
| Step 2. Software Setups and Programming | |
|---|---|
| | Step 2-1 Slave and Unit Configurations |
| | Step 2-2 Controller Setup |
| | Step 2-3 Programming |
| | Step 2-4 Offline Debugging |

**Step 3. Mounting and Setting Hardware**

**Step 4. Wiring**

**Step 5. Confirming Operation and Starting Actual System Operation**

Refer to *1-3 Overall Operating Procedure for the NJ-series Controller* for details.

<table>
<tr><th>Designing the Tasks</th><th>Reference</th></tr>
<tr><td>● Design the task configuration.<br>Design the task configuration based on the I/O response performance that is required by the controlled devices.</td><td>5-2-3 Basic Operation of Tasks<br>5-3 Task Design Example and I/O Response Times</td></tr>
<tr><td>● Determine whether to use the primary periodic task or the priority-16 periodic task for the I/O refreshing of each Unit and slave.<br></td><td>5-2-4 Assigning I/O Refreshing to Tasks</td></tr>
<tr><td>● Determine which programs to assign to the primary periodic task, and to the priority-16 to priority-18 periodic tasks.</td><td>5-2-5 Assigning Tasks to Programs</td></tr>
<tr><td>● Design the exclusive control methods for variables between tasks.<br>Design the exclusive control methods for variables between tasks when the same global variables are used in different tasks.</td><td>5-2-7 Ensuring Concurrency of Variable Values between Tasks</td></tr>
<tr><td>● Design the tasks to access variables from outside of the Controller.<br>Design the tasks to enable synchronizing accessing variables in the CPU Unit from outside of the Controller (including EtherNet/IP tag data links) with the execution of a program in a specific task.</td><td>5-2-8 Synchronizing Variable Access from Outside the Controller with Task Execution</td></tr>
</table>

## Task Settings on the Sysmac Studio

| Setting the Tasks | Reference |
|---|---|
| ● **Initial Settings for the PLC Function Module:**<br>Task Settings: Task Periods, I/O Settings, Program Assignments, Task Interface Settings, and other settings | *4-2 Initial Settings for the PLC Function Module* |

## Offline Debugging with the Sysmac Studio

| Desktop Operation Check | Reference |
| --- | --- |
| • **Perform desktop debugging of sequence control and motion control with the Simulator (virtual controller).**<br>• **Monitor the task execution times in the Task Execution Time Monitor Display.** | *Section 7 Simulation, Transferring Projects to the Physical CPU Unit, and Operation*<br>*5-2-12 Monitoring Task Execution Status and Task Execution Times* |

# 5-2 Task System

This section describes the task system used by NJ-series Controllers.

## 5-2-1 Introduction

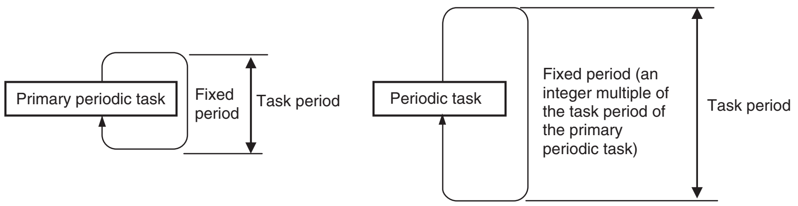
### Tasks

Tasks are used to assign an execution condition and execution order to a series of processes, such as I/O refreshing and user program execution.

There are two kinds of tasks, as shown in the following table. They are defined by their execution conditions and execution priorities.

| Type of task | Number of tasks | Task execution priority | Definition | Main processing content |
|---|---|---|---|---|
| Primary periodic task | 1 | 4 (fixed) | The primary periodic task is executed once every task period. It has higher priority than any other task. Motion control and EtherCAT communications are executed on the primary periodic task period. | I/O refreshing, user program execution, and motion control |
| Periodic tasks | 0 to 3 | 16, 17, or 18 | The periodic tasks are executed once every task period. | The processing that can be performed depends on the task execution priority.<br>• Execution priority 16: I/O refreshing and user program execution<br>• Execution priority 17 or 18: User program execution |

The CPU Unit periodically executes both the primary periodic task and periodic tasks.
(The interval in which the CPU Unit executes the primary periodic task or a periodic task is called the task period.)




From 1 to 128 programs can be assigned to one task. The programs that are assigned to a task are executed in the order that they are assigned. Execution of the all of the programs assigned to each task is called user program execution.

Exchanging data with CJ-series Units or EtherCAT slaves is called I/O refreshing.

You can assign I/O refreshing for each slave and Unit to the primary periodic task or priority-16 periodic task. (By default, refreshing for all slaves and Units is assigned to the primary periodic task.)

### Task Configurations

| | | | |
|---|---|---|---|
| Primary periodic task | I/O refreshing | User program execution | Motion control |
| Priority-16 periodic task | I/O refreshing | User program execution | |
| Priority-17 periodic task | | User program execution | |

## Examples of Task Separation

For example, if you separate the tasks by the I/O response performance that is required by the controlled devices, you can achieve the control performance that is required for devices that need high-speed response and execute programming that requires more processing time in separate tasks.

# 5-2-2 Specifications

<table>
<tr><th>Item</th><th>Specification</th></tr>
<tr><td>Type of task</td><td>• Primary periodic task<br>• Periodic task</td></tr>
<tr><td>Numbers of tasks</td><td>• Primary periodic task: 1<br>• Periodic tasks: 0 to 3 tasks</td></tr>
<tr><td>Number of programs per task</td><td>128 max.</td></tr>
<tr><td>Task period of the primary periodic task</td><td>500 µs, 1 ms, 2 ms, or 4 ms</td></tr>
<tr><td>Task periods of periodic tasks</td><td>Set the task period of each periodic task to an integer multiple of the task period of the primary periodic task.<br>Any of the following can be set.
<table>
<tr><th>Task period of the primary periodic task</th><th>Task periods that you can set for periodic tasks</th></tr>
<tr><td>500 µs</td><td>1 ms, 2 ms, 3 ms, 4 ms, 5 ms, 8 ms, 10 ms, 15 ms, 20 ms, 25 ms, 30 ms, 40 ms, 50 ms, 60 ms, 75 ms, or 100 ms</td></tr>
<tr><td>1 ms</td><td>1 ms, 2 ms, 3 ms, 4 ms, 5 ms, 8 ms, 10 ms, 15 ms, 20 ms, 25 ms, 30 ms, 40 ms, 50 ms, 60 ms, 75 ms, or 100 ms</td></tr>
<tr><td>2 ms</td><td>2 ms, 4 ms, 8 ms, 10 ms, 20 ms, 30 ms, 40 ms, 50 ms, 60 ms, or 100 ms</td></tr>
<tr><td>4 ms</td><td>4 ms, 8 ms, 20 ms, 40 ms, 60 ms, or 100 ms</td></tr>
</table>
</td></tr>
</table>

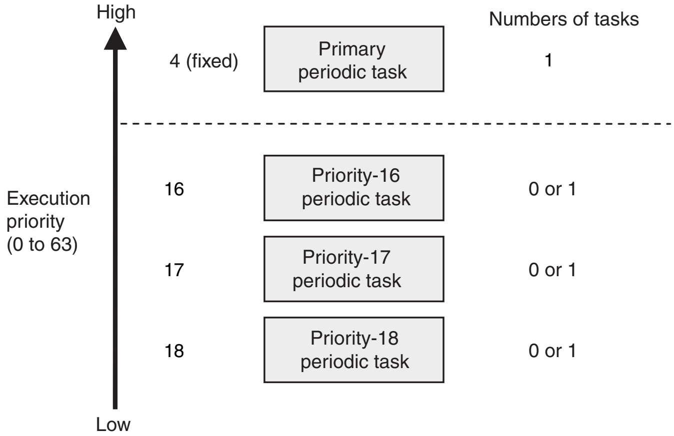
# 5-2-3 Basic Operation of Tasks

## Task Execution Priority

The CPU Unit executes the task with the highest execution priority first.

If the execution conditions are met for another task with a higher execution priority while a task is under execution, the task with the higher execution priority is given priority in execution.

- The primary periodic task has the highest execution priority. The Controller executes it with a higher priority than any other task.
- There are three execution priority levels for periodic tasks.

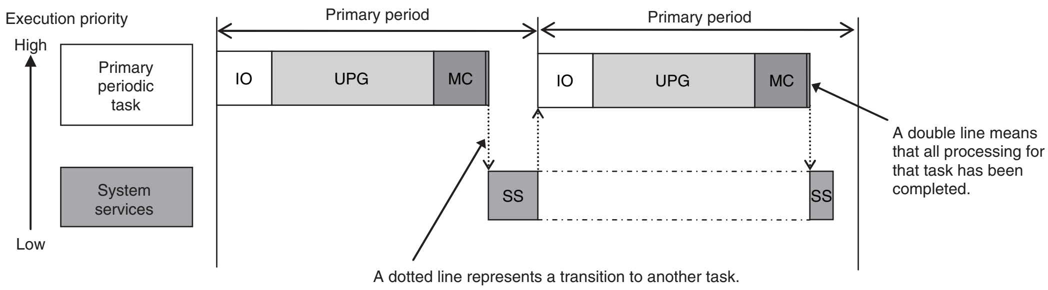



## Overall Operation

Tasks operate with the task period of the primary periodic task (called the primary period) as the standard period.

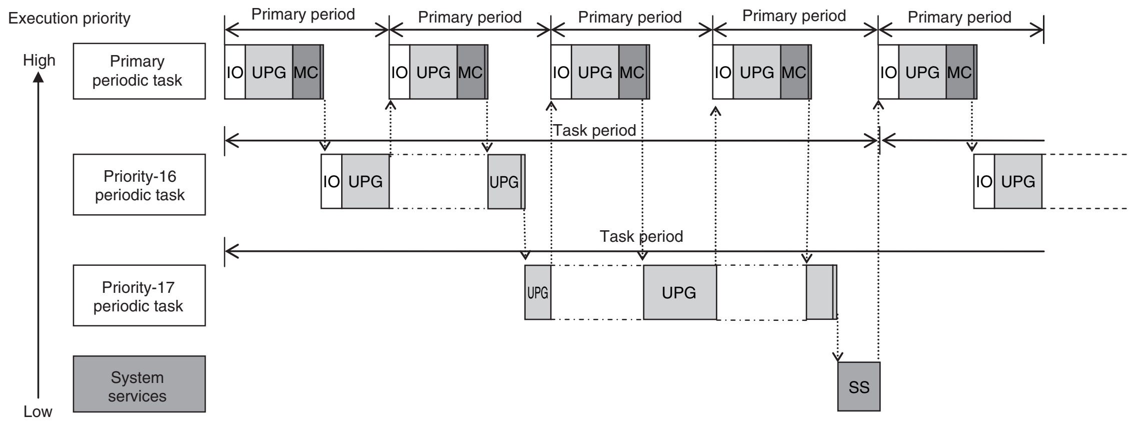
- The Controller executes a periodic task once during multiple primary periods.
  For example, if the task period of the primary periodic task is set to 1 ms and the task period of the priority-16 periodic task is set to 4 ms, the priority-16 periodic task is executed once while the primary periodic task is executed four times.
- The primary periodic task and periodic tasks are processed during the task periods even in PROGRAM mode. The user program is executed in RUN mode.
- I/O refreshing is executed according to the task periods.
- The CPU Unit executes system services, such as communications processing, during the unused time between executions of all of the tasks.

### ● Primary Periodic Task Only




IO: Indicates I/O refreshing (data outputs and then data inputs).
UPG: User program execution.
MC: Indicates motion control.
SS: Indicates system services.

- **Primary Periodic Task, Priority-16 Periodic Task, and Priority-17 Periodic Task**




**Note** The execution order of tasks does not depend on the above execution priority order alone. For details, refer to *Task Execution Order,* below.

## Task Execution Order

The execution order of tasks does not depend only on the execution priority order. A task with a lower execution priority is sometimes executed even during execution of a task with a higher execution priority.

The execution order of tasks depends only on the following points.

- The primary periodic task is never interrupted to execute any other task.
- When the execution of the primary periodic task is completed, execution of the priority-16 periodic task is started.

**Precautions for Correct Use**

When you exchange data between tasks, use exclusive control of variables between the tasks to ensure proper operation. Refer to *5-2-7 Ensuring Concurrency of Variable Values between Tasks* for details.

## Operating Mode

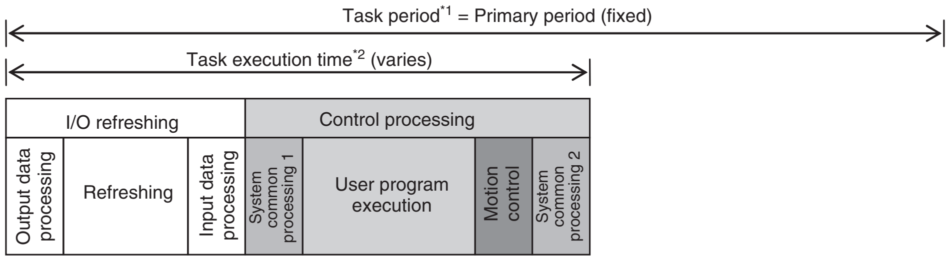
Tasks are executed in both RUN mode and PROGRAM mode. User program execution is not performed in PROGRAM mode.

## Processing of Tasks and System Services

- **Primary Periodic Task**

The primary periodic task has the highest execution priority. It executes processes with high speed and high precision.

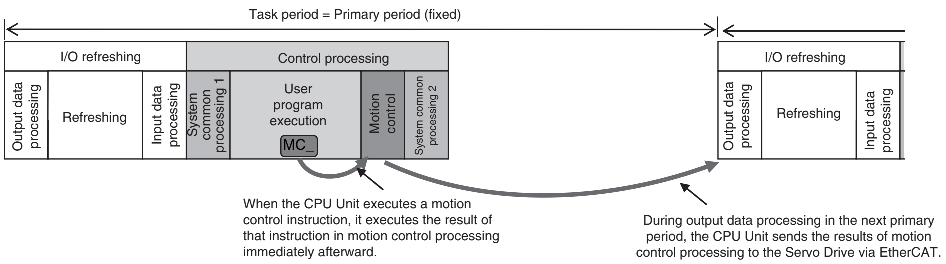
In every period, this task performs system common processing, I/O refreshing, user program execution, and motion control. Unlike periodic tasks, the primary periodic task performs motion control processing (MC).




| | |
|---|---|
| *1: Task period | The CPU Unit executes tasks in this fixed period. This is a preset, fixed time. |
| *2: Task execution time | This is the actual time it takes from the point that the execution condition is met until execution is completed. |

| Processing | | Processing contents |
|---|---|---|
| I/O refreshing | Output data processing | • Output refresh data is created for Output Units that refresh I/O.<br>• If forced refreshing is set, the forced refreshing values are reflected in the output refresh data. |
| | Refreshing | • This process exchanges data with I/O. |
| | Input data processing | • Input refresh data is loaded from Input Units that refresh I/O.<br>• If forced refreshing is set, the forced refreshing values are reflected in the input refresh data that was read. |
| System common processing 1 | | • Processing for exclusive control of variables in tasks (when accessing tasks are set)<br>• Motion input processing is performed.<br>• Data trace processing (sampling and trigger checking) is performed. |
| User program execution | | • Programs assigned to tasks are executed in the order that they are assigned. |
| Motion control* | | • The motion control commands from the motion control instructions in the user program execution are executed.<br>• Processing the motion outputs for I/O refreshing in the next primary periodic task. |
| System common processing 2 | | • Processing for exclusive control of variables in tasks (when refreshing tasks are set)<br>• Processing for variables accessed from outside of the Controller is performed to maintain concurrency with task execution (executed for the variable access time that is set in the Task Settings).<br>**Note** If there is communications processing for EtherNet/IP tag data links and refreshing tasks are set for the tags (i.e., variables with a Network Publish attribute), variable access processing is performed as part of system common processing 2. |

* When there are motion control instructions in user program execution in the primary periodic task, the CPU Unit executes the results from those instructions immediately afterward in motion control processing. The CPU Unit outputs the results to the Servo Drives during I/O refreshing in the next primary periodic task.




When there is a motion control instruction in user program execution in the periodic task, the CPU Unit executes the result from that instruction in the motion control processing (MC) of the next primary periodic task.

For details, refer to *5-3-4 System Input and Output Response Times.*

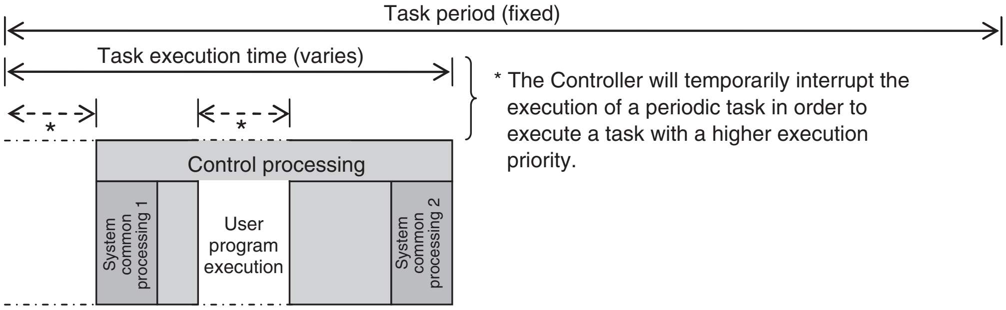
## ● Periodic Tasks

A periodic task executes its programs every task period, which is an integer multiple of the primary period. You can use 0 to 3 periodic tasks.

The priority-16 periodic task can also refresh I/O.

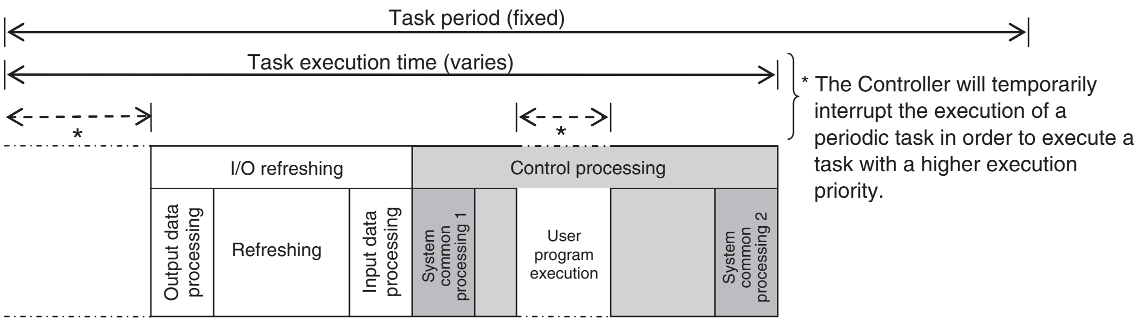
Processing for periodic tasks that do not control I/O is different from processing for periodic tasks that do control I/O.

### Periodic Tasks That Do Not Control I/O




| Processing | Processing contents |
|---|---|
| System common processing 1 | • Processing for exclusive control of variables in tasks (when accessing tasks are set)<br>• Data trace processing (sampling and trigger checking) is performed. |
| User program execution | • Programs assigned to tasks are executed in the order that they are assigned. |
| System common processing 2 | • Processing for exclusive control of variables in tasks (when refreshing tasks are set)<br>• Processing for variables accessed from outside of the Controller is performed to maintain concurrency with task execution (executed for the variable access time that is set in the Task Settings).<br>**Note** If there is communications processing for EtherNet/IP tag data links and refreshing tasks are set for the tags (i.e., variables with a Network Publish attribute), variable access processing is performed as part of system common processing 2. |

### Periodic Tasks That Control I/O




| Processing | | Processing contents |
|---|---|---|
| I/O refreshing | Output data processing | • Output refresh data is created for Output Units that refresh I/O.<br>• If forced refreshing is set, the forced refreshing values are reflected in the output refresh data. |
| | Refreshing | • This process exchanges data with I/O. |
| | Input data processing | • Input refresh data is loaded from Input Units that refresh I/O.<br>• If forced refreshing is set, the forced refreshing values are reflected in the input refresh data that was read. |

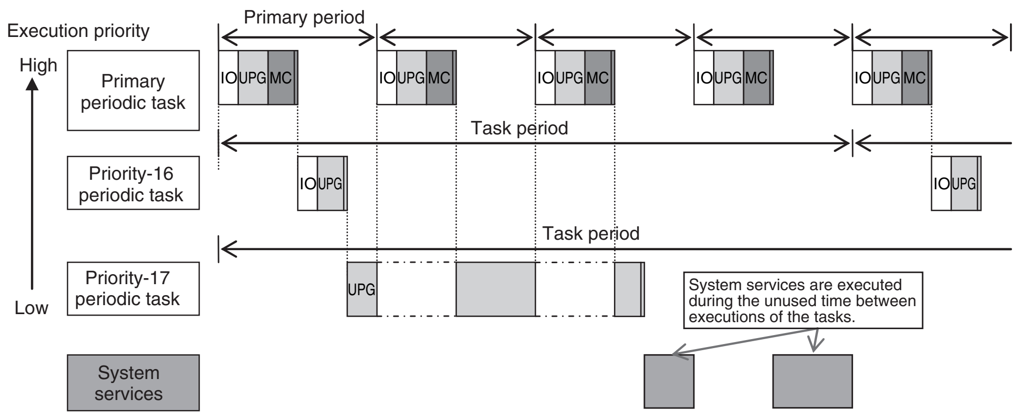
| Processing | Processing contents |
|---|---|
| System common processing 1 | • Processing for exclusive control of variables in tasks (when accessing tasks are set)<br>• Data trace processing (sampling and trigger checking) is performed. |
| User program execution | • Programs assigned to tasks are executed in the order that they are assigned. |
| System common processing 2 | • Processing for exclusive control of variables in tasks (when refreshing tasks are set)<br>• Processing for variables accessed from outside of the Controller is performed to maintain concurrency with task execution (executed for the variable access time that is set in the Task Settings).<br>**Note** If there is communications processing for EtherNet/IP tag data links and refreshing tasks are set for the tags (i.e., variables with a Network Publish attribute), variable access processing is performed as part of system common processing 2. |

## ● System Services

System services are the processes other than task processing that the CPU Unit executes. System services include the following processes.

| System service | Description |
|---|---|
| USB port service | • Processing of service requests from the Sysmac Studio or an HMI, such as CIP commands |
| Built-in EtherNet/IP port service | • Processing of message service requests, such as CIP commands, from the Sysmac Studio, an HMI, host computers, or other Controllers<br>• EtherNet/IP tag data link communications processing<br>**Note** If there is communications processing for EtherNet/IP tag data links and refreshing tasks are set for the tags (i.e., variables with a Network Publish attribute), variable access processing is performed as part of system common processing 2 for the task that is set as the refreshing task and not as a system service. |
| Service for CJ-series Special Units | • Event servicing for CJ-series Special Units<br>• Execution of communications instructions (CIP)<br>**Note** The CPU Unit exchanges data between CJ-series Special Units and their allocated memory words during I/O refreshing. |
| SD Memory Card service | • Access from FTP client<br>• SD Memory Card operations from the Sysmac Studio<br>• Execution of SD Memory Card instructions |
| Self-diagnosis | • Hardware error detection |

System services are executed during the unused time between executions of all of the tasks, as shown below.



### System Service Monitoring Settings

You can use the Basic Settings in the Operation Settings of the Sysmac Studio to set the execution time interval and execution time percentage of monitoring for system services.

| Access point | Setting group | Setting [unit] | Description | Set values | Default | Update timing | Changes in RUN mode |
|---|---|---|---|---|---|---|---|
| Operation Settings, Operation Settings Tab, Basic Settings | System Service Monitoring Settings | System Service Execution Interval [ms] | Sets the interval of system service execution. | 10 ms to 1 s | 10 ms | When transferred to CPU Unit | Not allowed. |
| | | System Service Execution Time Ratio [%] | Sets the ratio for monitoring system service execution. | 5% to 50% | 10% | When transferred to CPU Unit | Not allowed. |

**Precautions for Correct Use**

- The System Service Monitoring Settings are used to monitor whether the specified system service execution time can be obtained. System services will not necessarily be executed for the specified time.
- To increase the system service processing time, increase the task period or take other steps to increase the unused time between task execution.
- If the system service monitoring setting is too high for the unused time between task execution, an Insufficient System Service Time Error occurs and user program execution stops. Set system service monitoring setting to the minimum value that is required to meet the response performance for the required system services.
- Depending on the execution of system service processing, a Task Period Exceeded Error may occur for the priority-17 or priority-18 periodic task. Design the tasks so that the task processing for the priority-17 and priority-18 periodic tasks is completed even if system service processing is performed for the times that is specified in the system service monitoring setting.

## 5-2-4 Assigning I/O Refreshing to Tasks

CJ-series Units and EtherCAT slaves are assigned to the tasks. You can assign them to the following tasks.

| Classification | Assigned unit | I/O refresh target | Tasks to which assignment is possible |
|---|---|---|---|
| CJ-series Units | By Unit | Basic I/O Units | Primary periodic task and priority-16 periodic task |
| | | Special I/O Units | |
| | | CPU Bus Units | |
| EtherCAT slaves | By slave | Slaves assigned to axes | Primary periodic task |
| | | Other slaves | Primary periodic task and priority-16 periodic task |

### ● Sysmac Studio Setting Procedure

Set the tasks in which to perform I/O refreshing for the slaves and Units in the I/O Control Task Settings on the Task Settings Tab Page of the Sysmac Studio.

For details, refer to *I/O Control Task Settings* on page 4-6.

**Precautions for Safe Use**

If two different function modules are used together, such as when you use CJ-series Basic Output Units and EtherCAT slave outputs, take suitable measures in the user program and external controls to ensure that safety is maintained in the controlled system if one of the function modules stops.

The relevant outputs will stop if a partial fault level Controller error occurs in one of the function modules.

Refer to *12-1 Operation after an Error* for details on partial fault level Controller errors.

### Accessing I/O from the User Program

You use device variables to access I/O ports from the user program. Access the device variables from a program in the task that is set as the I/O control task.

## 5-2-5 Assigning Tasks to Programs

You assign the programs to execute to tasks. (You can assign up to 128 programs to one task.)

### Order of Program Execution

The order of execution of the programs in a task is set with the Sysmac Studio.

- **Sysmac Studio Setting Procedure**

Assign programs to tasks and set the order of program execution within the tasks in the Program Assignment Settings on the Task Settings Tab Page of the Sysmac Studio.

For details, refer to *4-2-3 Task Settings*.

### POUs That You Can Assign to Tasks

From 0 to 128 programs can be assigned to one task.
You cannot assign the same program to more than one task.

## 5-2-6 Parameters for Primary Periodic Task and Periodic Tasks

The parameters for primary periodic task and periodic tasks are given below.

Parameters for Primary Periodic Task

| Parameter | | Setting range | Default | Update timing | Changes in RUN mode |
|---|---|---|---|---|---|
| Task Type | | Specify the primary periodic task. | --- | When transferred to CPU Unit | Not allowed. |
| | Execution priority | Always 4. | --- | | |
| Task Name | | Text string | --- | | |
| Period/Execution Conditions | Task period<br>* The process data communications cycle in the EtherCAT settings will be the same as this period. | 500 µs, 1 ms, 2 ms, or 4 ms | 1 ms | | |
| Task Period Exceeded Detection | | Specify whether to detect an error if the task execution time exceeds the specified task period.<br>• Detect (a minor fault level Controller error is generated).<br>• Do not detect (an observation is recorded in event log).<br>Refer to *Task Period Exceeded Error* on page 5-21 for details. | Detect. | | |
| Task Timeout Detection Time | | Set the time to detect timeouts if task execution does not end, e.g., if there is an infinite loop. Set a multiple of the task period.<br>1 to 5<br>Refer to *Task Execution Timeout Error* on page 5-22 for details. | 5 | | |
| Variable Access Time [%] | | Set the percentage of the task period to assign to variable access.<br>1% to 50%<br>Refer to *Variable Access Time Ratio* on page 5-19 for details. | 3% | | |

Parameters for Periodic Tasks

| Parameter | | Setting range | Default | Update timing | Changes in RUN mode |
|---|---|---|---|---|---|
| Task Type | | You can set any of the following.<br>Priority-16 periodic task<br>Priority-17 periodic task<br>Priority-18 periodic task | --- | When transferred to CPU Unit | Not allowed. |
| | Execution priority | Automatically set to 16, 17, or 18. | --- | | |
| Task Name | | Text string | --- | | |
| Period/Execution Conditions | Task period | Refer to *5-2-2 Specifications* | 10 ms | | |
| Task Period Exceeded Detection | | The same as for the primary periodic task. | The same as for the primary periodic task. | | |
| Task Timeout Detection Time | | | | | |
| Variable Access Time [%] | | | | | |

- **Sysmac Studio Setting Procedure**

Add and set the tasks in the **Task Settings** under **Configurations and Setup** on the Sysmac Studio. For details, refer to *Task Settings* on page 4-5.

## 5-2-7 Ensuring Concurrency of Variable Values between Tasks

If more than one task reads or writes the same global variable, you can use either of the following two methods to ensure the concurrency of the value of the global variable between the tasks.

Method 1: Write the global variable from only one task and read the variable from the other tasks.
Use the settings for exclusive control of variables in tasks.

Method 2: Lock other tasks so that they cannot write to the global variable.
Use the task exclusive control instructions.

### Method 1: Settings for Exclusive Control of Variables in Tasks

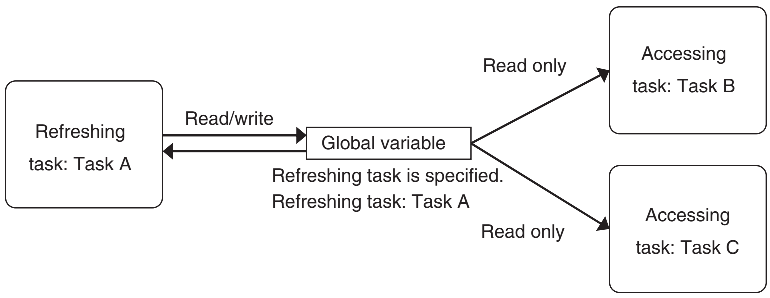
- **Introduction**

You can specify the task that refreshes a global variable and the tasks that access the global variable. This ensures the concurrency of the value of the global variable from the point of view of the tasks that access the variable.

A single task is set to write the value of a specified global variable. That task is called the refreshing task. If a refreshing task is specified, other tasks cannot write the value of the global variable.

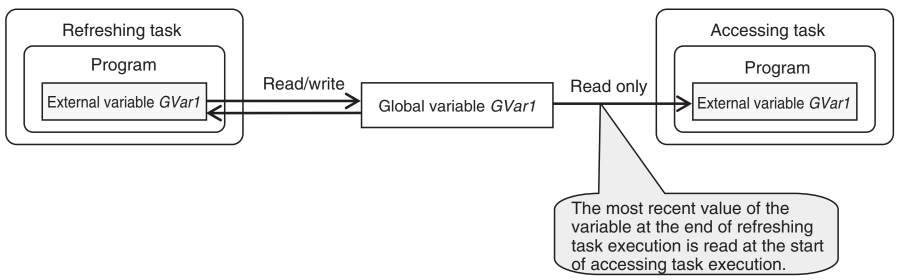
If a refreshing task is not specified for a global variable, the value of the variable can be written at any time by any of the tasks, so the value will change depending on when it is read.

The tasks that read the value of the global variable (called accessing tasks) are also specified in advance.



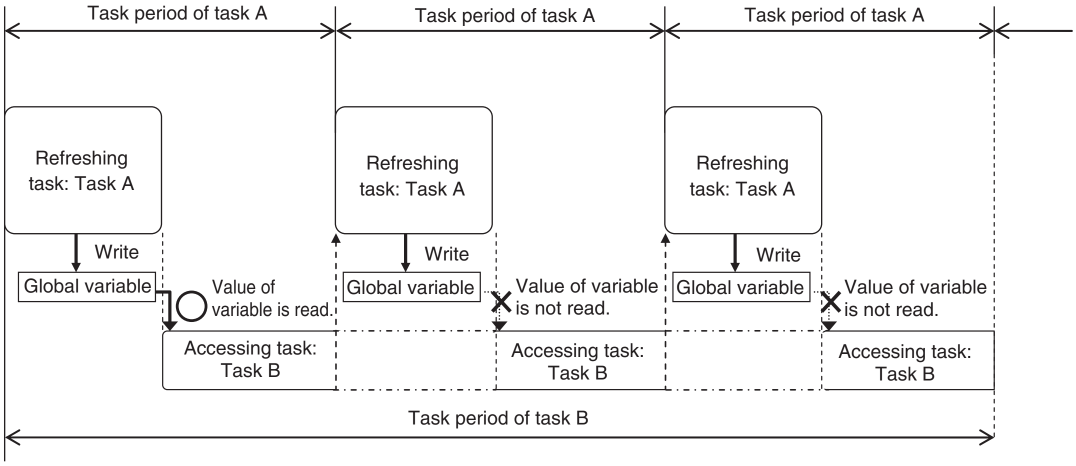

- **Application Example**

The refreshing task specification is used to ensure the concurrency of the value of a global variable within a periodic task when the variable is written in the primary periodic task.



## ● System

If a refreshing task is set for a global variable, the accessing task, at the start of accessing task execution, always reads the most recent value of the variable that was written at the completion of refreshing task execution.




This will allow you to maintain the concurrency of the values of global variables within the tasks without performing any special programming.

If an instruction that writes the value to a global variable is used in the accessing task, an error will occur when you check the program on the Sysmac Studio.

## ● Restrictions

- Only one refreshing task can be set for each global variable. If it is necessary to write a global variable from more than one task, use the task exclusive control instructions described below to ensure concurrency.
- If you specify a refreshing task for a structure or union variable, you must specify only one refreshing task for the entire structure or union variable. You cannot specify a different refreshing task for different structure or union members.
- If you specify a refreshing task for an array variable, you must specify only one refreshing task for the entire array variable. You cannot specify a different refreshing task for different array elements.

## ● Sysmac Studio Setting Procedure

Set the global variables for which to specify refreshing tasks, and set the accessing tasks in the Settings for Exclusive Control of Variables in Tasks on the Task Settings Tab Page on the Sysmac Studio.

For details, refer to *Settings for Exclusive Control of Variables in Tasks* on page 4-7.

# Method 2: Task Exclusive Control Instructions

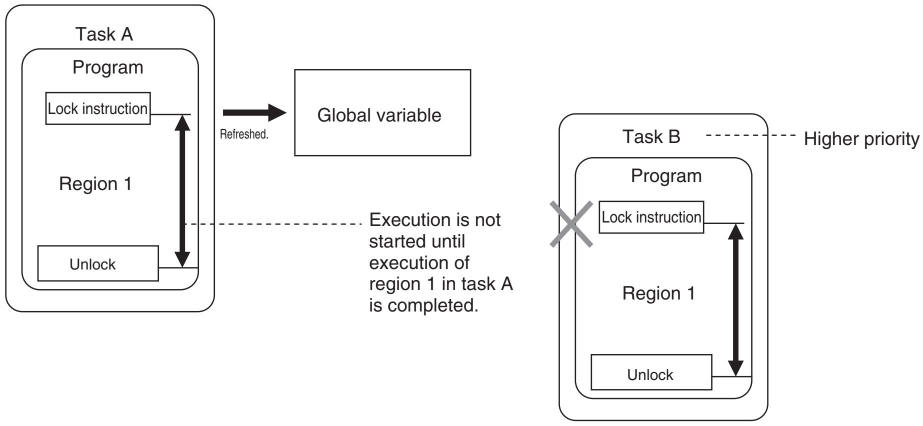
Use the task exclusive control instructions (Lock and Unlock instructions) when it is necessary to write the value of a global variable from more than one task.

The Lock and Unlock instructions are used to prevent execution of program regions between Lock and Unlock between different tasks.

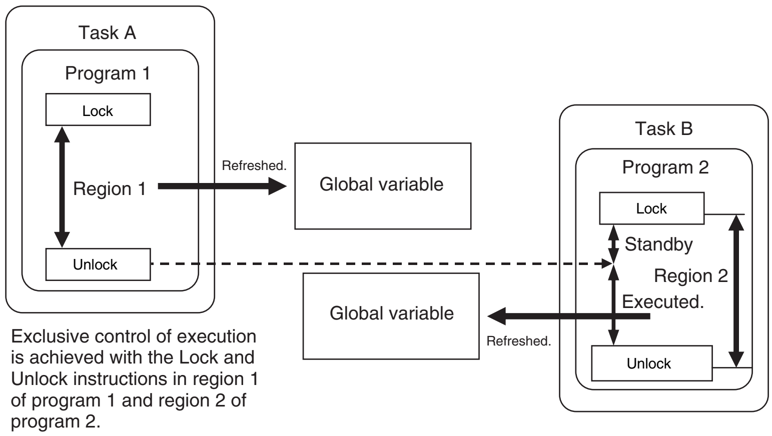
Refer to information on the Lock and Unlock instructions in the *NJ-series Instructions Reference Manual* (Cat. No. W502) for details.

Example:

If execution of region 1 in task B is attempted during execution of region 1 in task A, region 1 in task B is not executed until execution of region 1 in task A is completed, even if the execution priority of task B is higher. Here, execution of region 1 in task A is given priority.




When execution of region 1 in task A is completed, region 1 in task B is executed, as shown below.




### Precautions for Correct Use

- Do not make the locked regions any longer than necessary. If the lock regions are too long, the task execution period may be exceeded.
- Always use the Lock and Unlock instructions in a pair in the same section of the same POU.

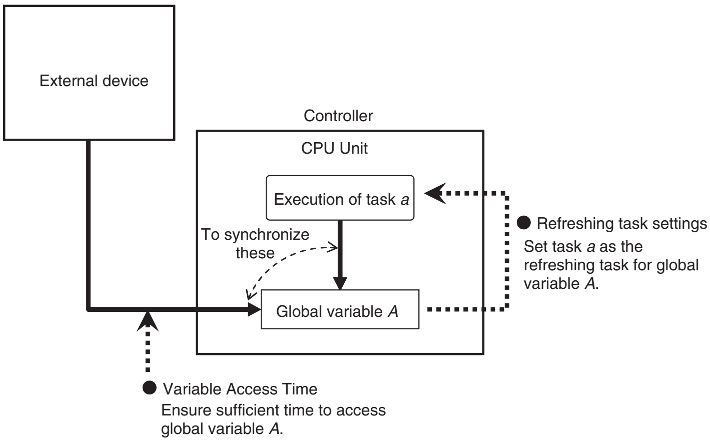
## 5-2-8 Synchronizing Variable Access from Outside the Controller with Task Execution

### Introduction

To synchronize variable access from outside the Controller with task execution, make the settings for exclusive control in tasks in the Task Settings. Also, particularly when using tag data links, set the Variable Access Time in the Task Settings of the Sysmac Studio.

You can use the following methods to access global variables from outside of the Controller.

- EtherNet/IP tag data links
- Accessing variables from an NS-series PT
- Accessing variables from the Sysmac Studio (Synchronization with task execution is achieved only for writing.)
- Accessing variables with CIP communications from a host computer




### Settings for Exclusive Control of Variables in Tasks (Refreshing Task Settings)

When accessing global variables* from outside of the Controller, you can set a specific task as the refreshing task for those global variables to synchronize with the execution of programs in that task.

Particularly when using EtherNet/IP tag data links, always set the same task as the refreshing task for tags in the same tag set (variables with a Network Publish attribute) to ensure concurrency between the tags in the tag set.

* You cannot set a refreshing task for the following assigned global variables. The tasks that are given below are automatically set as the refreshing task.

- Device variables for EtherCAT slaves: Task set as the I/O control task
- Device variables for CJ-series I/O Units: Task set as the I/O control task
- Device variables for CJ-series Special Units: Primary periodic task
- Variables with AT specifications in memory used for CJ-series Units: Primary periodic task

#### Sysmac Studio Setting Procedure

Set the global variables for which to specify refreshing tasks, and set the accessing tasks in the Settings for Exclusive Control of Variables in Tasks on the Task Settings Tab Page on the Sysmac Studio.

For details, refer to *Settings for Exclusive Control of Variables in Tasks* on page 4-7.

### Variable Access Time Ratio

Set the variable access time for accessing variables from outside of the Controller to ensure concurrency between accessing variables from outside of the Controller and task execution.

Refer to the *NJ-series CPU Unit Built-in EtherNet/IP Port User's Manual* (Cat. No. W506) for the setting procedure for the Variable Access Time to use tag data links.

## 5-2-9 Instructions Related to Tasks

The following instructions are supported to read the status of the current task, to determine if execution is in progress for other tasks, and to perform exclusive control for regional concurrency between tasks.

| Instruction | Instruction name | Introduction | |
|---|---|---|---|
| GetMyTaskStatus | Read Current Task Status | Reads the following status of the current task.<br>Last Task Execution Time, Maximum Task Execution Time, Minimum Task Execution Time, Task Execution Count, Task Period Exceeded Flag, and Task Period Exceeded Count | |
| Task_IsActive | Determine Task Status | Determines if the specified task is currently in execution. | |
| Lock | Lock Tasks | Starts a lock between tasks. | Execution of any other task with a lock region with the same lock number is disabled. |
| Unlock | Unlock Tasks | Stops a lock between tasks. | |

## 5-2-10 System-defined Variables Related to Tasks

The following system-defined variables are provided for each task to show task status.

Example: The Task Period Exceeded Flag for the task named MainTask is *_MainTask_Exceeded*.

Do not use this variable in the user program. There may be a delay in updating it and concurrency problems in relation to the error status of the function module. It is used only to sample the task status for data tracing from the Sysmac Studio.

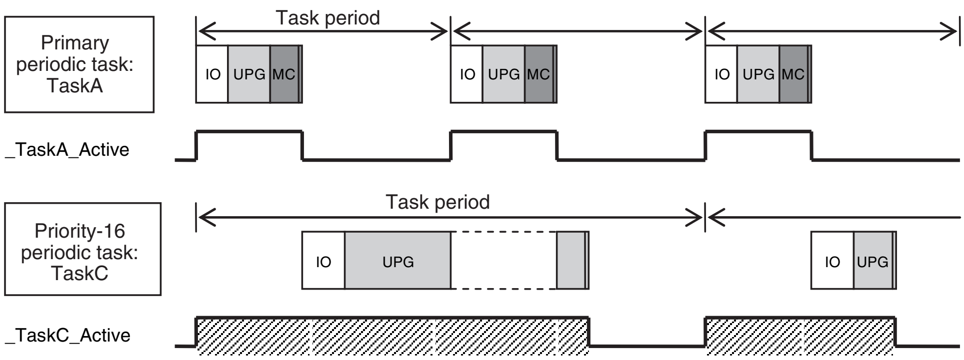
You can also use the GetMyTaskStatus and Task_IsActive instructions to read task status from the user program. You cannot access the following variables directly through system-defined variables.

| Variable name | Meaning | Description | Data type | R/W |
|---|---|---|---|---|
| _*TaskName*_Active | Task Active Flag | TRUE during task execution.<br>FALSE when task execution is not in progress. | BOOL | R |
| _*TaskName*_LastExecTime | Last Task Execution Time | Gives the last execution time of the task. | TIME | R |
| _*TaskName*_MaxExecTime | Maximum Task Execution Time | Gives the maximum value of the task execution time. | TIME | R |
| _*TaskName*_MinExecTime | Minimum Task Execution Time | Gives the minimum value of the task execution time. | TIME | R |

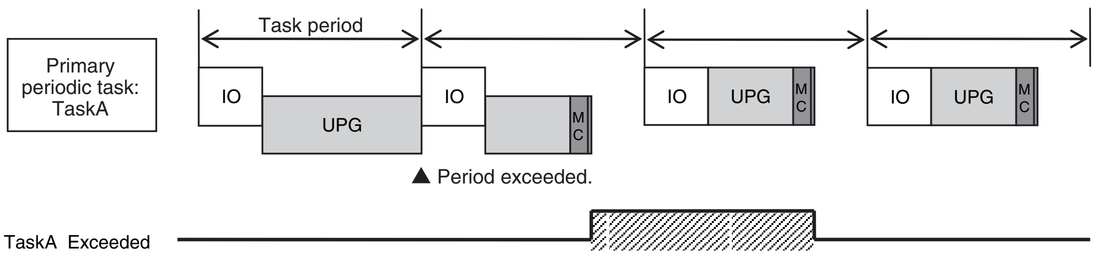
| Variable name | Meaning | Description | Data type | R/W |
|---|---|---|---|---|
| _*TaskName*_ExecCount | Number of Task Executions | Contains the number of executions of the task.<br>If the present value exceeds the maximum value of the data type, the present value returns to 0 and the count is continued. | UDINT | R |
| _*TaskName*_Exceeded | Task Period Exceeded Flag | TRUE if the task period was exceeded. FALSE if task execution is completed within the task period. | BOOL | R |
| _*TaskName*_ExceedCount | Task Period Exceeded Count | Contains the number of times that the task period was exceeded.<br>If the present value exceeds the maximum value of the data type, the present value returns to 0 and the count is continued. | UDINT | R |

## Flag Operation

### ● Task Active Flag (_*TaskName*_Active)




### ● Task Period Exceeded Flag (_*TaskName*_Exceeded)




# 5-2-11 Errors Related to Tasks

This section describes the following errors.

- Task Period Exceeded Error
- Motion Control Period Exceeded Error
- Task Execution Timeout Error
- I/O Refreshing Timeout Error
- Insufficient System Service Time Error

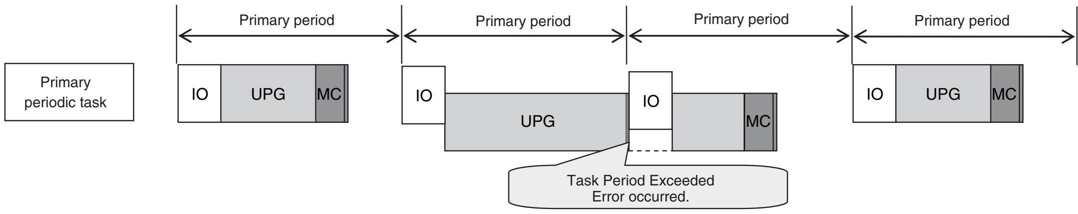
## Task Period Exceeded Error

A Task Period Exceeded Error occurs if the task execution time exceeds the specified task period.

This is a minor fault level Controller error. Operation continues even when this error occurs.

It can occur for the primary periodic task and periodic tasks.

Task Period Exceeded Errors can be disabled in the settings. Use the Task Period Exceeded Detection setting in the Task Settings of the Sysmac Studio. The default setting is to detect the error.




Even if detection of Task Period Exceeded Errors is disabled, information will be output to the following if task processing is not completed within the period: Task Period Exceeded Flag (_*TaskName_Exceeded*), Task Period Exceeded Count (_*TaskName_ExceedCount*), Controller Error Status (_*ErrSta*), and the event log.

I/O is refreshed as follows if task processing is not completed within the task period.

Outputs: The values from the previous period are output.

Inputs: Refresh values for inputs are not reflected in the user program.

### ● Task Period Exceeded Error

| Error name | Error level | Correction |
|---|---|---|
| Task Period Exceeded Error | Minor fault | Review the task settings and programs and download the project again. Cycle the power supply or reset the CPU Unit to reset the error. |

**Precautions for Correct Use**

If the Task Period Exceeded Error occurs, shorten the programs to fit in the task period or increase the setting of the task period.

## Motion Control Period Exceeded Error

A Motion Control Period Exceeded Error occurs if the motion control processing (MC) is not completed within the primary period (i.e., the motion control period) twice in a row. A partial fault level Controller error will occur in the Motion Control Function Module. A Task Period Exceeded Error will occur at the same time.

### ● Motion Control Period Exceeded Error

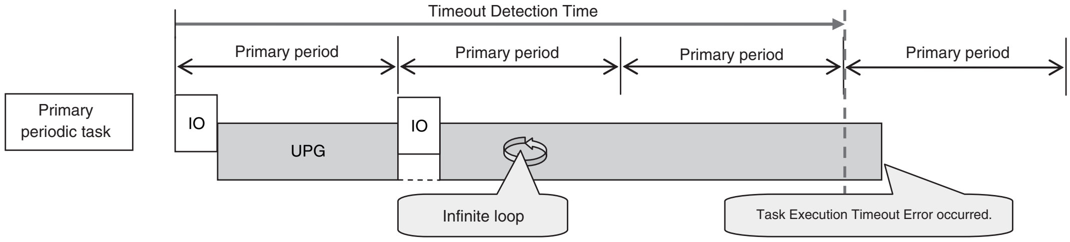
| Error name | Error level | Correction |
|---|---|---|
| Motion Control Period Exceeded Error | Minor fault | Reduce the amount of processing in the programs or increase the control period within the range that does not adversely affect operation. |

## Task Execution Timeout Error

A Task Execution Timeout Error occurs if task processing is not completed within the specified Task Execution Timeout Time.

This is a major fault level Controller error. Execution of the user program stops when the error occurs.

This error also occurs when normal task operation is not possible due to errors in program logic, such as infinite loops.




### ● Task Execution Timeout Error

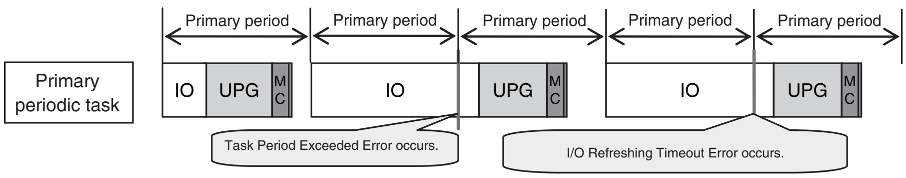
| Error name | Error level | Correction |
|---|---|---|
| Task Execution Timeout Error | Major fault | Review the task settings and download the user program again.<br>The power supply must be cycled or the CPU Unit reset. |

## I/O Refreshing Timeout Error

An I/O Refreshing Timeout Error occurs when I/O refreshing is not completed within the period twice in a row.

This is a major fault level Controller error. Execution of the user program stops when the error occurs.

This error occurs only for the primary period task and, if I/O refreshing is set, the priority-16 period task.




### ● I/O Refreshing Timeout Error

| Error name | Error level | Correction |
|---|---|---|
| I/O Refreshing Timeout Error | Major fault | Review the task settings and download the project again.<br>The power supply must be cycled or the CPU Unit reset. |

## Insufficient System Service Time Error

An Insufficient System Service Time Error occurs if the time that is specified in the time that is set for the system service monitoring setting cannot be obtained.
This is a major fault level Controller error. Execution of the user program stops when the error occurs.

### ● Insufficient System Service Time Error

| Error name | Error level | Correction |
|---|---|---|
| Insufficient System Service Time Error | Major fault | Review the task settings and the system service monitoring settings and download the project again.<br>The power supply must be cycled or the CPU Unit reset. |

# 5-2-12 Monitoring Task Execution Status and Task Execution Times

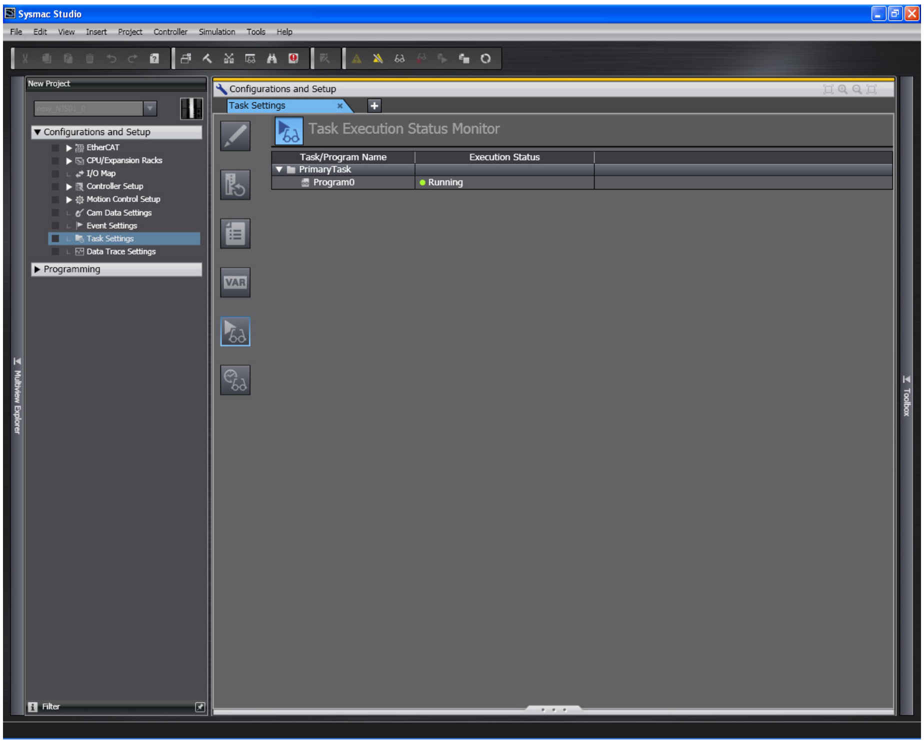
You can use online operations from the Sysmac Studio to monitor the task execution status and task execution times.

## Monitoring Task Execution Status

You can monitor the execution status of the programs in all of the tasks (started/stopped) from the Sysmac Studio.

### ● Sysmac Studio Operation

Place the Sysmac Studio online with the CPU Unit and select **Task Settings** – **Task Execution Status Monitor**. The following tab page is displayed.



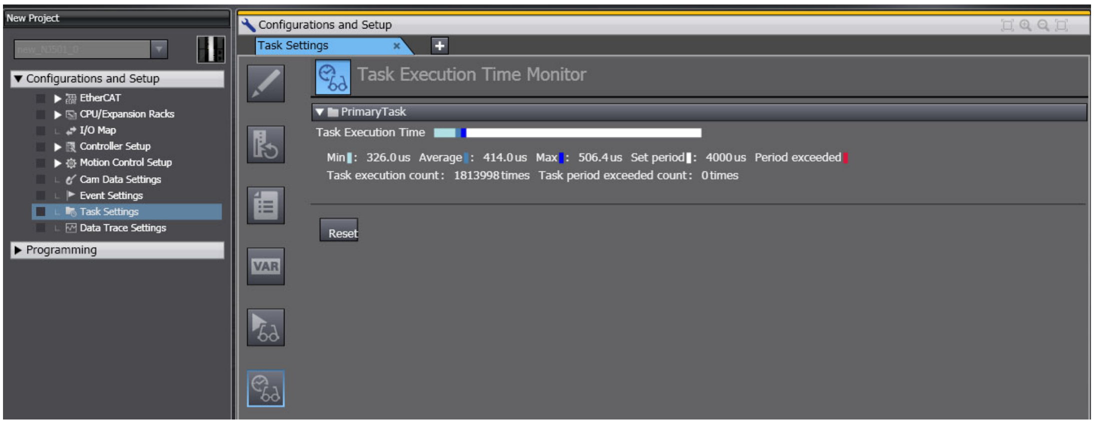
## Task Execution Time Monitor

You can monitor the execution time of each task from the Sysmac Studio.

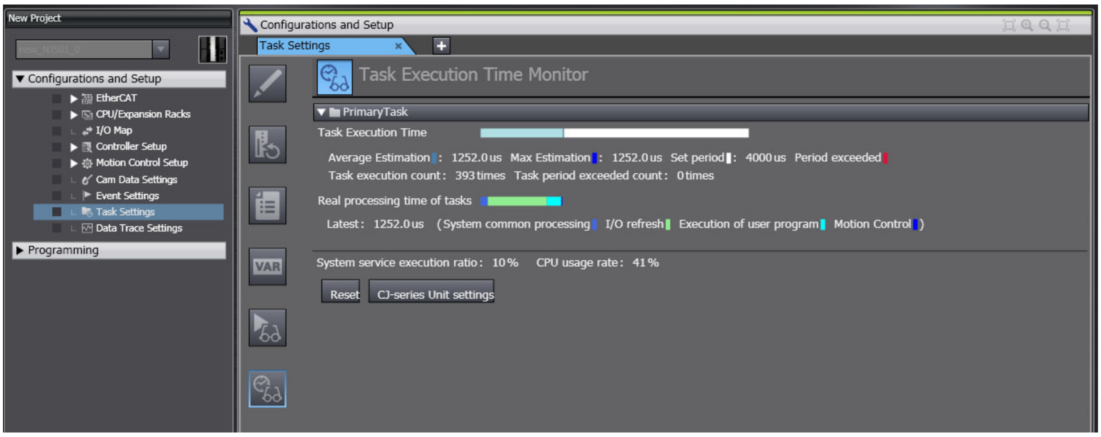
### ● Values You Can Monitor from the Sysmac Studio

Connect online to the CPU Unit from the Sysmac Studio and click the Task Execution Time Monitor Button on the Task Settings Tap Page. The following display appears.
The items that you can monitor depends on whether you connect to the physical Controller or to the Simulator.

#### Connected to the Controller




#### Connected to the Simulator

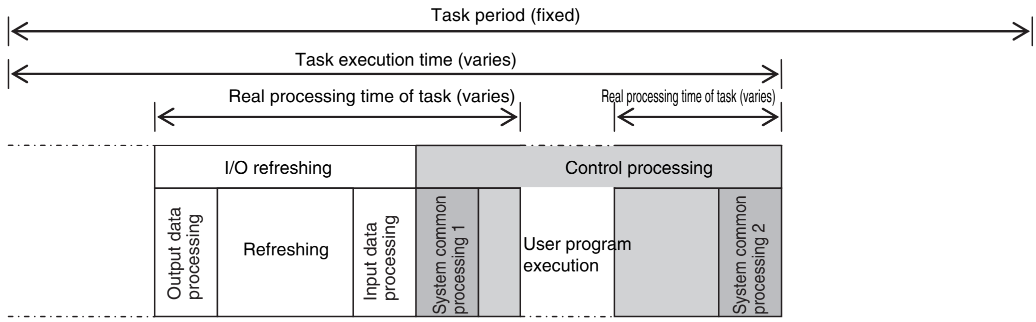


You can monitor the following items.

| Monitor item | | Description | Connected to the Controller | Connected to the Simulator |
|---|---|---|---|---|
| Task execution time*1 | Min. | The minimum value of the task execution time. | Displayed. | Not displayed. |
| | Average | The maximum value of the task execution time. | | Displayed. |
| | Max. | The maximum value of the task execution time. | | |
| Set period | | The specified task period. | | |
| Period exceeded | | If the task execution time exceeds the task period (i.e., if the Task Period Exceeded Flag system-defined variable is TRUE), the amount by which the time was exceeded is displayed in the bar. | | |
| Task execution count | | Displays the number of executions of the task. The value of the Task Execution Count system-defined variable is displayed. | | |
| Real processing time of tasks*2 | | The time ratios are displayed with bars for the system common processing, I/O refreshing, user program execution, and motion control processing. (Specific time values are not displayed.) | None | Displayed. |
| | Average estimation | The estimated average value of the real processing time of task is displayed. | | |
| | Max estimation | The estimated maximum value of the real processing time of task is displayed. | | |

*1 This is the actual time required from the point that task execution was started until it was completed. This interval includes both the time to execute other tasks and the time for system services that were executed from when task execution was started until it was completed.

*2 This interval is the time required to execute only the task itself. It is the same as the task execution time for the primary periodic task. For periodic tasks, this is the task execution time minus the time to execute other tasks and the time for system services that were executed between the point that the execution condition is met until execution is completed.




### Precautions for Correct Use

The above values when connected to the Simulator of the Sysmac Studio may contain more error in comparison to the times when connected to the physical Controller. Use them as guidelines. Always confirm operation while connected to the physical Controller to study the designs and before starting actual system operation.

# 5-3 Task Design Example and I/O Response Times

This section provides information on estimating task execution times, information on confirming system service monitoring settings, an example of task designing, and information on I/O response times.

The primary periodic task and periodic tasks of an NJ-series CPU Unit operate according to the specified task periods. If the actual execution time exceeds the task period, an error occurs.

This section uses an example that consists of one primary periodic task to describe estimation and appraisal methods.

**Precautions for Safe Use**

The execution times in the physical Controller depends on the logic operations that are performed in the user program, the presence of communications commands and data links, on whether data tracing is performed, and on other factors. Before starting actual operation, you must test performance under all foreseeable conditions on the actual system and make sure that the task periods are not exceeded and that suitable communications performance is achieved.

## 5-3-1 Checking the Task Execution Time

Always design your system so that the average and maximum task execution times that are estimated with the methods that are described in this section sufficiently fit within the specified task periods.

### ● Desktop Calculations

First, refer to *A-2 Calculating Guidelines for Task Execution Times* to make a rough estimate of the average task execution time on paper. You cannot estimate the maximum value on paper.

### ● Estimating with the Simulator on the Sysmac Studio

Use the Task Execution Time Monitor of the Simulator on the Sysmac Studio to estimate the average and maximum task execution times. Use the following procedure to check operation on the Simulator.

1. Create the Unit and slave configurations, create the global variables and device variables, and create the axes (to create the Axis Variables).
2. Create the programs to check.
3. Set up the tasks and build the project.
4. Start the Simulator in Execution Time Estimation Mode.
5. Set the Expanded number of I/O points for CJ-series Unit parameter in the Task Execution Time Monitor to create user-defined variables for specified CJ-series Special Units and set the sizes of the expansion areas (e.g., fixed I/O allocation areas for the DeviceNet Master Unit) for AT specifications (i.e., the number of output words and the number of input words). These sizes are used to calculate the I/O refresh time for the specific Special Units.
6. Estimate the task execution times in the Task Execution Time Monitor.

You can check the following values in the Task Execution Time Monitor when you start the Simulator in Execution Time Estimation Mode.

- Values That You Can Monitor with the Task Execution Time Monitor in the Simulator

| Connected to the Simulator |
|---|
| • The average and maximum values of the task execution time<br>• Real processing time of task (estimated average values)<br>• System common processing time, I/O refreshing time, user program execution time, and motion control time (Bar graphs show the amount by which the task period is exceeded.)<br>• CPU usage |

**Additional Information**

You can check the following values when connected to the Simulator of the Sysmac Studio. You cannot check these values when connected to the physical Controller.

- CPU usage: Displays how much of the task period is used by the total of the maximum estimated task processing time and the system service processing time for the specified system service monitoring settings. If CPU usage exceeds 100%, it means that there is not sufficient time for task processing and the system service monitoring settings.
- Real processing time of tasks: This is the time that was required for the task from when task execution is started until it is completed. The time to execute other tasks that were executed from when task execution was started until it was completed is not included.

### ● Calculating Times on the Physical Controller

You can check the following values in the Task Execution Time Monitor when you are connected to the physical Controller.

| Connected to the Controller |
|---|
| • The minimum, average, and maximum values of the task execution time.<br>• The degree to which the period is exceeded and the task period exceeded count |

The maximum values that are displayed on the Sysmac Studio are the results of operation on the physical Controller. As described previously, the maximum value of the task execution time varies depending on the internal status of the physical Controller. As a result, the maximum values obtained here may be exceeded in actual operation. Use the following maximum values as guidelines.

| Estimated Maximum Values for Task Execution Times Based on Information from the Physical Controller |
|---|
| • Task period of 500 µs: Average value of task execution time + (Average value of task execution time – Minimum value of task execution time) + 100 µs<br>• Task period of 1, 2, or 4 ms: Average value of task execution time + (Average value of task execution time – Minimum value of task execution time) + 120 µs |

## 5-3-2 Checking the System Service Monitoring Settings

System services are executed during the unused time between executions of all of the tasks.

The CPU Unit monitors the percentage of the task period that is used for execution of system services based on the System Service Monitoring Settings in the Controller Setup. The system service execution times must be greater than the values in the System Service Monitoring Settings. If they are not, an Insufficient System Service Time Error occurs and user program execution is stopped. You must therefore ensure that there is sufficient time available.

In a configuration that consists of only a primary periodic task, the system service execution time is the task period minus the task execution time. By default, system service execution time is monitored at 10% of the task period. Therefore, you would design the system so that the average task execution time was less than 90% of the task period.

However, some system servicing is executed in parallel with task execution. Also, the task execution time varies greatly with the external environment. Therefore, you cannot judge system performance based on this one condition. Use it as a guideline.

## 5-3-3 Examples of Task Design

This section describes the steps that are required for an example that consists of one primary periodic task. In any actual application or for specific conditions, you may need to change the order of the design steps or consider different elements. This example is therefore for reference only.

1. Find the I/O response times that are required for the system from the equipment specifications.
2. From the system I/O response times, determine the task period for the primary periodic task.
3. See if the task execution time fits into the task period that you found in step 2, above.

   Then, work on paper or use the Task Execution Time Monitor of the Sysmac Studio to estimate the average and maximum values of the task execution time.
4. See if the system service times are within the monitor settings.

   If you use the Sysmac Studio, check the CPU usage.
5. Use the physical Controller to see if the task execution time fits into the task period.

   Place the Sysmac Studio online with the physical Controller and use Task Execution Time Monitor to check the task execution times.

### ● If it is necessary to alter the user program, consider the following corrections for the task configuration.

- Separating a task
- Changing program assignments
- Changing the task period

### ● If a task is separated, the periodic task will vary greatly with the unused time for primary periodic task execution.

For a periodic task, use twice the average and maximum values calculated for the task execution time to set the task period and then fine-tune the setting from there.

## 5-3-4 System Input and Output Response Times

The times that are required for the system to produce an output after it receives an input are described in this section.

The I/O response times depend on various conditions.

The input response times and output response times between external devices and the slaves and Units must be added to the system I/O response times.

### Sequence Control with Basic I/O Units

Refreshing between Basic I/O Units and external devices is performed in the primary periodic task or the priority-16 periodic task.

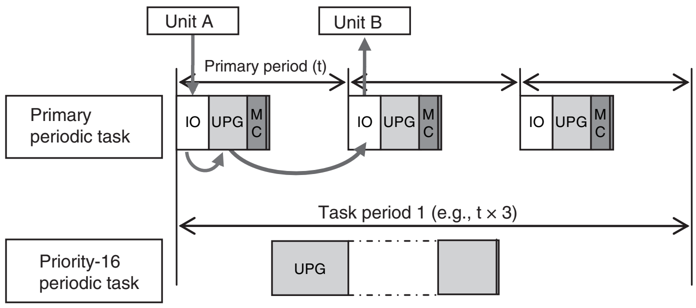
The I/O response times that include EtherCAT communications times are given below.

#### ● Performing Control with the Programs in the Primary Periodic Task

The Controller makes a response in the following I/O response time.

| Minimum I/O response time = Primary period |
| --- |

Example: Controlling Unit A and Unit B with the Primary Periodic Task




**Note:** The above diagram shows only one input and one output.

However, the I/O response time may be as follows depending on the timing of the input from the Unit.

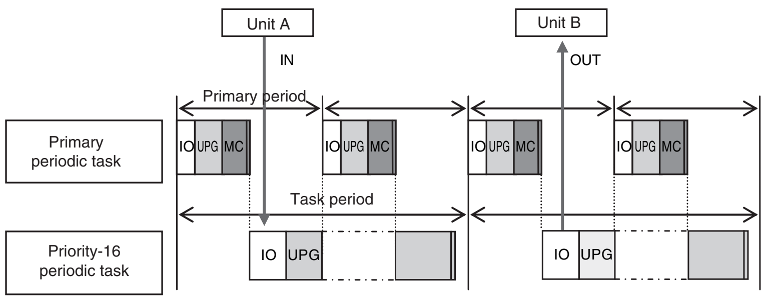
| Maximum I/O response time = Primary task period × 2 |
| --- |

#### ● Performing Control with the Programs in the Priority-16 Periodic Task

The Controller makes a response in the following I/O response time.

| Minimum I/O response time = Priority-16 periodic task period |
| --- |

Example: Controlling Unit A and Unit B with the Priority-16 Periodic Task




**Note:** The above diagram shows only one input and one output.

However, the I/O response time may be as follows depending on the timing of the input from the Unit.

| Maximum I/O response time = Priority-16 periodic task period × 2 |
| --- |

## Sequence Control with EtherCAT Slaves

For EtherCAT slaves, EtherCAT communications with external devices is performed for I/O refreshing in the primary periodic task.

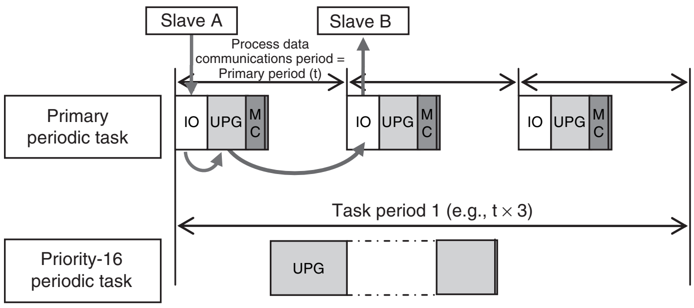
The I/O response times that include EtherCAT communications times are given below.

### ● Performing Control with the Programs in the Primary Periodic Task

The Controller makes a response in the following I/O response time.

| Minimum I/O response time = Primary period (= process data communications cycle) |
| --- |

Example: Controlling EtherCAT Input Slave A and EtherCAT Output Slave B with the Primary Periodic Task




**Note:** The above diagram shows only one input and one output.

However, the I/O response time may be as follows depending on the timing of the input from the slave.

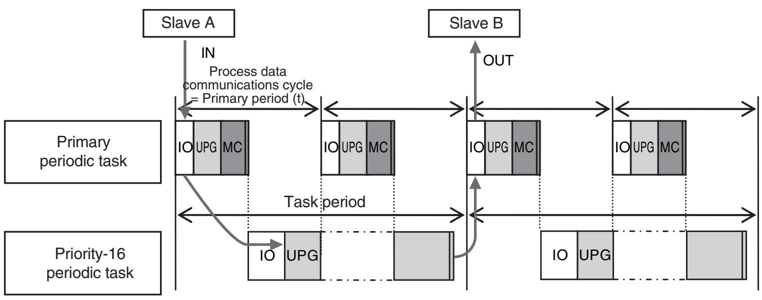
| Maximum I/O response time = Primary period (= process data communications cycle) × 2 |
| --- |

### ● Performing Control with the Programs in the Priority-16 Periodic Task

The Controller makes a response in the following I/O response time.

| I/O response time = Priority-16 periodic task period |
| --- |

Example: Controlling EtherCAT Input Slave A and EtherCAT Output Slave B with the Priority-16 Periodic Task




**Note:** The above diagram shows only one input and one output.

However, the I/O response time may be as follows depending on the timing of the input from the slave.

| Maximum I/O response time = Priority-16 periodic task period × 2 |
| --- |

## Performing Motion Control with Motion Control Instructions

Motion control instructions access the Servo Drives and encoder input slaves to which axes are assigned.

Motion control instructions can be used in the primary periodic task and in a priority-16 periodic task.

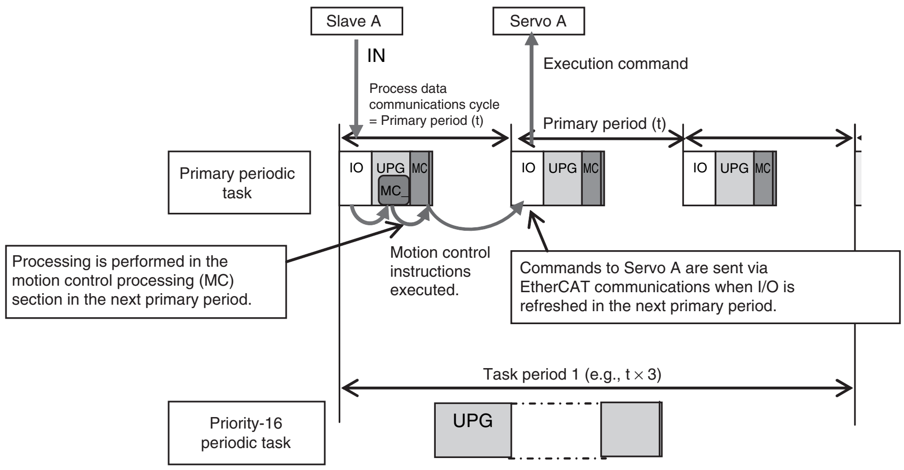
In either case, the motion control instructions are processed in the motion control processing (MC) section of the primary periodic task.

The I/O response times that include EtherCAT communications times are given below.

### ● Programming Motion Control Instructions in the Primary Periodic Task

The motion control instructions are processed in the next motion control processing (MC) section of the primary periodic task. The results of processing are output via EtherCAT communications to the Servo Drive to which the axis is assigned during the I/O refresh period in the next primary periodic task.
The Controller makes a response in the following I/O response time.

| I/O response time = Primary period (= process data communications cycle) |
|---|




**Note:** The above diagram shows only one input and one output.

However, the I/O response time may be as follows depending on the timing of the input from the slave.

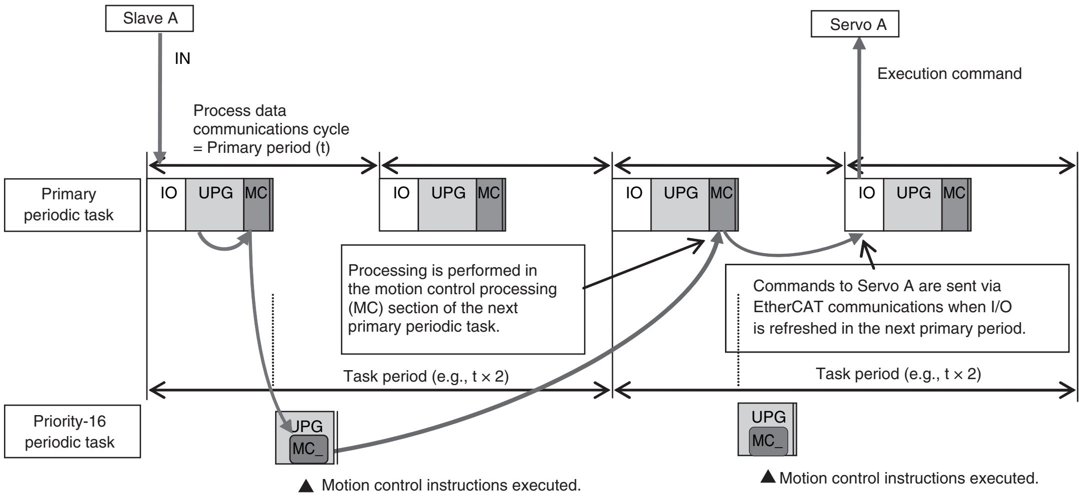
| Maximum I/O response time = Primary period (= process data communications cycle) × 2 |
|---|

### ● Programming Motion Control Instructions in the Priority-16 Periodic Task

The motion control instructions are processed in the next motion control processing (MC) section of the primary periodic task after the priority-16 periodic task. The results of processing are output via EtherCAT communications to the Servo Drive to which the axis is assigned during the I/O refresh period in the next primary periodic task.

The Controller responds in the following I/O response time regardless of the execution timing of the motion control instructions.

| Minimum I/O response time = Priority-16 periodic task period +<br>Primary period (= process data communications cycle) |
|---|

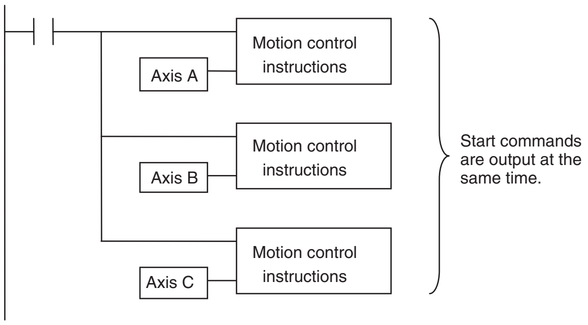



**Note:** The above diagram shows only one input and one output.

However, the response time may be as follows depending on the timing of the input from the slave.

| |
|---|
| Maximum I/O response time = Priority-16 periodic task period + Primary period (= process data communications cycle) × 2 |

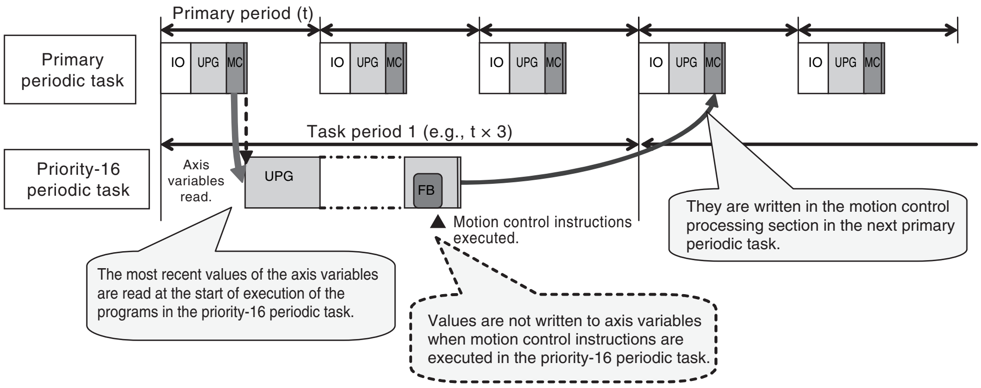
If more than one axis is controlled by the programs in the priority-16 periodic task, they can be started at the same time. (This is the same as controlling more than one axis in the primary periodic task.)



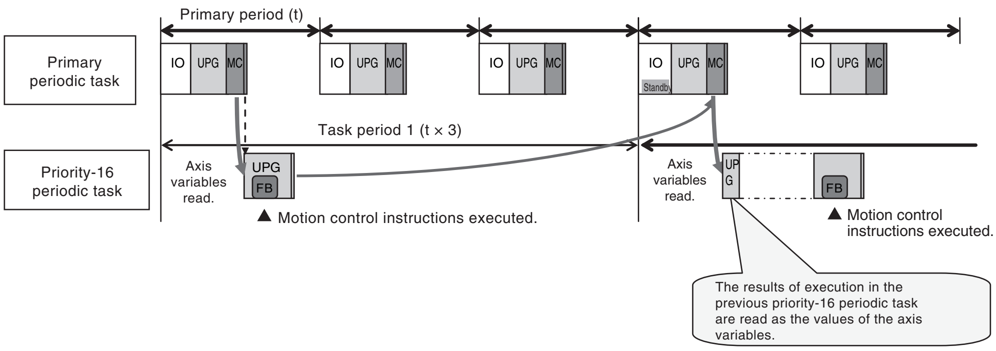
### Additional Information

**Reference: Reading the Values of Axis Variables in the Priority-16 Periodic Task**

- If an axis variable is read in the priority-16 periodic task, the most recent values of the axis variable when the program execution for the priority-16 periodic task started are read. These values show the results of motion control processing in the immediately proceeding primary periodic task.
- Values are not written to axis variables when motion control instructions are executed in the priority-16 periodic task. They are written in the motion control processing (MC) section of the next primary periodic task.




- The results of execution of motion control instruction in the previous priority-16 periodic task are read as the value of the axis variable in the next priority-16 periodic task.



# 6

# Programming

This section describes programming, including the programming languages, and the variables and instructions that are used in programming.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# 6-1 Overview of Programming Procedures

This section provides an overview of programming procedures.

The shaded steps in the overall procedure that is shown below are related to programming.

**Step 1. Software Design**

- Step 1-1 Designing I/O and Processing
- Step 1-2 Designing Tasks
- Step 1-3 Designing Programs

↓

**Step 2. Software Setups and Programming**

- Step 2-1 Slave and Unit Configurations
- Step 2-2 Controller Setup
- Step 2-3 Programming
- Step 2-4 Offline Debugging

↓

**Step 3. Mounting and Setting Hardware**

↓

**Step 4. Wiring**

↓

**Step 5. Confirming Operation and Starting Actual System Operation**

Refer to *1-3 Overall Operating Procedure for the NJ-series Controller* for details.

| POU (Program Organization Unit) Design | Reference |
|---|---|
| ● **Determine which processes to put into which POUs and design the POUs.**<br><br>**Note** Functions cannot contain function block instructions or function blocks. | *6-2 POUs (Program Organization Units)* |
| ● **Determine which languages, such as ladder diagrams, inline ST, and ST, to use to create each process.**<br><br>**Note** Inline ST is structured text that is written as an element of a ladder diagram. | *6-5 Programming Languages* |

| Variable Design | Reference |
|---|---|
| ● **Design the user-defined variables that you need to create.** | *6-3-1 Variables*<br>*6-3-2 Types of Variables* |
| ● **Separate variables into those that you use in more than one POU (global variables) and variables that you use in only specific POUs (local variables).** | *6-3-3 Types of User-defined Variables in Respect to POUs* |
| ● **Determine if you need to automatically generate the variable names for the device variables that you use to access slaves and Units or if you need to define them yourself.** | *2-2-2 Variables and I/O Assignments* |
| ● **Design the attributes for the variables.**<br>Variable Name, Data Type, AT Specification, Initial Value, Retain, Constant, and Network Publish<br>Decide the data types of your variables (including array specifications, range specifications, structures, and enumerations). | *6-3-4 Attributes of Variables*<br>*6-3-5 Data Types*<br>*6-3-6 Derivative Data Types* |
| ● **Keep the following precautions in mind when you design variables.**<br>• Retention:<br>Set the Retain attributes to determine the values that are used for variables when the power supply is turned ON or when the operating mode changes.<br>• Structures:<br>When a structure is used for a variable in an instruction, design the program to use the same structure data type for the input parameter, output parameter, or in-out parameter.<br>Example: Communications Instructions<br>• Array Specifications:<br>When an array variable is used for the variable for an instruction, design the program to use an array variable for the input parameter, output parameter, or in-out parameter.<br>Examples: Shift Instructions, Stack Instructions, and Table Instructions<br>• AT Specifications:<br>Use AT specifications for the variables used for input parameters to certain instructions.<br>Example: Fixed or user I/O allocations for DeviceNet Units<br>• Network Publishing:<br>Design the variables for EtherNet/IP tag data links. | *6-3-4 Attributes of Variables*<br>*6-3-5 Data Types*<br>*6-3-6 Derivative Data Types* |

# 6-2 POUs (Program Organization Units)

The user program that runs on an NJ-series CPU Unit is made from a combination of POUs (program organization units).
This section describes the configuration and specifications of POUs.
Refer to the *Sysmac Studio Version 1 Operation Manual* (Cat. No. W504) for details on creating POUs in the Sysmac Studio.

## 6-2-1 What Are POUs?

A POU (program organization unit) is a unit that is defined in the IEC 61131-3 user program execution model. A POU includes a local variable table and an algorithm (i.e., a series of code or logic). It is the basic unit used to build the user program.
You combine POUs to build a complete user program.

There are three types of POUs, as described below.

- Programs
  A program corresponds to a main routine. It is the main type of POU that is used for algorithms.
  You can place any instruction, function, or function block in the algorithm of a program.
- Function Blocks (FBs)
  A function block can output different values even with the same inputs. Function blocks are executed when they are called from a program or another function block.
- Functions (FUNs)
  A function always outputs the same values for the same inputs. Functions are executed when they are called from a program, another function, or a function block.

The POUs consists of a combination of these three types of POUs. You can create many POUs.
You assign the programs to tasks to execute them.

## 6-2-2 Overview of the Three Types of POUs

### Programs

#### Executing Programs and Execution Conditions

- You execute a task to execute the programs that are assigned to that task.
- Programs are always executed.

#### Notation

- The POUs must include at least one program. You can assign up to 128 programs to a single task.

### Function Blocks (FBs)

#### Executing Function Blocks and Execution Conditions

- You can call function blocks from programs or other function blocks to execute them.
- Function blocks are always executed.
- If you want a function block to execute only when a condition is met, you must define an input variable that sets the execution condition.

#### Notation

- You can use any instruction, user-defined function, or user-defined function block in the algorithm of a function block.
- You can retain the values of internal variables. Therefore, you can retain status, such as for timers and counters.
- There are both user-defined and system-defined function blocks.
  User-defined function blocks are called user-defined function blocks. System-defined function blocks are sometimes called FB instructions.

For details on function blocks, refer to *6-2-5 Details on Function Blocks*.

### Functions

#### Executing Functions and Execution Conditions

- You can call functions from programs, other functions, or function blocks to execute them.
- The *EN* input variable specifies the execution condition. A function is executed only once each time *EN* changes to TRUE.

#### Notation

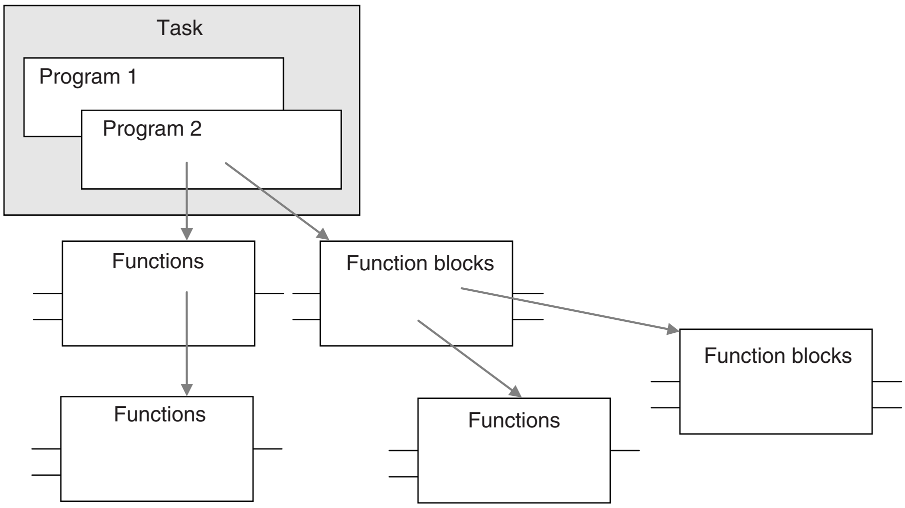
- You cannot use FB instructions or user-defined function blocks in algorithms.
- The values of internal variables are not retained. Therefore, the output value remains constant.
- There are both user-defined and system-defined function blocks.
  User-defined functions are called user-defined functions. System-defined functions are sometimes called FUN instructions.

For details on functions, refer to *6-2-6 Details on Functions*.

## 6-2-3 Differences between Programs, Functions, and Function Blocks

| Item | POU type | Programs | Function blocks | Functions |
|---|---|---|---|---|
| **Execution method** | | Executed upon execution of assigned task. | Called from a program or another function block. | Called from a program, function, or function block. |
| **Algorithm** | **Any instructions** | Supported. | Supported. | Not supported. |
| | **User-defined functions** | Supported. | Supported. | Not supported. |
| | **User-defined function blocks** | Supported. | Supported. | Not supported. |
| **Execution condition** | | Executed each period. | Executed each period.<br>Specify the execution condition with an input variable. | Specify the execution condition with the EN input. |

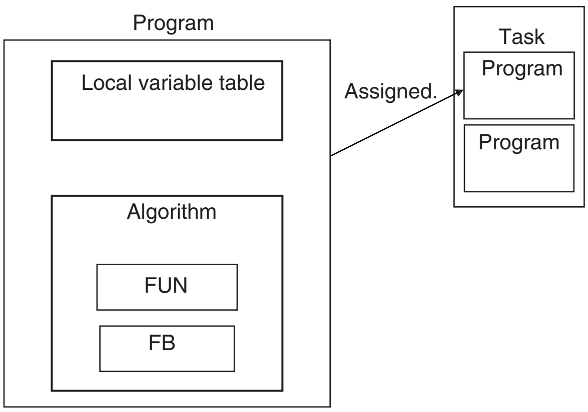
The hierarchical relationships between programs, functions, and function blocks are shown in the following figure.




## 6-2-4 Details on Programs

### Program Structure

Programs consist of a local variable table and an algorithm.
You can use any function or function block in the algorithm of a program.




You cannot call programs from other POUs.

## Program Execution Conditions

Programs are executed when the task they are assigned to is executed.

### Order of Execution

You can set the order of execution of all programs in a task. You specify this order under **Task Setup** – **Program Assignments** in the Sysmac Studio.

### Related System-defined Variables

Programs all have the following system-defined variables in the local variables (i.e., internal variables).

| Variable name | Meaning | Function | Data type | Read/write |
|---|---|---|---|---|
| P_First_Run Mode | First RUN Period Flag | TRUE for one period when PROGRAM mode changes to RUN mode.<br>Use this flag to perform initial processing when the CPU Unit begins operation. | BOOL | Read |
| P_PRGER | Instruction Error Flag | This flag changes to and remains TRUE when an instruction error occurs. After this flag changes to TRUE, it stays TRUE until the program changes it back to FALSE. | BOOL | Read/write |
| P_CY | Carry Flag | This flag is updated by some instructions. | BOOL | Read |

# 6-2-5 Details on Function Blocks

## Procedure to Create Function Blocks

A function block consists of a function block definition that is made in advance and instances that are used in the actual programs. Create function blocks in the following order.

1. Creating the Function Block Definition

   Create the algorithm.

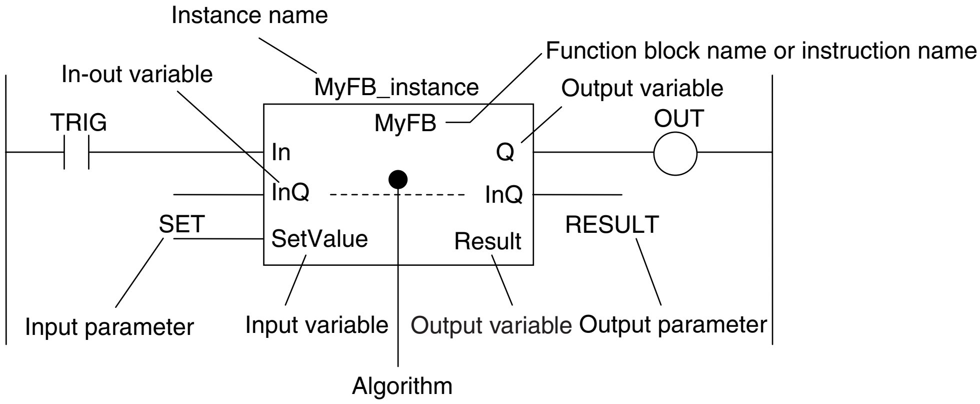
2. Placing an Instance of the Function Block Definition in a Program

   Call the function block definition from a program or another function block.
   You can call the same function block definition from more than one program or function block.
   After you place an instance of a function block definition in a program or in another function block, you can manipulate and execute it as an independent entity.

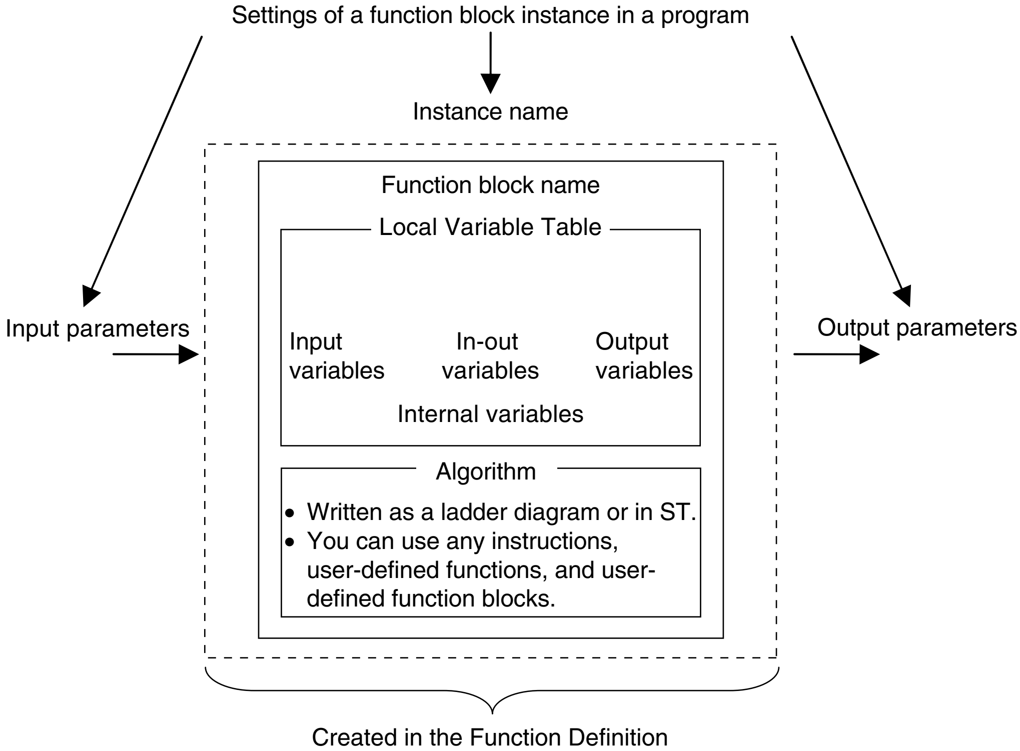
## Structure of Function Blocks

In a ladder diagram, function blocks are represented as rectangular boxes as shown below. Refer to the *Expressing Functions in ST* on page 6-18 for details about how to express function blocks in ST.
Function blocks consist of the following parts.

- Function Block in Ladder Diagram:




- Function Block Settings
  When you create an instance of a function block definition, make the following settings.




### ● Function Block Name or Instruction Name

This is the function block name or instruction name assigned in the function block definition when the function block is created.

### ● Instance Name

You give an instance name to a function block instance in a program to enable managing it. You specify an instance name when you call a function block definition from a program or another function block.

### Algorithm

You can code the algorithm either as a ladder diagram or in ST. You can use any instruction, user-defined function, or user-defined function block in the algorithm.

### Local Variable Table

The local variable table is used to define input variables, output variables, in-out variables, internal variables, and external variables.
Refer to *Variable Designations for Function Blocks* on page 6-11 for details.

### Parameters

**Input Parameters to Input Variables**

An input parameter passes a value to an input variable in a function block when function block execution begins. An input parameter can be either a variable or a constant.

**Output Parameters from Output Variables**

An output parameter receives a value from an output variable in a function block when function block execution is completed. A variable is given as the parameter.

**In-Out Parameters Shared between In-Out Variables**

The value of the in-out parameter changes within the function block. The same variable is used for both the input and output.

**Additional Information**

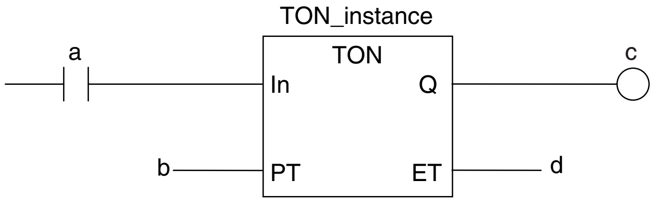
You can omit input and output parameters. Refer to information on operation when parameters are omitted in *6-2-7 Operation That Applies to Both Functions and Function Blocks* for details.

## Calling Function Blocks from ST

The following example shows how to call function blocks from ST.

*instance_name(input_variable_1:=input_parameter_1, ... input_variable_N:=input_parameter_N,in-out_variable_1:=in-out_parameter_1, ... in-out_variable_N:=in-out_parameter_N,output_variable_1=>output_parameter_1, ... output_variable_N=>output_parameter_N);*

You can also omit input variable names and other variable names, and give only the parameters. (If you do, the parameters must be given in the order that they are given in the function block definition.) Also, the number of parameters must match the number of input variables and other variables in the function block definition.



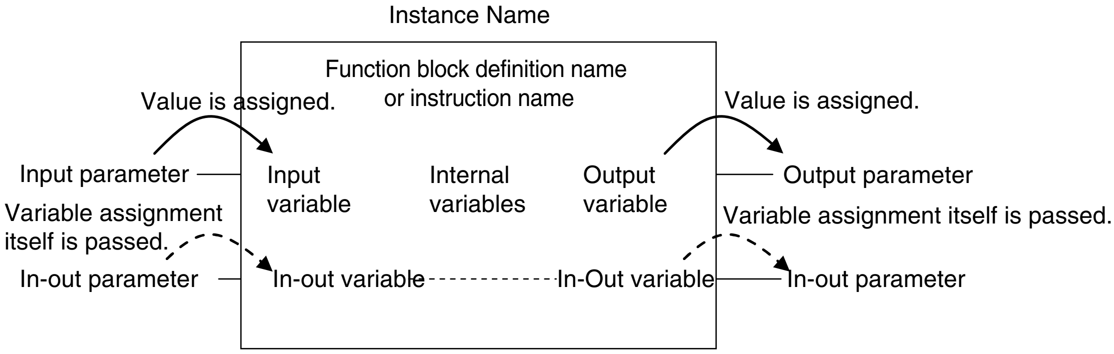

Function Blocks Expressed in ST:

Instance name

```
TON_instance(In:=a, PT:=b, Q=>c, ET=>d);
TON_instance(In:=a, PT:=b, Q=>c); (*The ET output is omitted here.*)
TON_instance(a,b,c,d); (*Input and output variables are omitted here.*)
```

Refer to *Function Block Calls* in *ST Language Statement* on page 6-94 for details.

## Variable Designations for Function Blocks




The specifications for variables in function blocks are given below.

| Variables | Number | Specification |
|---|---|---|
| **Input variables** | 1 to 64 | Input variables are used as input arguments within the function block. They cannot be changed inside the function block. |
| | | • When the function block is executed, the input variables are set to the values of the input parameters.<br>• You can specify either constants or variables for input parameters.<br>• Omitting Input Parameters:<br>Refer to information on operation when parameters are omitted in *6-2-7 Operation That Applies to Both Functions and Function Blocks*.<br>• At least one BOOL input variable is required.<br>• You can specify to detect when the variable changes to TRUE or changes to FALSE.<br>• You can access the values of input variables from outside of the function block. Access these values with the following format: *InstanceName.InputVariableName*. However, you cannot write values directly to an input variable. |
| **Output variables** | 1 to 64 | Output variables are used as output arguments from the function block. |
| | | • The output parameters are set to the values of the output variables at the end of function block execution.<br>• You cannot specify a constant for an output parameter. You must specify a variable.<br>• At least one BOOL output variable (including *ENO*) is required.<br>• You can omit output parameter connections. If you omit an output parameter, the value of the output variable is not assigned to any parameter.<br>• You can access the values of output variables from outside of the function block. Access these values with the following format: *InstanceName.OutputVariableName*. However, you cannot write values directly to an output variable. |
| **In-out variables** | 0 to 64 | In-out variables are used as inputs to and outputs from the function block. They can be changed inside the function block. |
| | | • The value of an in-out parameter is passed to an in-out variable and the value of the in-out variable is then passed to the in-out parameter.<br>• You cannot specify a constant for an in-out parameter. You must specify a variable.<br>• If you change the value of an in-out variable within a function block, the value of the in-out parameter changes at that time.<br>• You cannot omit in-out parameters. |

| Variables | Number | Specification |
|---|---|---|
| **Internal variables** | No limit | Internal variables are used for temporary storage within a function block. |
| | | • The values of internal variables are retained regardless of whether the function block is executed.<br>• Internal variables can have Retain attributes.<br>• You cannot access the values of internal variables from outside of the function block. |
| **External variables** | No limit | External variables are used to access global variables. |
| **EN** | 0 | An *EN* variable cannot be used in a function block. (This applies to both user-defined function blocks and FB instructions.) |
| **ENO** | 0 or 1 | Generally, this is a BOOL output variable that is set to TRUE for a normal end, and to FALSE for an error end. |
| | | • You can also omit it for some FB instructions.<br>• Refer to *ENO*, below, for details. |

Refer to *6-3-4 Attributes of Variables* on setting variable attributes.

**Additional Information**

If you define an external variable with the same name as a global variable in a function block, it is defined automatically based on that global variable.

## ● ENO

- When *ENO* is FALSE, the previous values of all other output variables are retained.

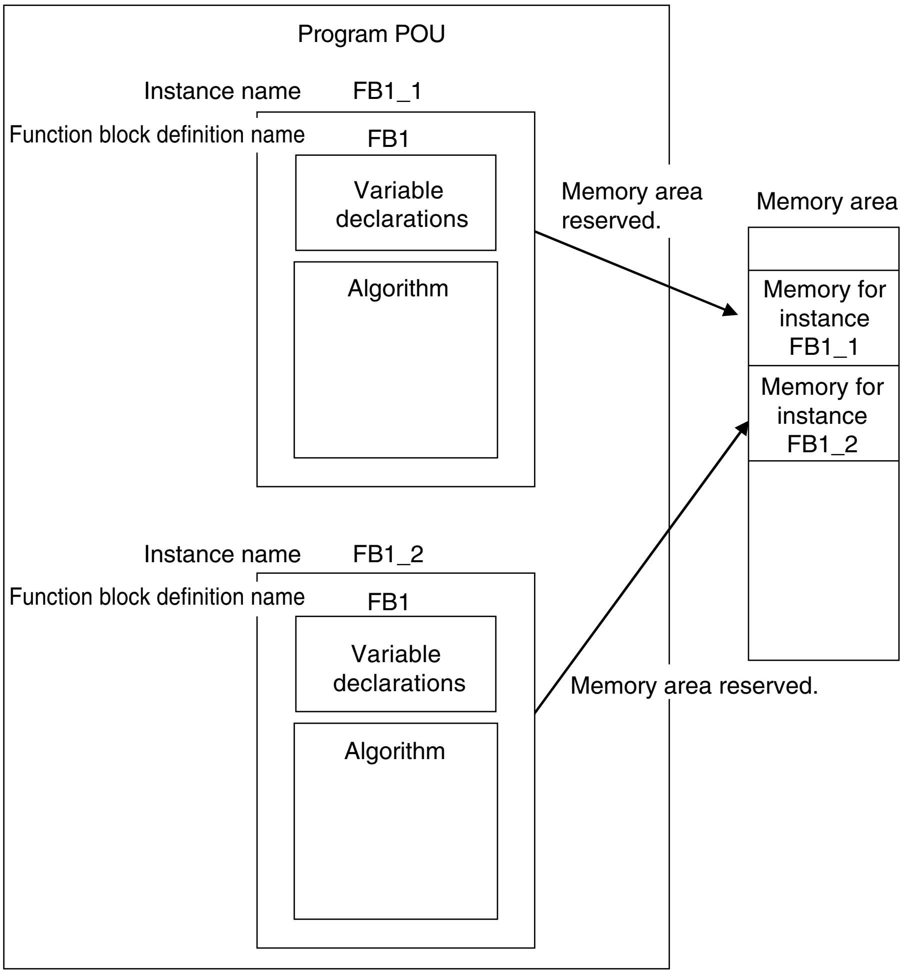
## Function Block Definitions and Instances

A function block consists of a function block definition that is made in advance and instances that are then used in the actual programs. All instances of a function block are based on the function block definition.
A function block definition consists of an algorithm and a local variable table.

### ● Function Block Instance

When you place an instance of a function block definition in a program or another function block, the function block definition is treated as a part of that program or function block.
Function block definitions that are called from a program or another function block are called instances.
Every instance of a function block has an identifier known as an instance name associated with it, and every instance uses memory.

You can create instances of a function block definition to process different I/O data in the same way.

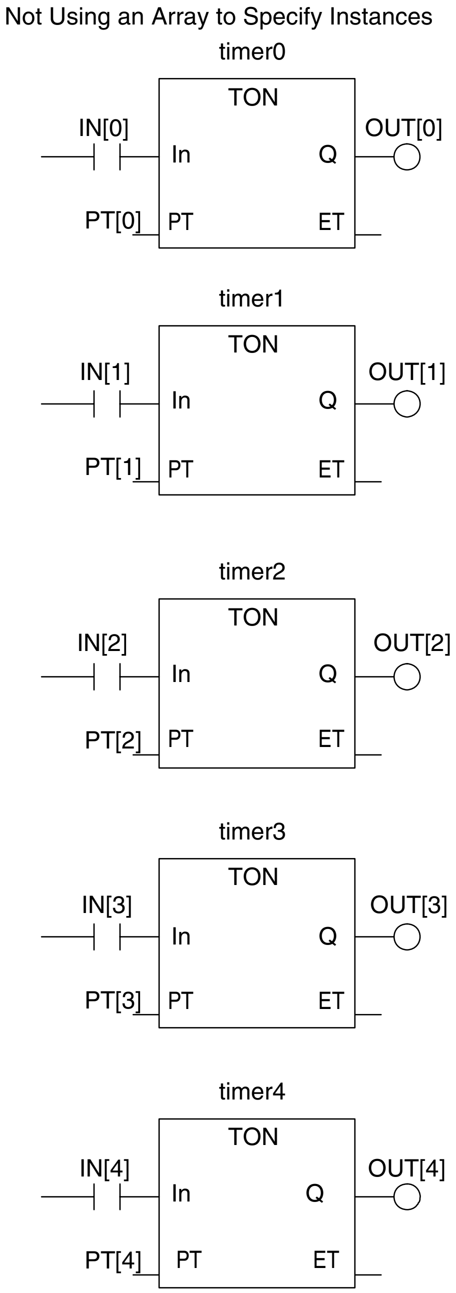


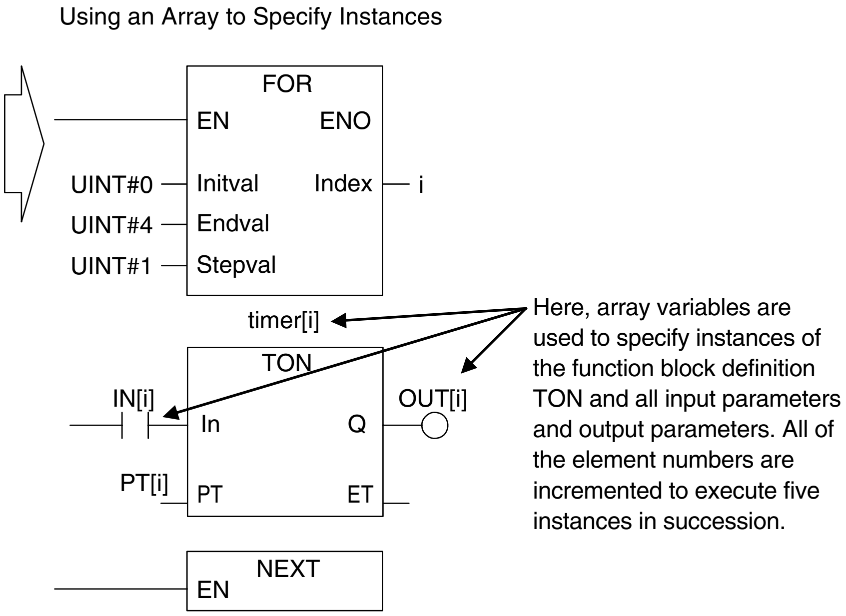

Instances cannot be read from other programs or function blocks. If an instance with the same name as another instance is placed in a different program or another function block, that instance will operate as a completely separate instance.

### Array Specifications for Instances

Array specifications can be made for instances. You can indirectly specify an array element number with a variable to execute multiple instances with one instance name. Furthermore, you can switch input sources and output destinations and effectively execute multiple instances with a single instance name if you use an array specification for the input parameter and output parameter and specify the element numbers with the same variable.

Example:




Variable Table

| Variable name | Data type |
|---|---|
| IN | ARRAY [0..4] OF BOOL |
| OUT | ARRAY [0..4] OF BOOL |
| PT | ARRAY [0..4] OF TIME |
| timer | ARRAY [0..4] OF TON |
| i | UINT |

## Execution Conditions for Function Blocks

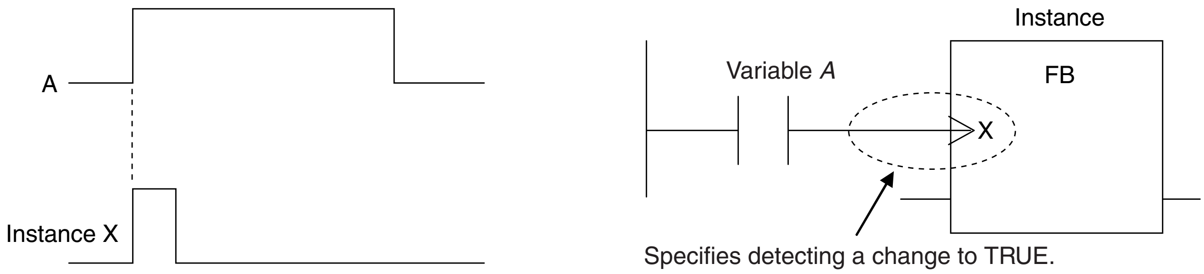
Function blocks do not have an EN input like functions. They are executed each period.

### Processes That Require Constant Data Monitoring

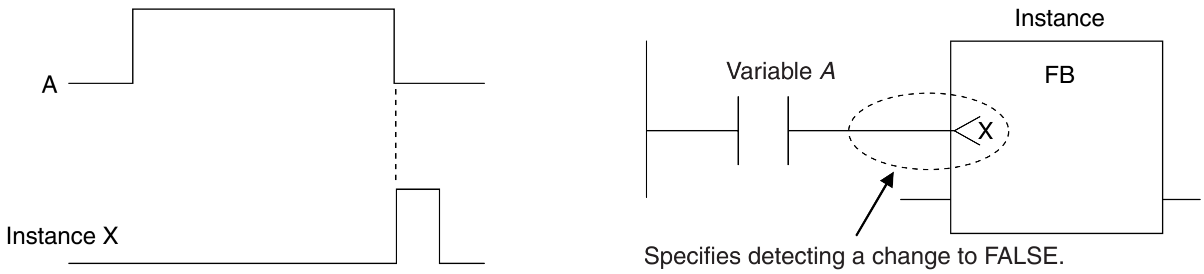
| Case | Algorithm in FB | | ENO | Operations other than ENO |
|---|---|---|---|---|
| Normal operation | Executed. | Normal end | TRUE | Output parameters: Values are updated according to the internal algorithm.<br>In-out parameters: Values are updated according to the internal algorithm. |
| | | Error end | FALSE | Output parameters: Retained<br>In-out parameters: Values are updated according to the internal algorithm. |
| Inside a master control region | Executed when the state of the power flow input is FALSE. | | User-specified | One of the above, depending on the value of ENO. |

Refer to *6-5-2 Ladder Diagram Language* for details on power flow output and parameter output.

You can specify the edge for an input variable to make the variable TRUE only when the input parameter changes to TRUE.




You can specify falling edges too.



## Accessing Variables in a Function Block from Outside the Function Block

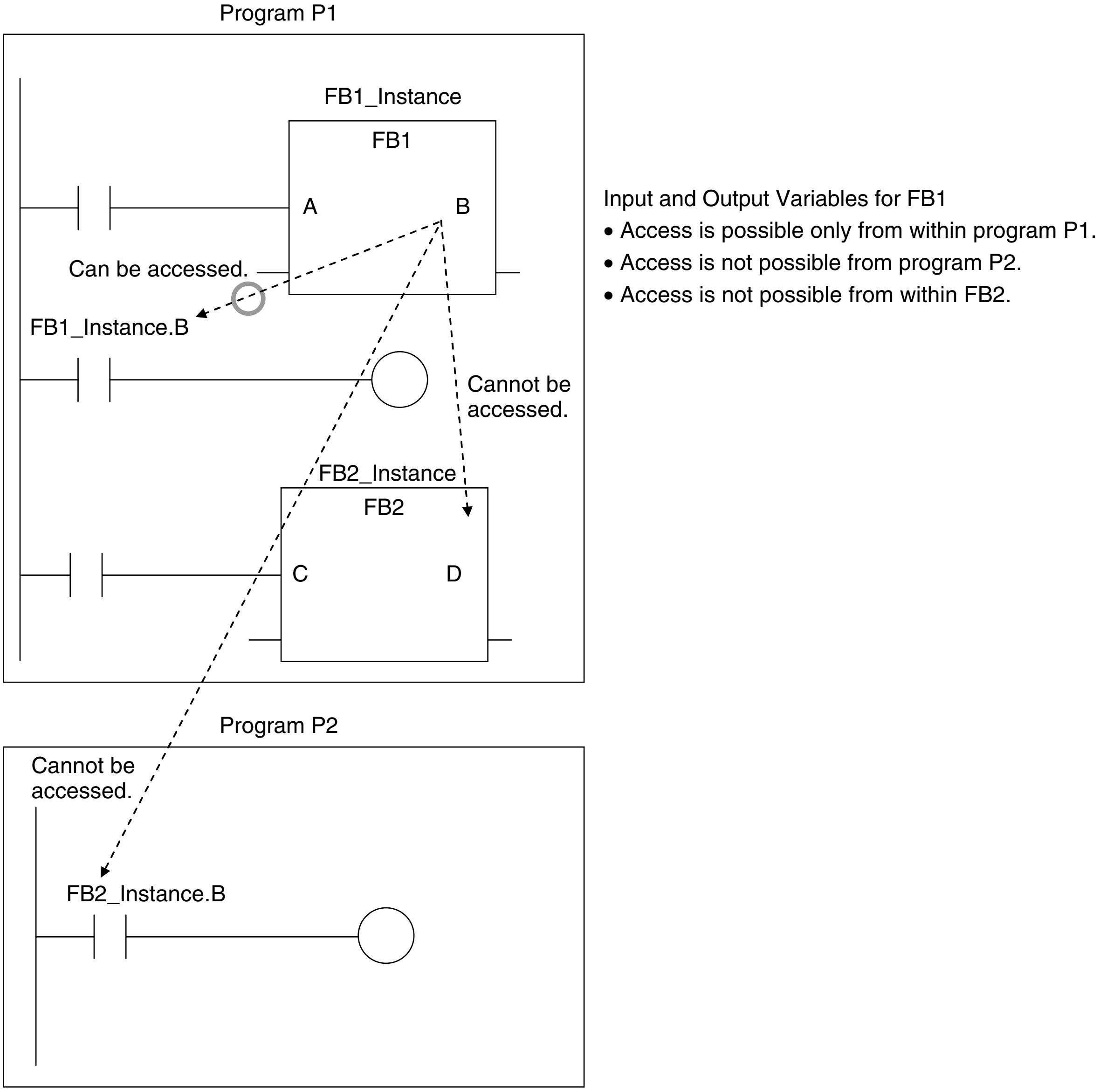
You can access the input and output variables of a function block from outside the function block. Variables are written as follows:

*InstanceName.VariableName*

Example: To Access Output Variable B of Function Block Instance *FB1_Instance*

FB1_Instance.B

You can access the input and output variables for a function block only within the program that contains the function block. However, you cannot access these variables from within other function block instances even if they are in the same program. You cannot access them from other programs.



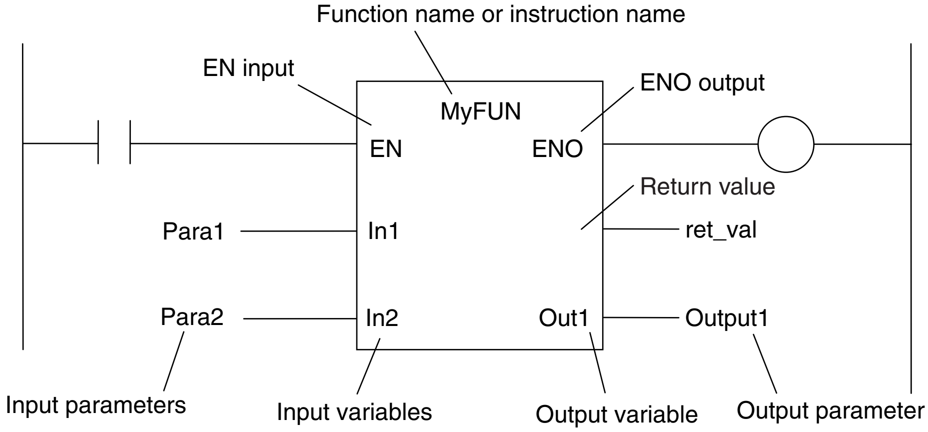

The in-out variables, and input variables for some instructions, cannot be accessed from external devices.
Refer to the *NJ-series Instructions Reference Manual* (Cat. No. W502) for details.

## 6-2-6 Details on Functions

### Structure of Functions

In a ladder diagram, functions are represented as rectangular boxes as shown below. Refer to *Expressing Functions in ST* on page 6-18 for details about how to express functions in ST. A function consists of the following parts.

Function in Ladder Diagram:




#### Function Name or Instruction Name

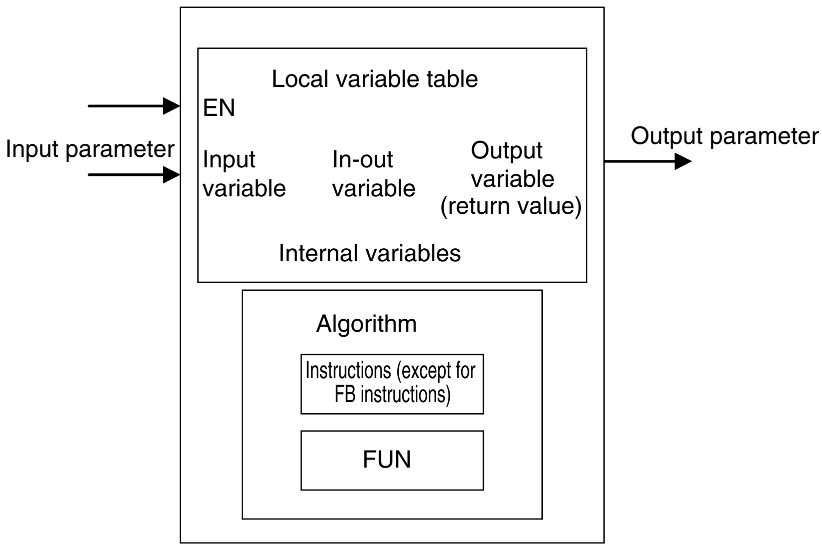
This is the function name or instruction name assigned in the function definition when the function is defined.

#### Instance Name

Functions do not have instance names.

#### Algorithm

You can code the algorithm either as a ladder diagram or in ST. You can use any instructions, functions, or user-defined functions in the algorithm of a function. You cannot use any FB instructions or user-defined function blocks. You also cannot use a differentiated instruction (e.g., R_TRIG or UP).



### ● Local Variable Table

A local variable table defines the input variables, output variables, in-out variables, internal variables, and external variables.

Refer to *Variable Designations for Functions* below for details.

### ● Parameters

**Input Parameters to Input Variables**

An input parameter passes a value to an input variable in a function when function execution begins. An input parameter can be either a variable or a constant.

**Output Parameters from Output Variables**

An output parameter receives a value from an output variable in a function when function execution is completed. A variable is given as the parameter.

**In-Out Parameters Shared between In-Out Variables**

The value of the in-out parameter changes within the function. The same variable is used for both the input and output.

## Expressing Functions in ST

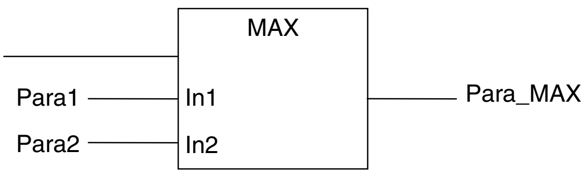
The following example shows how to call functions from ST.

*return_value:=function_name (input_variable_1:=input_parameter_1, ... input_variable_N:=input_parameter_N,in-out_variable_1:=in-out_parameter_1, ... in-out_variable_N:=in-out_parameter_N,output_variable_1=>output_parameter_1, ... output_variable_N=>output_parameter_N);*

However, you can also omit the return value.

You can also omit input variable names and other variable names, and give only the parameters. (If you do, the parameters must be given in the order that they are given in the function definition.) Also, the number of parameters must match the number of input variables and other variables in the function definition.

Functions Expressed in ST:



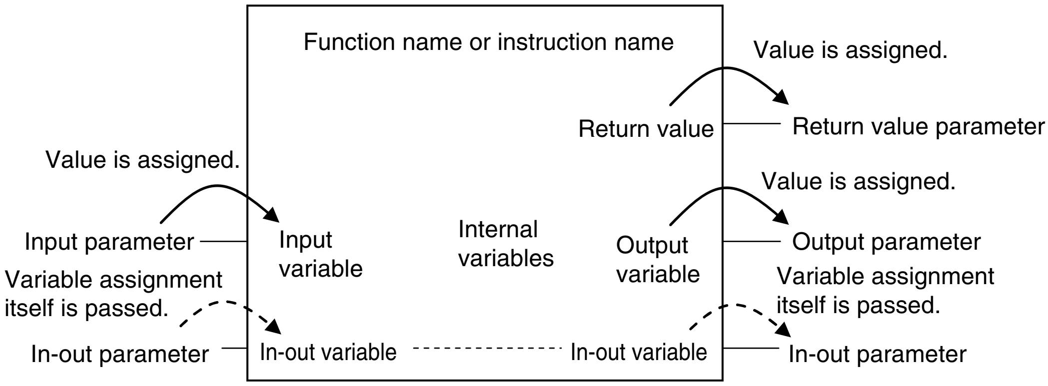

Function name

Para_MAX := MAX(In1:=Para1, In2:=Para2);

Para_MAX := MAX(Para1, Para2); (*The input variables are omitted here.*)

Refer to *Function Calls* in *ST Language Statements* on page 6-97 for details.

## Variable Designations for Functions




The specifications for variables in functions are given below.

| Variables | Number | Specification |
|---|---|---|
| **Input variables** | 0 to 64 | Input variables are used as input arguments within the function. They cannot be changed inside the function. |
| | | • When the function is executed, the input variables are set to the values of the input parameters.<br>• You can specify either constants or variables for input parameters.<br>• Omitting Input Parameters:<br>Refer to information on operation when parameters are omitted in *6-2-7 Operation That Applies to Both Functions and Function Blocks*.<br>• Unlike function blocks, you cannot specify to detect changes to TRUE or FALSE.<br>• You cannot access the values of input variables from outside of the function.<br>• Some of the instructions provided by OMRON can have varying numbers of input variables, but you cannot make a user-created function that has a varying number of input variables. |
| **Output variables** | 0 to 64 | Output variables are used as output arguments from the function. |
| | | • The output parameters are set to the values of the output variables at the end of function execution.<br>• You cannot specify a constant for an output parameter. You must specify a variable.<br>• At least one BOOL output variable (including *ENO* and the return value) is required.<br>• You can omit output parameter connections.<br>If you omit an output parameter, the value of the output variable is not assigned to any parameter.<br>• You cannot access the values of output variables from outside of the function. |
| **In-out variables** | 0 to 64 | In-out variables are used as inputs to and outputs from the function. They can be changed inside the function. |
| | | • In-out parameters (variable designations) are directly passed to or received from the in-out variables.<br>• You cannot specify a constant for an in-out parameter. You must specify a variable.<br>• If you change the value of an in-out variable within a function, the value of the in-out parameter changes at that time.<br>• You cannot omit in-out parameters.<br>• You cannot access the values of in-out variables from outside of the function. |
| **Internal variables** | No limit | Internal variables are used for temporary storage within a function. |
| | | • The value is not retained after execution is completed.<br>• You cannot access the values of internal variables from outside of the function. |

| Variables | Number | Specification |
|---|---|---|
| **External variables** | No limit | External variables access global variables. |
| **EN** | 1 | This is a BOOL input variable used to execute the function. |
| | | • The function is executed when *EN* is TRUE.<br>• You must have one *EN* variable. (This applies to both user-defined functions and FUN instructions). |
| **ENO** | 0 or 1 | Generally, this is a BOOL output variable that is set to TRUE for a normal end, and to FALSE for an error end. |
| | | • You can omit the *ENO* variable from user-defined functions.<br>• Refer to *ENO*, below, for details. |
| **Return value** | 1 | The return value is the value that is returned from the function to the POU that called the function. |
| | | The return value is the value that is returned to the calling instruction. It represents the results of the process after the algorithm in the function is executed. |
| | | • Each function must have one return value.<br>• You can specify enumerations of all basic data types. You cannot specify an array, structure, or union.<br>• Refer to *Return Values*, below, for details. |

Refer to *6-3-4 Attributes of Variables* for details on setting variable attributes.

**Additional Information**

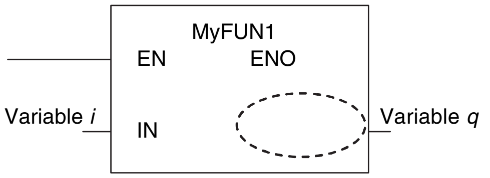
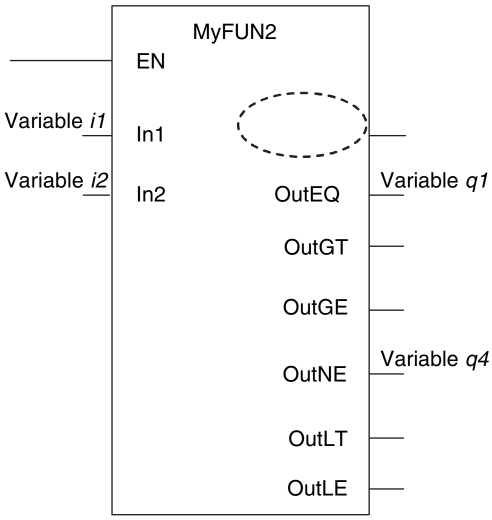
You can register global variables as external variables in a function variable table to access global variables. We recommend that you create your functions so that they produce output values uniquely based on their input parameter values. Algorithms that access global variables and use them to affect the output values are not recommended. When you check the program on the Sysmac Studio, a message will appear that says that it is not recommended to use global variables in functions. Take appropriate measures if necessary.

## ● ENO

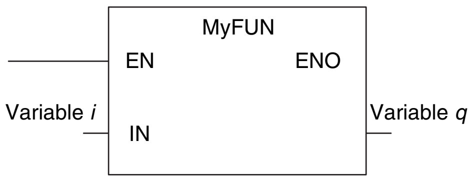
- When *ENO* is FALSE, the previous values of all other output variables are retained.

## Return Values

- Return values are blank in ladder diagrams.

| Case | Ladder diagram notation | ST language notation |
|---|---|---|
| **Using return values** |  | *variable_q*:=<br>MyFUN1(*variable_i*); |
| **Not using a return value** |  | MyFUN2(In1:=*variable_i1*,In2:=*v*<br>*ariable_i2*,<br>OutEQ=>*variable_q1*,<br>OutNE=>*variable_q4* ); |

- The calling instruction is not required to use the return value in either a ladder diagram or ST.
- If you set the return value within a function algorithm, set the value to a variable with the same name as the function.
  For example, the return value of a function called *MyFUN* is *MyFUN*.



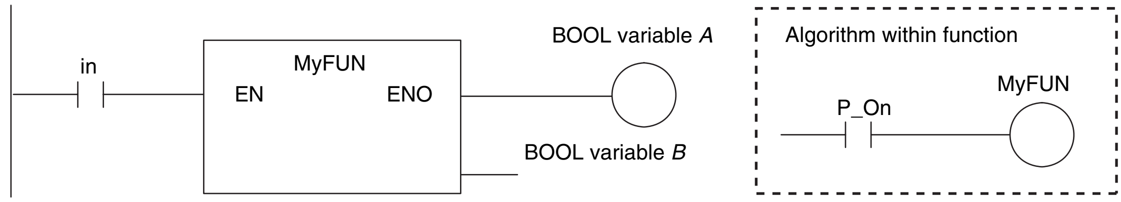

```
Definition of MyFUN

  IF IN>100
    MyFUN:=100;
  ELSE
    MyFUN:=IN;
  END_IF;
```

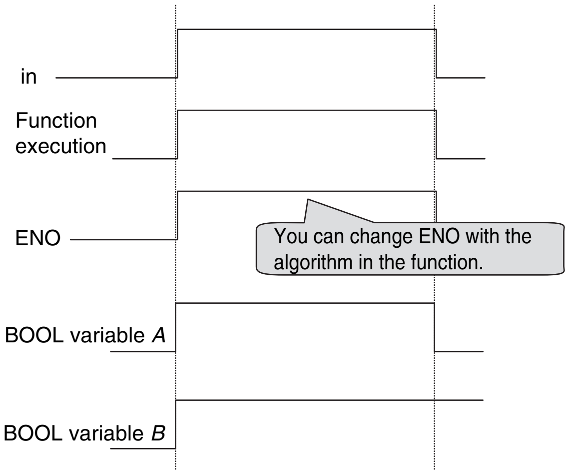
# Execution Conditions for Functions

A function is executed when *EN* is TRUE. The function stops processing when *EN* changes to FALSE.

| Input variables | Algorithm in FUN | | ENO | Operations other than ENO |
|---|---|---|---|---|
| EN = TRUE | Executed. | Normal end | TRUE | Output parameters: Values are updated according to the internal algorithm.<br>In-out parameters: Values are updated according to the internal algorithm. |
| | | Error end | FALSE | Output parameters: Values are retained.<br>In-out parameters: Values are updated according to the internal algorithm. |
| EN = FALSE | Not executed. | | FALSE | Output parameters and in-out parameters: Values are retained. |
| Inside a master control region | Not executed. | | FALSE | Output parameters and in-out parameters: Values are retained. |

Example:




## 6-2-7 Operation That Applies to Both Functions and Function Blocks

### Using or Omitting *EN* and *ENO*

The following table shows when you can use and when you can omit *EN* and *ENO* in functions and function blocks.

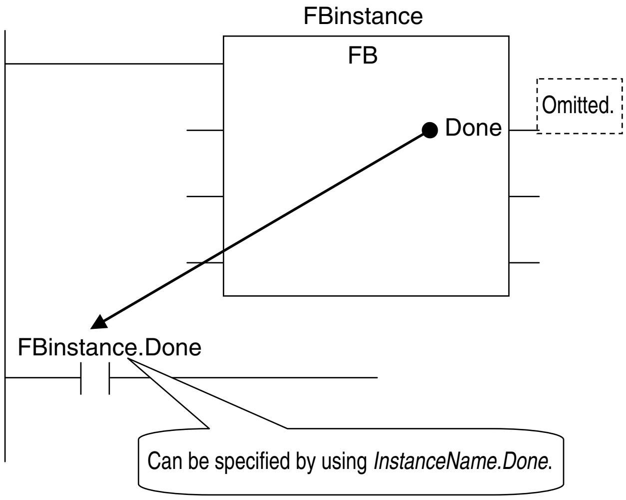
| POU | | EN | ENO |
|---|---|---|---|
| FB | User-defined functions | Cannot be used.<br>A compiling error occurs if you try to define *EN* in the variable table from the Sysmac Studio. | Can be used or omitted.<br>You define *ENO* as an output variable in the Sysmac Studio. |
| | Instruction | All FB instructions do not use *EN*. | Some instructions use *ENO*, and others do not. |
| FUN | User-defined functions | Required.<br>When you create a function, the Sysmac Studio automatically adds *EN* to the variable table by default. | Can be used or omitted.<br>You define *ENO* as an output variable in the Sysmac Studio. |
| | Instruction | All FUN instructions use *EN*. | Some instructions use *ENO*, and others do not. |

## Operation When Parameters Are Omitted

You can omit both input and output parameters.

| | Operation when omitted | |
|---|---|---|
| **Parameters omitted in** | **FB** | **FUN** |
| **Input parameters to input variables** | • When the first time the instance is executed, the initial value is used.<br>• Thereafter, the function block is executed with the previous value (if the input variable is omitted, the initial value is always used). | The initial value is used for operation. |
| **Output parameters from output variables** | Can be omitted.<br>You can access the results of the operation outside of the instruction by using *InstanceName.OutputVariableName*.* | You can omit the output parameter. If it is omitted, there is no way to retrieve the result of the operation. |
| **In-out parameters to/from in-out variables** | Cannot be omitted. | Cannot be omitted. |

* You can access the input and output variables of a function block from outside of the function block (but only within the same program) with *InstanceName.VariableName*. However, you cannot access the input and output variables of a function from outside the function.



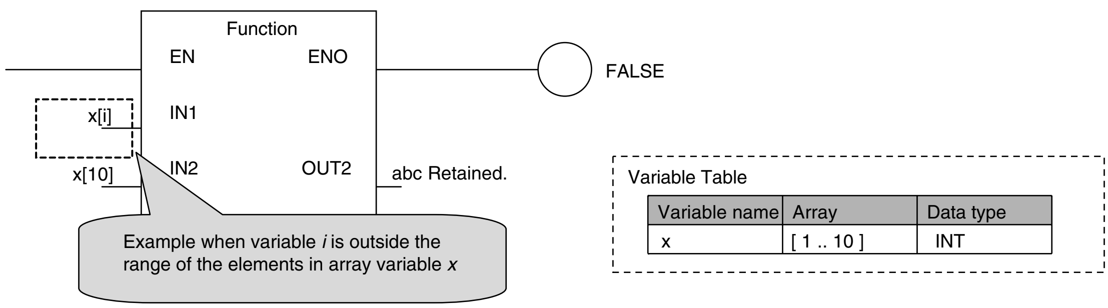

## Operation for Parameter Errors

The following operation occurs when there is an error in an input parameter, output parameter, or in-out parameter.

### ● Errors in Input Parameters

If an error is detected in an input parameter, the function or function block is not executed and *ENO* is FALSE. The power flow output is also FALSE, but all other values are retained.

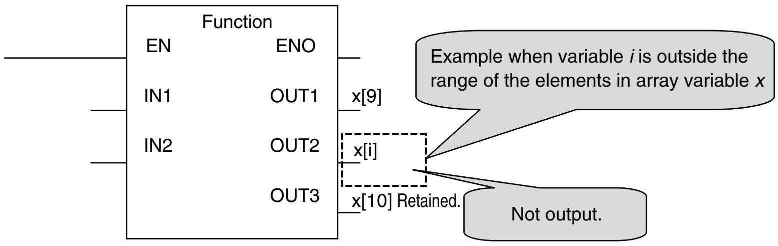
Example:



- **Errors in Output Parameters**

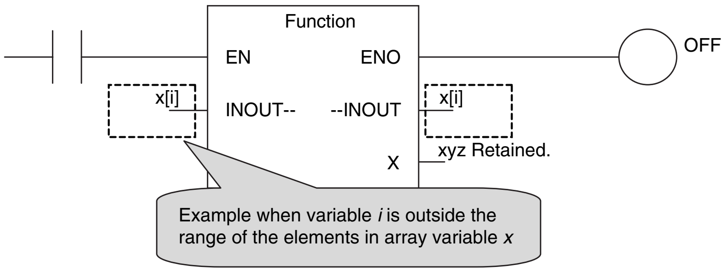
If an error is detected in an output parameter, all values after that parameter are not output but their values are retained.

Example:




- **Errors in In-Out Parameters**

If an error is detected in an in-out parameter, the function or function block is not executed and *ENO* is FALSE. The power flow output is also FALSE, but all other values are retained.




## Recursive Calling

The following recursive calls are not allowed for functions or function blocks. They will result in an error when you compile the user program on the Sysmac Studio.

- A function or function block cannot call itself.
- A called function or function block cannot call the calling parent.

# 6-2-8 POU Restrictions

This section describes the restrictions in the creation of POUs.

## Names

Refer to *6-3-12 Restrictions on Variable Names and Other Program-related Names* for restrictions on POU names and function block instance names.

## Passing Multiple Arguments

If you need to pass multiple arguments to a function or function block, use an array specification or structure to pass the required data.
This will make your program simpler. However, be aware that if you use an in-out variable, the data passed to the function block or function as a parameter is written and the original data is not retained.

### Additional Information

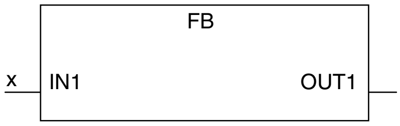
**Specifying an Array Variable or Structure Variable as a Parameter**

You can also specify an array variable or a structure variable as an input or output parameter. However, it will take longer to pass and receive data for these data types in comparison to a variable with a basic data type (depending on the size). Therefore, when handling array variables or structure variables in a function block, we recommend that you design them in such a way that these variables are passed to and received from in-out variables.

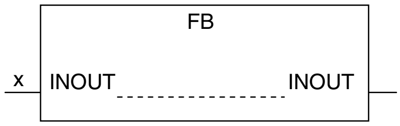
Example 1: Specifying an Array

Program Variable Table

| Variable name | Data type |
|---|---|
| x | ARRAY[0..199] OF INT |




Do not assign INT variable *x [0..199]* to the function block input variable *IN1* (Data type of the *IN1* input variable in the function block: ARRAY[0..199] OF INT).

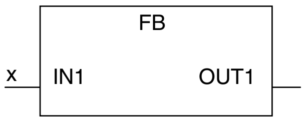



Instead, assign INT variable *x [0..199]* to the *INOUT* in-out variable of the function block. (Data type of INOUT in-out variable in the function block: ARRAY[0..199] OF INT)

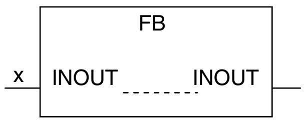
Example 2: Specifying a Structure Variable

Program Variable Table

| Variable name | Data type |
|---|---|
| x | MyStructure |




Do not assign MyStructure variable x to the *IN1* input variable of the function block (Data type of *IN1* input variable of the function block: MyStructure).

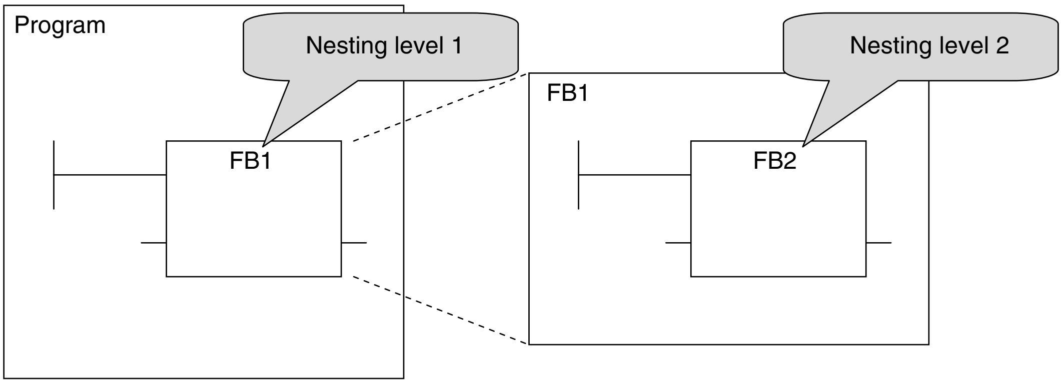



Instead, assign MyStructure variable x to the *INOUT* in-out variable of the function block. (Data type of *INOUT* in-out variable of the function block: MyStructure)

## Nesting Levels

Calling another function block from a function block that was called from a program is called nesting. You can nest function blocks up to eight levels deep.

You can nest user-defined functions and user-defined function blocks up to eight levels deep total.



# 6-3 Variables

In the NJ-series System, variables are used to exchange I/O information with external devices, to perform data calculations, and to perform other processes. This section describes variable designations in detail.
Refer to the *Sysmac Studio Version 1 Operation Manual* (Cat. No. W504) for details on setting variables with the Sysmac Studio.

## 6-3-1 Variables

Variables store I/O data for exchange with external devices or temporary data that is used for internal POU processing. In other words, a variable is a container for data with a name, data type, and other attributes.

You do not need to assign a memory address to a variable. However, you can assign a specific memory address if necessary (see note). The NJ-series CPU Unit automatically allocates memory addresses in the memory area for variables.

**Note** This is done to use specific functions for some CJ-series Special Units. You must specify the CJ-series Unit memory address in the AT Specification attribute of the variable. Refer to *AT Specification* on page 6-51 for details.

## 6-3-2 Types of Variables

Variables are broadly classified into the following three types.

### ● User-defined Variables

The user defines all of the attributes of a user-defined variable. The rest of this section describes user-defined variables.

### ● Semi-user-defined Variables

These variables are used to access specific devices and data. There are two types of semi-user-defined variables: device variables and cam data variables. Refer to *2-2-1 Types of Variables* and *3-4-1 I/O Ports and Device Variables* for details on device variables.

### ● System-defined Variables

System-defined variables are provided in advance in an NJ-series CPU Unit. The names and all attributes are defined by the system. They have specific functions. System-defined variables are supplied for each function module. Refer to *A-3 System-defined Variables* for details.

Refer to *2-2-1 Types of Variables* for details on the different types of variables.

## 6-3-3 Types of User-defined Variables in Respect to POUs

There are six types of user-defined variables as defined according to their function in a POU.

| Type of user-defined variable | | POU type | | |
|---|---|---|---|---|
| | | Programs | FB | FUN |
| Local variables | Internal variables | Supported. | Supported. | Supported. |
| | Input variables | Not supported. | Supported. | Supported. |
| | Output variables | Not supported. | Supported. | Supported. |
| | In-out variables | Not supported. | Supported. | Supported. |
| Global variables | | Supported (see note). | Supported (see note). | Supported (see note). |
| External variables | | Supported. | Supported. | Supported. |

**Note** You can define global variables as external variables to access the global variables through the external variables.

### Local Variables

Local variables can be read and written only in the POU (program, function, or function block) in which it is defined. Local variables are the same as internal variables if the POU is a program. If the POU is a function block or a function, “local variable” is a collective term for internal variables, input variables, output variables, in-out variables, and external variables.

#### ● Internal Variables

An internal variable can be used only within one POU. An internal variable is declared in the local variable table for the POU. You cannot access the values of internal variables from outside of the POU. You can declare internal variables with the same names in different POUs. Each of those variables is assigned to a different memory area.

#### ● Input Variables

When a POU is called, the input variables are assigned to the values of the input parameters from the calling POU. An input variable is declared in the local variable table of the POU.

#### ● Output Variables

Before processing a POU is completed, the output parameters returned to the calling POU are assigned to the output variables. An output variable is declared in the local variable table of the POU.

#### ● In-Out Variables

When a POU is called, the in-out variables are assigned to the in-out parameters themselves (variable designations) from the calling POU. If you change the value of an in-out variable within a POU, the value of the in-out parameter changes at that time. An in-out variable is declared in the local variable table of the POU.

#### ● External Variables

External variables are used to access data outside of a POU. You can access global variables from POUs.

## Global Variables

A global variable is declared in the global variable table.

Device variables that are automatically generated from the Unit configuration and slave configuration and axis/axes group variables that are generated from the Axis Setting Table are automatically registered as global variables.

## 6-3-4 Attributes of Variables

You can set the following attributes for variables.

## Variable Attributes According to Variable Type

### ● Attributes of Variables

| Attribute | Description | Specification | Default |
|---|---|---|---|
| **Variable Name** | The variable name is used to identify the variable. | | |
| **Data Type** | The data type defines the format of the data that is stored in the variable. | | INT |
| **AT Specification** | If you want to handle a specific address for a CJ-series Unit as a variable, specify the address to assign to that variable. | • Not specified.<br>• Specify. | Not specified. |
| **Retain** | Specify whether to retain the value of the variable in the following cases.<br>• When power is turned ON after a power interruption<br>• When the CPU Unit changes to RUN mode<br>• When operation for a major fault level Controller error has occurred. | • Retain: Value specified on the left is retained if there is a Battery.<br>• Non-retain: Changes to initial value. | Non-retain: Reset to initial value |
| **Initial Value** | You can select to set or not set an initial value.<br>Initial value setting: Specify the value of the variable in the following cases and do not specify the Retain attribute.<br>• When power turned ON<br>• When operating mode changes<br>• When a major fault level Controller error occurs<br>If the initial value is not set, the value is not retained. | Initial Value<br>• Yes<br>• None | Depends on the data type. (Refer to the section on initial values.) |
| **Constant** | If you set the Constant attribute, you can set the initial value of the variable when it is downloaded, but you cannot overwrite the value afterwards. | Specify making the value a constant or not a constant. | |
| **Network Publish** | This attribute allows you to use CIP communications and data links to read/write variables from outside of the Controller. | • Do not publish<br>• Publish Only<br>• Input<br>• Output | Do not publish |

| Attribute | Description | Specification | Default |
|---|---|---|---|
| **Edge** | An Edge attribute allows you to detect when the input parameter of a function block changes to TRUE or changes to FALSE. This can be used only on BOOL input variables. | • None<br>• Change to TRUE<br>• Change to FALSE | None |

**Additional Information**

**Exclusive Control between Tasks**

You can restrict writing to global variables to a single task to prevent changes to the values of global variables during processing. Specify this as a task setting, not as a variable attribute.

### ● Attributes Supported by Each Type of Variable

| Type of variable | | Variable Name | Data Type | AT Specification | Retain | Initial Value | Constant | Network Publish | Edge |
|---|---|---|---|---|---|---|---|---|---|
| **Global variables** | | Supported. | Supported. | Supported. | Supported. | Supported. | Supported. | Supported. | Not supported. |
| **Programs** | **Internal variables** | Supported. | Supported | Supported | Supported | Supported | Supported | Not supported. | Not supported. |
| | **External variables** | Not supported. | Not supported. | Not supported. | Not supported. | Not supported. | Supported. | Not supported. | Not supported. |
| **Function blocks** | **Internal variables** | Supported. | Supported. | Supported. | Supported. | Supported. | Supported. | Not supported. | Not supported. |
| | **Input variable** | Supported. | Supported. | Not supported. | Supported. | Supported. | Supported. | Not supported. | Supported. |
| | **Output variables** | Supported. | Supported. | Not supported. | Supported. | Not supported. | Not supported. | Not supported. | Not supported. |
| | **In-out variables** | Supported. | Supported. | Not supported. | Not supported. | Not supported. | Supported. | Not supported. | Not supported. |
| | **External variables** | Not supported. | Not supported. | Not supported. | Not supported. | Not supported. | Supported. | Not supported. | Not supported. |
| **Functions** | **Internal variables** | Supported. | Supported. | Not supported. | Not supported. | Supported. | Supported. | Not supported. | Not supported. |
| | **Input variables** | Supported. | Supported. | Not supported. | Not supported. | Supported. | Supported. | Not supported. | Not supported. |
| | **Output variable** | Supported. | Supported. | Not supported. | Not supported. | Not supported. | Not supported. | Not supported. | Not supported. |
| | **In-out variables** | Supported. | Supported. | Not supported. | Not supported. | Not supported. | Supported. | Not supported. | Not supported. |
| | **External variables** | Not supported. | Not supported. | Not supported. | Not supported. | Not supported. | Supported. | Not supported. | Not supported. |

## 6-3-5 Data Types

The Data Type attribute defines the type of data and range of data that is expressed by a variable.

The amount of memory that is allocated when you declare a variable depends on the data type of that variable. The more memory allocated, the larger the range of values that the variable can express.

The data types for the input, output, and in-out variables of instructions depend on the instruction. Set the data types of input, output, and in-out parameters for the instruction arguments according to the data types of the input, output, and in-out variables for that instruction.

## Basic Data Types and Derivative Data Types

There are two kinds of data types: basic data types, which have predefined specifications, and derivative data types, which are defined according to user specifications.

### ● Basic Data Types

The different kinds of basic data types are listed below.

| Classification | Definition |
|---|---|
| **Boolean** | A data type with a value of either TRUE or FALSE. |
| **Bit string** | A data type that represents a value as a bit string. |
| **Integer** | A data type that represents an integer value. |
| **Real number** | A data type that represents a real number. |
| **Duration** | A data type that represents a time duration (days, hours, minutes, seconds, and milliseconds). |
| **Time of day** | A data type that represents a specific time of day (hour, minutes, and seconds). |
| **Date** | A data type that represents a date (year, month, and day). |
| **Date and time** | A data type that represents a date and time (year, month, day, hour, minutes, seconds, and milliseconds). |
| **Text string** | A data type that contains a value that represents a text string. |

There are a total of twenty different basic data types. The specifications are given in the following table.

The meanings of the data size and alignment columns in the following table are as follows:

- Data size: The actual size of the value.
- Alignment: The unit used to allocate memory.

| Classification | Data type | Data size | Alignment | Range of values | Notation |
|---|---|---|---|---|---|
| **Boolean** | **BOOL** | 16 bits | 2 bytes | FALSE or TRUE | BOOL#1, BOOL#0, TRUE or FALSE |
| **Bit strings** | **BYTE** | 8 bits | 1 byte | BYTE#16#00 to FF | BYTE#2#01011010<br>BYTE#2#0101_1010<br>BYTE#16#5A<br>You can also use the “_” character as a separator. |
| | **WORD** | 16 bits | 2 bytes | WORD#16#0000 to FFFF | |
| | **DWORD** | 32 bits | 4 bytes | DWORD#16#00000000 to FFFFFFFF | |
| | **LWORD** | 64 bits | 8 bytes | LWORD#16#0000000000000000 to FFFFFFFFFFFFFFFF | |
| **Integers** | **SINT** | 8 bits | 1 byte | SINT#-128 to +127 | 100<br>INT#2#00000000_01100100<br>INT#8#144<br>INT#10#100<br>INT#16#64<br>–100 |
| | **INT** | 16 bits | 2 bytes | INT#-32768 to +32767 | |
| | **DINT** | 32 bits | 4 bytes | DINT#-2147483648 to +2147483647 | |
| | **LINT** | 64 bits | 8 bytes | LINT#-9223372036854775808 to +9223372036854775807 | |
| | **USINT** | 8 bits | 1 byte | USINT#0 to +255 | |
| | **UINT** | 16 bits | 2 bytes | UINT#0 to +65535 | |
| | **UDINT** | 32 bits | 4 bytes | UDINT#0 to +4294967295 | |
| | **ULINT** | 64 bits | 8 bytes | ULINT#0 to +18446744073709551615 | |

| Classification | Data type | Data size | Alignment | Range of values | Notation |
|---|---|---|---|---|---|
| **Real numbers** | **REAL** | 32 bits | 4 bytes | REAL#–3.402823e+38 to –1.175494e-38<br>0<br>–1.175494e-38 to 3.402823e+38<br>+∞ /–∞ | REAL#3.14<br>LREAL#3.14<br>3.14<br>–3.14<br>1.0E+6<br>1.234e4 |
| | **LREAL** | 64 bits | 8 bytes | LREAL#–1.79769313486231e<br>+308 to –2.22507385850720e-308<br>0<br>2.22507385850720e-308 to 1.79769313486231e+308<br>+∞ /–∞ | |
| **Durations** | **TIME** | 64 bits | 8 bytes | T#-9223372036854.775808ms (T#-106751d_23h_47m_16s_854.775808ms) to<br>T#+9223372036854.775807ms (T#+106751d_23h_47m_16s_854.775807ms) | T#12d3h3s<br>T#3s56ms<br>TIME#6d_10m<br>TIME#16d_5h_3m_4s<br>T#12d3.5h<br>T#10.12s<br>T#61m5s (Equivalent to T#1h1m5s)<br>TIME#25h_3m |
| **Date** | **DATE** | 64 bits | 8 bytes | D#1970-01-01 to D#2106-02-06 (January 1, 1970 to February 6, 2106) | Add “DATE#”, “date#”, “D#”, or “d#” to the beginning of the string and express the date in the yyyy-mm-dd format.<br>Example:<br>d#1994-09-23 |
| **Time of day** | **TIME_OF_DAY** | 64 bits | 8 bytes | TOD#00:00:00.000000000 to TOD#23:59:59.999999999 (00:00:0.000000000 to 23:59:59.999999999) | Add “TIME_OF_DAY#”, “time_of_day#”, “TOD#”, or “tod #” to the beginning of the string and express the time of day in the hh-mm-ss format.<br>Example:<br>tod#12:16:28.12 |
| **Date and time** | **DATE_AND_TIME** | 64 bits | 8 bytes | DT#1970-01-01-00:00:00.000000000 to DT#2106-02-06-23:59:59.999999999 (January 1, 1970 00:00:0.000000000 to July 21, February 6, 2106, 23:59.999999999 seconds.) | Add “DT#” or “dt#” to the beginning of the string and express the date and time in the yyyy-mm-dd-hh:mm:ss format.<br>Example:<br>dt#1994-09-23-12:16:28.12 |
| **Text strings** | **STRING** | (Number of single-byte characters plus 1) × 8 bits | 1 byte | The character code is UTF-8.<br>0 to 1,986 bytes*1*2 (0 to 1,985 single-byte alphanumeric characters)<br>A NULL character is added to the end of text strings. The number of bytes is therefore the number of single-byte characters plus 1.<br>**Note** You must set the number of bytes used by a STRING variable (number of single-byte alphanumeric characters plus 1) in the Sysmac Studio. The default setting is 256 bytes. | Enclose the string in single-byte single quotation marks (‘).<br>Example:<br>‘OMRON’‘PLC’ |

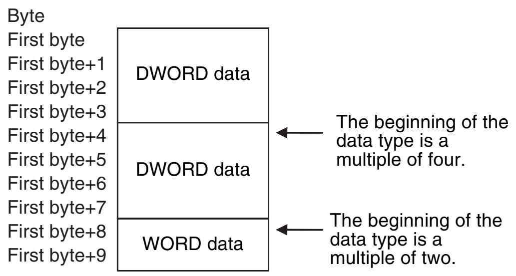
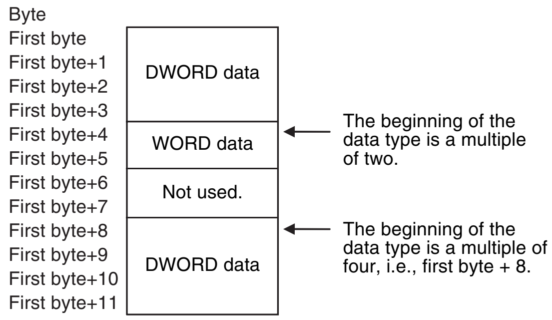
*1 For single-byte alphanumeric characters, this is equal to 0 to 1,985 characters. For Japanese, this is approximately equal to 0 to 661 characters.

*2 If you want to insert tabs, vertical tab codes, or other special characters, use a dollar sign ($) as an escape character before them. Refer to *Escape Character List* on page 6-64.

**Precautions for Correct Use**

The total amount of memory required by all variables is not equal to the total of the data sizes of each of those variables. This is because the first position where data is stored in memory is automatically set to a multiple of the alignment value for that data type. This results in some empty space in memory between data types. For example, even if the data types are the same, the overall memory space required depends on the order of data types, as shown below.

Example:

| DWORD -> DWORD -> WORD: Requires a total of 10 bytes. | DWORD -> WORD -> DWORD: Requires a total of 12 bytes. |
|---|---|
|  |  |





You must be aware of the alignment values for different data types when you exchange data such as structure variables between devices so that you can properly align the position of the data in memory. Refer to *A-7 Variable Memory Allocation Methods* for details.

## ● Derivative Data Types

A derivative data type is a data type with user-defined specifications. Derivative data types are registered in the Data Type View in the Sysmac Studio. The following is a list of the derivative data types.

| Type | Description |
|---|---|
| Structures | This data type consists of multiple data types placed together into a single layered structure. |
| Unions | This data type allows you to handle the same data as different data types depending on the situation. |
| Enumerations | This data type uses one item from a prepared name list as its value. |

Refer to *6-3-6 Derivative Data Types* for details.

## ● Specifications for Data Types

The following array specifications and range specifications are possible for all data types.

| Type | Description |
|---|---|
| Array specification | An array is a group of elements with the same data type. You specify the number (subscript) of the element from the first element to specify the element. You can specify arrays for both basic data types and derivative data types. |
| Range specification | You can specify a specific range for a data type in advance.<br>You can specify a range for any integer basic data type. |

Refer to *6-3-7 Array Specifications and Range Specifications for Data Types* for details.

## Restrictions on Using Data Types

A list of the data types that you cannot use in different POUs is given below.

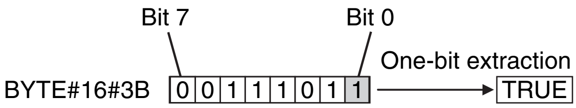
| POU type | Type of variable | Unusable data types | |
|---|---|---|---|
| | | Basic data types | Derivative data types |
| Programs | Local variables (i.e., internal variables) | None | |
| | Global variables | None | |
| FUN | Input variables, output variables, and in-out variables | None | Unions |
| | Internal variables | None | |
| | Return values | None | A structure or union |
| FB | Input variables, output variables, and in-out variables | None | Unions |
| | Internal variables | None | |

## Bit String, Real Number, and Text String Data Formats

This section describes the data formats for bit string data, real number data, and text string data.

### ● Bit String Data Format

Bit 0 is the least significant bit of a bit string variable. Bit values are represented by values of either 1 or 0. However, you can also represent the value of a single bit as a BOOL variable where 1 equals TRUE and 0 equals FALSE.




### ● Real Numbers (REAL and LREAL Data)

REAL and LREAL data have a real number data format. This section describes how to express real numbers and how to perform data processing with real number data types.

#### Data Size

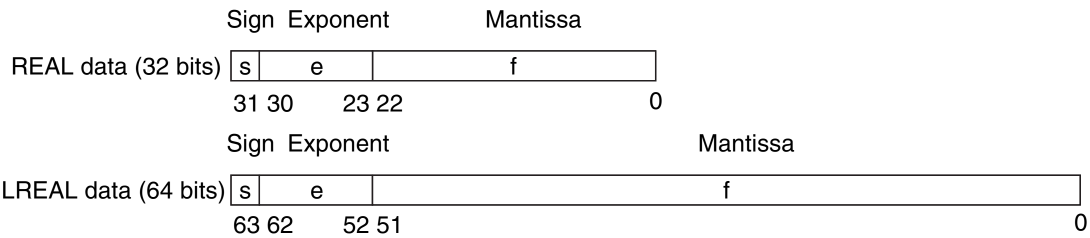
REAL data is 32 bits, while LREAL data is 64 bits.

#### Data Formats

The floating-point format is a way to express a real number as a combination of a sign, an exponent, and a mantissa. To express a real number as shown below, the value of s is the sign, the value of e is the exponent, and the value of f is the mantissa.

- REAL Data
  Number = $(-1)^s 2^{e-127}(1+f \times 2^{-23})$
- LREAL Data
  Number = $(-1)^s 2^{e-1023}(1+f \times 2^{-52})$

This floating-point format follows the IEEE 754 standard. The formats are given below.



Example: Expressing –86.625 as REAL Data

**1** This is a negative number, so s =1.

**2** 86.625 in binary is 1010110.101.

**3** Normalizing this value gives us $1.010110101 \times 2^6$.

**4** From the above expression we can determine that e–127 = 6, so e = 133 (or 10000101 in binary).

**5** Next we take the value after the decimal part of 1.010110101, which is 010110101. This is not enough for the 23-bit mantissa, so *f* is this number with the required amount of zeroes added to the end. Therefore, f = 01011010100000000000000.

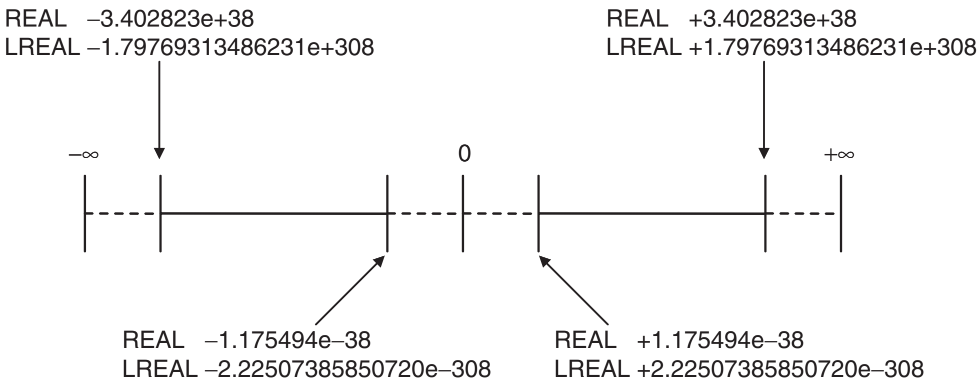
Therefore, you can express –86.625 as shown in the following figure.

| | Sign | Exponent | Mantissa |
|---|---|---|---|
| REAL data (32 bits) | 1 | 10000101 | 01011010100000000000000 |
| | 31 | 30   23 | 22   0 |

## Valid Ranges

The valid ranges for REAL and LREAL data are shown in the following table. There are a range of values that you cannot express as you approach 0.

| Data type | –∞ | Negative numbers | 0 | Positive numbers | +∞ |
|---|---|---|---|---|---|
| REAL | –∞ | –3.402823e+38 to –1.175494e-38 | 0 | +1.175494e–38 to +3.402823e+38 | +∞ |
| LREAL | –∞ | –1.79769313486231e+308 to –2.22507385850720e–308 | 0 | +2.22507385850720e–308 to +1.79769313486231e+308 | +∞ |




## Special Values

Values such as positive infinity, negative infinity, +0, –0, and nonnumeric data are called special values. Nonnumeric data refers to data that you cannot express as a floating-point number and therefore cannot be treated as a numeric value. Although +0 and –0 both mathematically mean 0, they are different for the purpose of data processing. This is discussed later in this section. The values for the sign s, exponent e, and mantissa f of special numbers are given in the following table.

| Data type name | Special values | Sign *s* | Exponent *e* | Mantissa *f* |
|---|---|---|---|---|
| REAL | +∞ | 0 | 255 | 0 |
| | –∞ | 1 | 255 | 0 |
| | +0 | 0 | 0 | 0 |
| | –0 | 1 | 0 | 0 |
| | Nonnumeric | --- | 255 | Not 0 |

| Data type name | Special values | Sign *s* | Exponent *e* | Mantissa *f* |
|---|---|---|---|---|
| LREAL | +∞ | 0 | 2047 | 0 |
| | −∞ | 1 | 2047 | 0 |
| | +0 | 0 | 0 | 0 |
| | −0 | 1 | 0 | 0 |
| | Nonnumeric | --- | 2047 | Not 0 |

## Subnormal Numbers

You cannot use the floating-point format to express values close to 0 (i.e., values with an extremely small absolute value). Therefore, you can use subnormal numbers to expand the valid range of numbers near 0. You can use subnormal numbers to express values with a smaller absolute value than with the normal data format (normal numbers). Any number where the exponent $e = 0$ and the mantissa $f \neq 0$ is a subnormal number and its value is expressed as shown below.

- REAL Data
  Number = $(-1)^s 2^{-126}(f \times 2^{-23})$
- LREAL Data
  Number = $(-1)^s 2^{-1022}(f \times 2^{-52})$

Example: Expressing $0.75 \times 2^{-127}$ as REAL Data

**1** This is a positive number, so $s = 0$.

**2** 0.75 in binary is 0.11.

**3** From $(0.11)_2 \times 2^{-127} = 2^{-126}(f \times 2^{-23})$ we can see that $f = (0.11)_2 \times 2^{22}$.

**4** From the above expression, f = 01100000000000000000000.

Therefore, you can express $0.75 \times 2^{-127}$ as shown in the following figure.

| | Sign | Exponent | Mantissa |
|---|---|---|---|
| REAL data (32 bits) | 0 | 00000000 | 01100000000000000000000 |
| | 31 | 30 … 23 | 22 … 0 |

Subnormal numbers have less effective digits than normal numbers. Therefore, if a calculation with normal numbers results in a subnormal number or if a subnormal number results in the middle of such a calculation, the effective digits of the result may be less than the effective digits of a normal number.

## Data Processing

The floating-point format expresses only an approximate value. Therefore, there may be a difference between the floating-point number and its true value. There is also a limited number of effective digits for these values. Therefore, the following actions are taken when you perform calculations with the floating-point format.

### Rounding

If the real value exceeds the effective digits of the mantissa, the value is rounded off according to the following rules.

- The result of the calculation will be the closest value to the value that can be expressed as a floating-point number.
- If there are two values that are the closest to the real value (e.g., if the real value is the median value of two approximate values), the mantissa with a least significant bit value of 0 is selected as the result of the calculation.

**Overflows and Underflows**

An overflow occurs when the absolute value of the true value is larger than the maximum value that can be expressed in the floating-point format. An underflow occurs when the absolute value of the true value is smaller than the minimum value that can be expressed in the floating-point format.

- If an overflow occurs and the true value is positive, the result of the calculation is positive infinity. If the true value is negative, the result of the calculation is negative infinity.
- If an underflow occurs and the true value is positive, the result of the calculation is positive zero. If the true value is negative, the result of the calculation is negative zero.

### Special Value Calculations

Calculations that involve special values (i.e., positive infinity, negative infinity, +0, –0, and nonnumeric data) are performed according to the following rules.

- Addition of positive and negative infinity results in nonnumeric data.
- Subtraction of two infinite values of the same sign results in nonnumeric data.
- Multiplication of +0 or –0 with infinity results in nonnumeric data.
- Division of +0 by itself, –0 by itself, or infinity by itself results in nonnumeric data.
- Addition of positive and negative zero results in positive zero.
- Subtracting +0 from itself or –0 from itself results in +0.
- Any arithmetic that involves nonnumeric data results in nonnumeric data.
- Comparison instructions (such as for the Cmp instruction) treat +0 and –0 as equal.
- If you compare nonnumeric data with anything else, the result is always not equal.

### ● Text String Data Format

All STRING variables are terminated with a NULL character (character code BYTE#16#00).

## Converting Data Types

When you use a variable of a different data type, the data type is automatically converted in some cases. You can also perform the conversion yourself with a data type conversion instruction.

### Data Type Conversion

All variables must have data types. Programs must operate properly according to these data types. For example, the left and right sides of an assignment expression should normally use the same data type. In some cases, however, it may be necessary to assign data of a different data type to a variable in order to program something successfully.

Example:

var3 := var1; —— Assigning a value to a variable of a different data type

*var1* is a variable of data type INT.

*var3* is a variable of data type REAL.

In order to assign the data in *var1* to the data type of *var3*, the data must first be converted. This type of conversion is called “data type conversion” or just “type conversion” for short.

### ● When Data Type Conversion Occurs

Converting between data types occurs in the following two cases.

**(1) Conversion by User Execution of Data Type Conversion Instructions**

**(2) Automatic Conversion for Assignments and Instructions**

- ST assignments
- Connecting lines in ladder diagrams

## 6-3-6 Derivative Data Types

A derivative data type has a configuration that is based on one of the basic data types. The following is a list of the derivative data types.

- Structures
- Unions
- Enumerations

Refer to *6-3-12 Restrictions on Variable Names and Other Program-related Names* for restrictions on the number of characters in data type names and other restrictions when you create a derivative data type.

**Additional Information**

NJ-series Controllers come with three different types of system-defined derivative data types.

- System-defined variables that are structures
- Structures used for input, output, and in-out variables for instructions
- Structures for Special Unit expansion memory (You must register these in the Unit Editor to use them.)

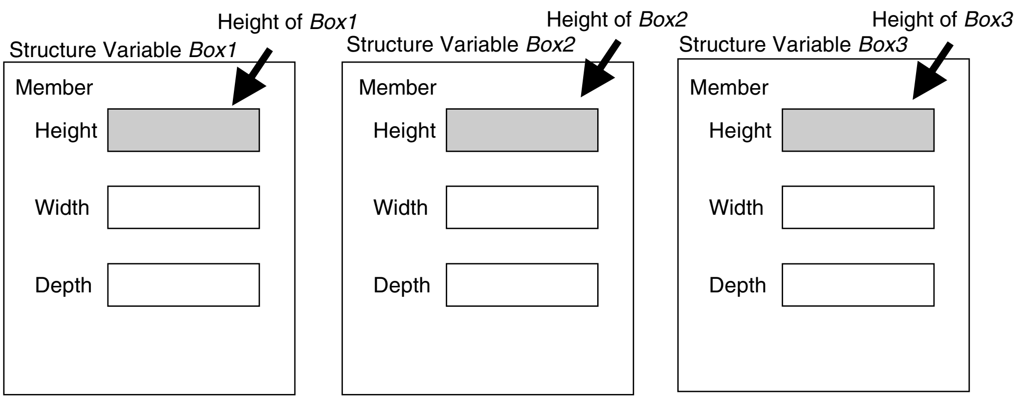
### Structures

A structure is a derivative data type that groups together data with the same or different variable types. You can easily change data and add new data if you place your data into a structure.

For example, you can define a “Box” structure that has three members (Width, Height, and Depth) in order to organize and group your data.

You can then use this structure data type to add a variable called *Box1*. You can then use it to access the different levels of the data by placing a period after the variable name followed by the name of the data you want to access. For example, *Box1.Width* or *Box1.Height*.

If you need to create a new variable to store more box data, you can perform the same steps to add a new variable called *Box2* to the variable table.




When a structure is used for a variable in an instruction, it is necessary to select a structure for the input parameter, output parameter, or in-out parameter, and register the variable.

Example: Communications Instructions

## Expressing Structure Variables and Structure Variable Members

### Specifying Members

The individual pieces of data that make up a structure are called “members.” You can express individual members of a structure by putting a period after the variable name that represents the entire structure followed by the member name that you want to access. You can even have a structure that is the member of another structure.

Example: *abc.x*: Member *x* of structure variable *abc*

*abc.Order.z*: Member *z* of member structure variable *Order* of structure variable *abc*

### Specifying the Structure

The structure represents all members that make up the structure. A structure is expressed by the name of the structure variable. In the example above, you would write *abc*.

## Creating a Structure

**1** Create a structure data type in the Data Type Table.

Specify the data type name, members, and the data type.

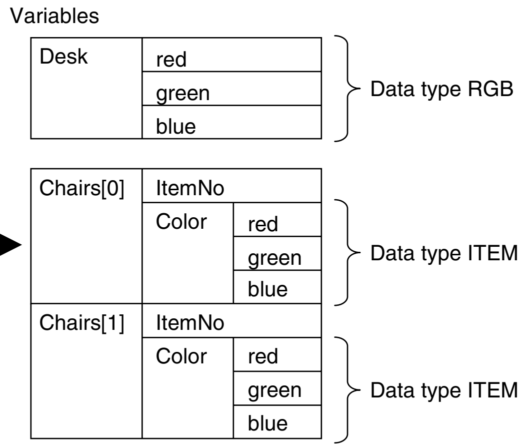
Data Type Table

| Name | Member | Data type |
|---|---|---|
| RGB | red | INT |
| | green | INT |
| | blue | INT |
| ITEM | ItemNo | INT |
| | Color | RGB |

**2** Specify the member name and the structure data type from above as the data type and register the variable in the variable table.

Variable Table

| Variable name | Data type |
|---|---|
| Desk | RGB |
| Chairs | ARRAY[0..1]OF ITEM |



## ● Structure Specifications

<table>
<tr><th>Item</th><th>Specification</th></tr>
<tr><td>Structure names</td><td>Names are not case sensitive. Prohibited characters and character length restrictions are the same as for variable names.</td></tr>
<tr><td>Member data types</td><td>
<table>
<tr><th>Classification</th><th>Data type</th><th>Usage</th></tr>
<tr><td rowspan="2">Basic data types</td><td>Boolean, bit string, integer, real, duration, date, time of day, date and time, or text string data</td><td>Supported.</td></tr>
<tr><td>Array of Boolean, bit string, integer, real, duration, date, time of day, date and time, or text string data</td><td>Supported.</td></tr>
<tr><td rowspan="2">Derivative data types</td><td>Arrays (see note), unions, and enumerations<br>Note Recursions and loops are not allowed. (An error will occur when the program is checked.)</td><td>Supported.</td></tr>
<tr><td>Array specifications for structures, unions, and enumerations</td><td>Supported.</td></tr>
<tr><td>POU instances</td><td></td><td>Not supported.</td></tr>
</table>
</td></tr>
<tr><td>Member attributes</td><td>Member Name<br>Comment</td></tr>
<tr><td>Number of members</td><td>1 to 2,048</td></tr>
<tr><td>Nesting depth of structures</td><td>Maximum of 8 levels (however, a member name must be 511 bytes or less, including the variable name)</td></tr>
<tr><td>Maximum size of one structure variable</td><td>No restrictions</td></tr>
</table>

## ● Arrays and Structures

You can set an array in which the elements are structures. You can also set a structure in which the members are arrays.

## ● Instructions That Take a Structure as a Parameter

Some instructions pass structure variables as parameters. To do so, specify the structure variable as the input parameter.

Example: Passing a Member of a Structure Variable to the MOVE Instruction and Passing a Structure Variable to the MOVE Instruction

When Not Using a Structure

Variable Table

| Variable name | Data type |
|---|---|
| Color1_red | UINT |
| Color1_green | UINT |
| Color1_blue | UINT |
| Color2_red | UINT |
| Color2_green | UINT |
| Color2_blue | UINT |

When Using a Structure

Data Type Table

| Name | Member | Data type |
|---|---|---|
| RGB | red | UINT |
| | green | UINT |
| | blue | UINT |

Variable Table

| Variable name | Data type |
|---|---|
| Color1 | RGB |
| Color2 | RGB |

```
Color1_green:=255;
Color1_red:=128;
Color2_red:= Color1_red;
Color2_green:= Color1_green;
Color2_blue:= Color1_blue;
```

```
Color1.green:=255;
Color1.red:=128;
Color2:= Color1
```

### Passing Values to System-defined Structure Input Variables for Certain Instructions

Some instructions take a predefined structure variable as an input variable.

Example: The *Port* input variable for the Serial Communications Instructions (which specifies the target port) is a structure with a data type name of *_sPORT*. When you use one of these instructions, follow the procedure provided below to create a user-defined structure variable and specify that variable for the input parameter to the instruction.

1. The system-defined data type for the instruction is registered in the Sysmac Studio in advance.

   Select that system-defined data type in the Sysmac Studio and add a user-defined structure variable to the variable table.
2. Use the user program or initial values to set the member values of that structure.
3. Specify the structure variable for the input parameter to the instruction.

## Unions

A union is a derivative data type that enables access to the same data with different data types. You can specify different data types to access the data, such as a BOOL array with 16 elements, 16 BOOL variables, or a WORD variable.

### ● Expressing Unions and Union Members

#### Specifying Members

When you define a union, you must name each data type that can be accessed. These names are called members. You can express individual members of a union by putting a period after the variable name that represents the entire union followed by the member name that you want to access.

Example:

Define the data type as a union as shown for *My Union* in the following example.

Data Type Definition

| Name | Member | Data type |
|---|---|---|
| My Union | data | WORD |
| | bit | ARRAY [0..15] OF BOOL |

Variable Table

| Variable name | Data type |
|---|---|
| Output | My Union |

Output.bit[0]: This notation specifies the 0th element, or value at bit 00, of union *Output* when it is treated as a 16-bit BOOL array variable.

Output.data: This notation specifies the value when union *Output* is treated as a single WORD variable.

### Specifying the Union

The union represents all members that make up the union. Unions are expressed by the name of the union variable. In the example above, you would write *Output*.

## ● Creating Unions

**1** Create a union data type in the Union Table.

Specify the data type names and different data types of the members of the union.

**2** Specify the union data type from above as the data type and register the variable in the variable table.

Example:

Here, *OUT16_ACCESS* is defined as the data type of a union. The members of this union are a BOOL array with 16 elements and a WORD variable. The variable *Output* is registered with a data type of OUT16_ACCESS. You can now read/write variable *Output* as a BOOL value for any of the 16 bits and as a WORD value.

Data Type Definitions

| Name | Member | Data type |
|---|---|---|
| OUT16ACCESS | BoolData | ARRAY[0..15] of BOOL |
| | ByteData | ARRAY[0..1] of BYTE |
| | WordData | WORD |

| Variable name | Data type |
|---|---|
| Output | OUT16ACCESS |

| | | | | | |
|---|---|---|---|---|---|
| BoolData [15] | · · · | BoolData [8] | BoolData [7] | · · · | BoolData [0] |
| ByteData [1] | | | ByteData [0] | | |
| WordData | | | | | |

```
Output.WordData := WORD#16#1234;
```

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BoolData | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| ByteData | 16#12 | | | | | | | | 16#34 | | | | | | | |
| WordData | 16#1234 | | | | | | | | | | | | | | | |

```
Output.BoolData[11] :=TRUE;
```

| | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BoolData | * | * | * | * | 1 | * | * | * | * | * | * | * | * | * | * | * |
| ByteData | Bit 04 of *ByteData[1]* is TRUE | | | | | | | | No change | | | | | | | |
| WordData | Bit 11 of *WordData* is TRUE | | | | | | | | | | | | | | | |

### ● Union Specifications

<table>
<tr><th>Item</th><th>Specification</th></tr>
<tr><td>Data types that can be specified for members</td><td>
<table>
<tr><th>Classification</th><th>Data type</th><th>Usage</th></tr>
<tr><td rowspan="2">Basic data types</td><td>Boolean and bit strings</td><td>Supported.</td></tr>
<tr><td>BOOL and bit string data array specifications</td><td>Supported.</td></tr>
<tr><td>Derivative data types</td><td>Array specification for structures, unions, and enumerations</td><td>Not supported.</td></tr>
<tr><td>POU instances</td><td></td><td>Not supported.</td></tr>
</table>
</td></tr>
<tr><td>Number of members</td><td>4 max.</td></tr>
<tr><td>Setting initial values</td><td>Not supported. Always zero.</td></tr>
</table>

### ● Restrictions

- The initial values for unions are always zero.
- You cannot move unions.
- You cannot specify unions for parameters to POUs.

## Enumerations (ENUM)

An enumeration is a derivative data type that uses text strings called enumerators to express variable values. To use an enumeration, you must first set the values that can be obtained from that variable as enumerators (text strings). Use enumerations to make it easier for humans to understand the meaning behind the values of a variable.

### ● Expressing Enumerations

When you define an enumeration, you must define the possible values of the variable as enumerators and give the enumeration a name.

### ● Creating Enumerations

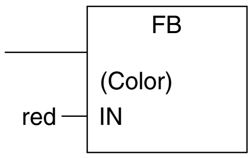
**1** Create an enumeration data type in the Enumeration Table.

Set the enumerators and their values for the enumeration.

**2** Specify the enumeration data type from above as the data type and register the variable in the variable table.

Example:

Here, *Color* is defined as the data type of an enumeration. For this example, we will set three enumerators: *red*, *yellow*, and *green*. The numbers associated with these enumerators are as follows: *red* = 0, *yellow* = 1, *green* = 2. The variable *DiscColor* is registered with a data type of Color. You can now select between three different enumerators for the variable *DiscColor*: *red*, *yellow*, and *green*. This will in turn write the appropriate value of 0, 1, or 2 to the variable *DiscColor*.




Enumeration Table

| Data type | |
|---|---|
| Color | ENUM |
| **Enumerator** | **Value** |
| red | 0 |
| yellow | 1 |
| green | 2 |

Variable Table

| Variable name | Data type |
|---|---|
| DiscColor | Color |

## ● Enumeration Specifications

| Item | Specification |
|---|---|
| Enumerator names | Enumerator names consist of single-byte alphanumeric characters. They are not case sensitive. Prohibited characters are the same as for variable names. A compiling error will occur if you specify the same enumerator more than once. A compiling error will occur if you specify an enumerator with the same name as a variable in the user program or if you specify an enumerator that already exists in another enumeration. |
| Values | Valid range: Integers between –2,147,483,648 and 2,147,483,647<br>Values do not have to be consecutive.<br>A compiling error will occur if you specify the same value more than once.<br>**Note** You cannot perform size comparisons with enumeration variables. You can only test to see if the enumerators are the same. |
| Number of enumerators | 1 to 2,048 |

## ● Value Checks

When a value is written to an enumerated variable through execution of an instruction, an error will not occur even if that value is not defined as one of the enumerators of that variable.

# 6-3-7 Array Specifications and Range Specifications for Data Types

You can specify the following attributes for variables with each data types.

- Array specifications
- Range specifications

## Array Specifications (ARRAY[]OF)

Use an array specification for a data type that handles a group of data with the same attributes as a single entity. You can use an array specification for the basic data types and derivative data types. Arrays are useful when you want to handle multiple pieces of data together as you would, for example, coordinate values for motion control.

### ● Expressing Arrays and Array Elements

#### Specifying Elements

The individual pieces of data that make up an array are called “elements.”
The elements of an array are expressed by adding a subscript (element number) from the start of the array to the name of the variable that represents the entire array.
Enclose the subscript in single-byte braces []. Subscripts can be either constants or variables. In ST, you can also use expressions to express subscripts.

Examples:

Variable Table

| Variable name | Data type |
|---|---|
| Mem | ARRAY[0..99] OF INT |

x:=10;
*Mem[x]*: This expression specifies the xth element of the array variable *Mem* (the variable *x* has a value of 10, so this would point to the 10th element).

Variable Table

| Variable name | Data type |
|---|---|
| Data | ARRAY[0..99] OF INT |

x:=10;
y:=20;

Data[x+y]: This expression specifies the x+yth element of the array variable *Data* (the variable *x* has a value of 10 and variable *y* has a value of 20, so this would point to the 30th element).

### Specifying An Array (i.e., the Entire Array)

The array represents all elements that make up the array. Arrays are expressed by the name of the array variable. In the above examples, the arrays are written as *Mem* and *Data*.

#### ● Creating an Array

1. Enter "A" into the Data Type Column of the variable table and select *ARRAY[?..?] OF ?* from the list of possible data type name candidates.
2. Enter the number of the first element in the array for the left question mark and the last number for the right question mark in the "[?..?]" section. Next, enter the data type for the question mark in the "OF ?" section and register the variable.

Variable Table

| Variable name | Data type |
|---|---|
| abc | ARRAY [ 0 .. 4 ] OF INT |

Represents the data type of the array variable.
Represents the last number of the elements of the array.
Represents the first number of the elements of the array.

| |
|---|
| abc[0] |
| abc[1] |
| abc[2] |
| abc[3] |
| abc[4] |

Array

## Array Variable Specifications

<table>
<tr><th>Item</th><th>Specification</th></tr>
<tr><td>Maximum number of elements for an array variable</td><td>65535</td></tr>
<tr><td>Element numbers</td><td>0 to 65535<br>The number for the first element in an array does not have to be 0.</td></tr>
<tr><td>Subscripts</td><td>Constants: Integer value between 0 and 65535<br>Variables:
<table>
<tr><th>Classification</th><th colspan="2">Data type</th><th>Usage</th></tr>
<tr><td rowspan="3">Basic data type</td><td rowspan="2">Integer</td><td>SINT, INT, DINT, USINT, UINT, or UDINT</td><td>Supported.</td></tr>
<tr><td>LINT or ULINT</td><td>Not supported.</td></tr>
<tr><td colspan="2">Boolean, bit string, real, duration, date, time of day, date and time, or text string data</td><td>Not supported.</td></tr>
<tr><td>Derivative data types</td><td colspan="2">Structures, unions, and enumerations</td><td>Not supported.</td></tr>
<tr><td>POU instances</td><td colspan="2"></td><td>Not supported.</td></tr>
</table>
Arithmetic expressions: Arithmetic expressions can be specified only in ST.<br>Example: y:= x[a+b];</td></tr>
</table>

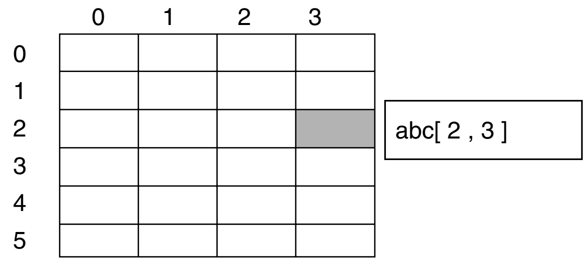
## Dimensions of Array Variables

You can regard the elements of a one-dimensional array as one-dimensional data lined up in a single row. You can set two-dimensional and three-dimensional arrays in the same way. The array elements are expressed by adding the same number of subscripts to the array variable name as the number of dimensions. Arrays can have a maximum of three dimensions.

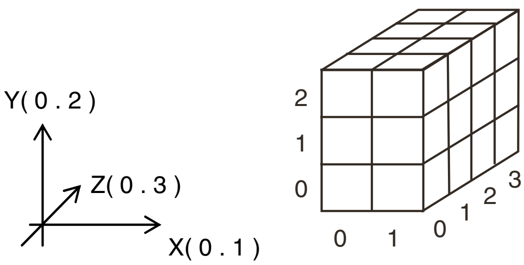
### Two-dimensional Array Specifications

Variable Table

| Variable name | Data type |
|---|---|
| abc | ARRAY [0..5 .. 0..3 ] OF INT |




### Three-dimensional Array Specifications




Variable Table

| Variable name | Data type |
|---|---|
| ITEM | ARRAY [ 0..1, 0..2, 0..3 ] OF INT |

## Arrays and Structures

You can set an array in which the elements are structures. You can also set a structure in which the members are arrays.

### Arrays with Structure Elements

Date Type Table

| Data type | Member | Member |
|---|---|---|
| Str | x<br>y | INT<br>DINT |

Variable Table

| Variable name | Data type |
|---|---|
| abc | ARRAY [1..4 ] OF Str |

Variables

| |
|---|
| abc[1].x |
| abc[1].y |
| : |
| abc[4].x |
| abc[4].y |

### Structure with Array Members

Data Type Table

| Data type | Member | Data type |
|---|---|---|
| Str | x | ARRAY [0..1] OF INT |
| | y | DINT |

Variable Table

| Variable name | Data type |
|---|---|
| abc | ARRAY [1..4 ] OF Str |

Variables

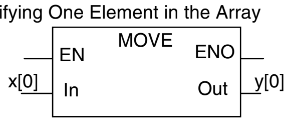
| |
|---|
| abc[1].x[0] |
| abc[1].x[1] |
| abc[1].y |
| : |
| abc[4].x[0] |
| abc[4].x[1] |
| abc[4].y |

## ● Instructions with an Array Parameter

Some instructions pass array variables as parameters. To do so, specify only the name of the array variable as the input parameter.

Example: Passing a Single Array Element to the MOVE Instruction and Passing an Array to the MOVE instruction

Specifying One Element in the Array

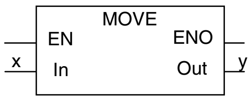



Moves INT variable *x[0]* to *y[0]*

Variable Table

| Variable name | Data type |
|---|---|
| x | ARRAY [ 0 .. 199 ]OF INT |
| y | ARRAY [ 0 .. 199 ]OF INT |

Specifying the Array

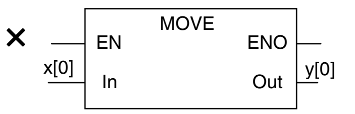


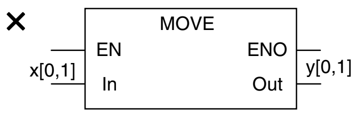

Moves INT variable *x[0..199]* to *y[0..199]*

Restrictions:
When you move an array variable, it must be moved to a variable of the same data type with the same range of element numbers.

### Additional Information

You cannot specify part of a multi-dimensional array as a parameter.




Variable Table

| Variable name | Data type |
|---|---|
| x | ARRAY [ 0..9 , 0..9 , 0..9 ]OF INT |
| y | ARRAY [ 0..9 , 0..9 , 0..9 ]OF INT |

## ● Array Protection

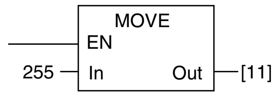
The following errors occur if you attempt to access an element that exceeds the number of elements in an array.

### When the Subscript Is a Constant

An error is displayed when you input the variable or when you check the program on the Sysmac Studio.

Variable Table

| Variable name | Data type |
|---|---|
| x | ARRAY [1..10] OF INT |

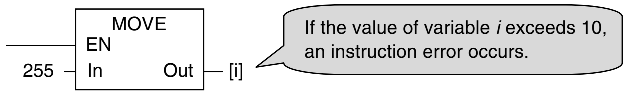



### When the Subscript Is a Variable

The CPU Unit checks for subscripts that are out of range when instructions are executed. When a subscript variable exceeds the range of the elements of the array variable, an instruction error occurs.

Variable Table

| Variable name | Data type |
|---|---|
| x | ARRAY [1..10] OF INT |




## Range Specifications

Use the range specification to restrict the values of the following integer variables to specific ranges of values.

| Classification | Data type |
|---|---|
| **Integers** | SINT, INT, DINT, LINT, USINT, UINT, UDINT, and ULINT |

You can check to make sure that the entered value is within the allowed range in the following cases.

- When you specify an initial value for a variable
- When you write a value to a variable with CIP message communications

### ● Making a Range Specification

Input the start point and end point after the data type name in the *Data Type* Column in the variable table.

Start point: The minimum value that you can store in the variable.

End point: The maximum value that you can store in the variable.

Example:

Variable Table

| Variable name | Data type |
|---|---|
| abc | INT (0 ,100) |

The end point of the range specification

The start point of the range specification

| abc | Range specification: Minimum 0 to maximum 100 |
|---|---|

## Specifications of Range Specifications

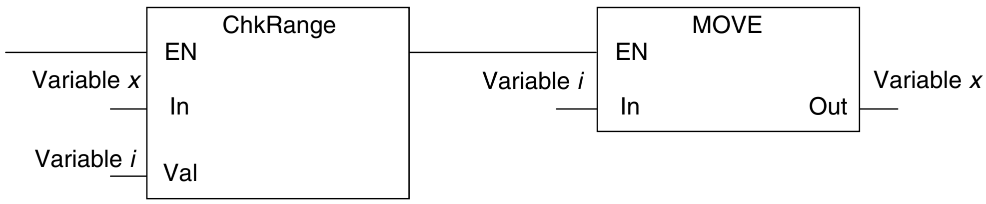
<table>
<tr><th>Item</th><th>Specification</th></tr>
<tr><td>Data types that you can specify</td><td>Variables only</td></tr>
<tr><td>Operation for attempts to write out-of-range value</td><td>
<table>
<tr><th colspan="2">Case</th><th colspan="2">Operation</th></tr>
<tr><td colspan="2">User program</td><td colspan="2">An error does not occur and the value is written. The CPU Unit does not perform a range check when the value of a variable changes due to the execution of an instruction.</td></tr>
<tr><td rowspan="6">Communi-cations</td><td rowspan="5">Write from the Sysmac Studio or a CIP mes-sage</td><td>When the value is an integer</td><td rowspan="3">A command error occurs.</td></tr>
<tr><td>For an element of an integer array variable</td></tr>
<tr><td>For a member of an integer structure</td></tr>
<tr><td>For an integer struc-ture</td><td rowspan="2">A command error does not occur and the value is writ-ten.</td></tr>
<tr><td>For an integer array</td></tr>
<tr><td>Tag data links (both via built-in EtherNet/IP ports and Eth-erNet/IP Units)</td><td colspan="2">An error occurs if you attempt to write to a single member that specifies a range. An error does not occur if you attempt to write to a structure that contains a member for which a range is specified.</td></tr>
<tr><td colspan="2">Input refreshing from slaves and Units</td><td colspan="2">An error does not occur and the value is written.</td></tr>
<tr><td colspan="2">Forced refreshing values</td><td colspan="2">An error does not occur and the value is written.</td></tr>
</table>
</td></tr>
</table>

**Precautions for Correct Use**

Variables with range specifications are not checked for changes in variable values that result from the execution of instructions in the user program. To check the range of values for a variable that are set from execution of the user program, use instructions that perform range checks.

Variable Table

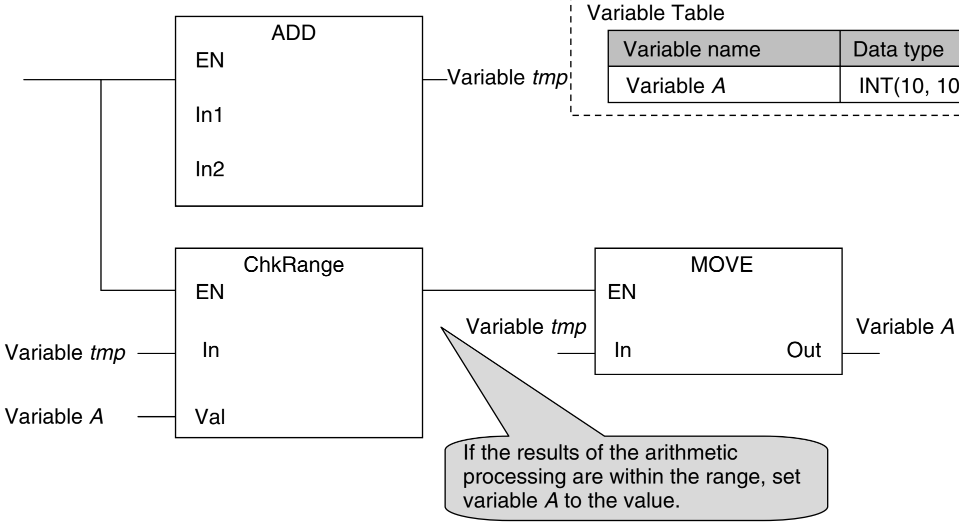
| Variable name | Data type |
|---|---|
| Variable *x* | INT(10, 100) |




You cannot perform any checks beforehand if you set data with arithmetic processing results. In this case, check the range of values after arithmetic processing (e.g., ADD).

Variable Table

| Variable name | Data type |
|---|---|
| Variable *A* | INT(10, 100) |




Make sure that the initial value is within the range specified for the Range Specification. If the initial value field on the Sysmac Studio is left blank, an initial value of 0 is used. This applies even if a range that does not include 0 is set for a Range Specification.

## 6-3-8 Variable Attributes

This section describes the variable attributes other than the Variable Name and Data Type.

### Variable Name

The variable name is used to identify the variable. Each variable in a POU must have a unique name. However, you can declare local variables with the same variable name in different POUs. These are treated as two separate variables. You cannot declare a local variable with the same variable name as a global variable.

Refer to *6-3-12 Restrictions on Variable Names and Other Program-related Names* for restrictions on variable names.

## AT Specification

Use the AT Specification attribute to specify the internal I/O memory address of a variable in memory used for CJ-series Units. AT specifications are used mainly to specify specific memory addresses for the following Special Units.

- Addresses in fixed allocations for DeviceNet Units
- Addresses in user-specified allocations for DeviceNet Units from the CX-Integrator
- Addresses in expansion memory for High-speed Counter Units
- Addresses in expansion memory for Process I/O Units

If this attribute is not set, the variable is automatically assigned to an address in variable memory.

**Additional Information**

When you assign a device variable to an I/O port, they are automatically given an AT specification internally.

### ● Allocation Areas

You can specify addresses in the following areas.

| Area | Expression |
|---|---|
| **CIO** | CIO 0 to CIO 6143 |
| **Work** | W0 to W511 |
| **Holding** | H0 to H1535 |
| **DM** | D0 to D32767 |
| **EM** | E0_0 to E18_32767 |

The following table gives the data assignments by variable data type.

| Variable data type | Assignment position |
|---|---|
| **BOOL** | You can specify an assignment for each bit. |
| **BYTE/SINT/USINT** | You can specify bit 0 or bit 8 of the specified CJ-series address as the start position of the data assignment.<br>Example 1: AT Specification at Bit 0 of D100 (%D100)<br>D100: 16#**12....One-byte data (12) is stored from bit 0.<br>Example 2: AT Specification at Bit 8 of D100 (%D100.8)<br>D100: 16#12**....One-byte data (12) is stored from bit 8. |
| **WORD/INT/UINT** | Stored in increments of the data size from bit 0 of the specified CJ-series address. |
| **DWORD/DINT/UDINT**<br>**REAL** | |
| **LWORD/LINT/ULINT**<br>**LREAL** | |
| **STRING** | You can specify bit 0 or bit 8 of the specified CJ-series address as the start position of the data assignment. |
| **TIME**<br>**DATE**<br>**TIME_OF_DAY**<br>**DATER_AND_TIME** | Stored in increments of the data size from bit 0 of the specified CJ-series address. |

### ● Variables for Which You Can Set AT Specifications

AT specifications are made separately for each variable. Set them for all elements and members of array, structure, and union variables.

## Attributes of Variables with AT Specifications

| | Specification | Remarks |
|---|---|---|
| **Name** | Supported. | |
| **Data Type** | Supported. | |
| **Retain** | Supported. | An error occurs if the setting of the Retain attribute does not agree with the attribute of the CJ-series Unit memory where the address is assigned. |
| **Initial Value** | Supported. | Set the initial value setting to *None* if you want to use the memory value as it is. |
| **Constant** | Supported. | You cannot write to a constant with an instruction. |
| **Network Publish** | Supported. | |
| **Edge** | Not supported. | (You can specify the Edge attribute only for function block input variables.) |

## Entering and Displaying AT Specifications

When you specify the AT Specification attribute, input the following in the Allocated Address Box of the variable table in the Sysmac Studio. The following is displayed in the Allocated Address Box of the variable table or the I/O Map.

| Type of variable | Entries and displays in the *AT* field. | Example |
|---|---|---|
| **User-defined variables with AT specifications to word addresses** | %[*word_address*] | %D100 |
| **User-defined variables with AT specifications to bit addresses** | %[*word_address*].[*bit_position*] | %W0.00 |

The following variables are also allocated an address internally. The following is displayed in the Allocated Address Box.

| Type of variable | Displays in the *AT* field. | Example |
|---|---|---|
| **Device variables for CJ-series Units** | IOBus://rack#[*rack_number*]/slot#[*slot_number*]/[*I/O_port_number*] | Basic I/O Units:<br>IOBus://rack#0/slot#1/Ch1_In/Ch1_In00<br>Special Units:<br>IOBus://rack#0/slot#1/PeakHold-Cmd/ch1_PeakHoldCmd |
| **Device variables for EtherCAT slaves** | ECAT://node#[*node_number*]/[*I/O_port_name*] | ECAT://node#1/Input1 |
| **Axis Variables** | MC://_MC_AX[] | MC://_MC_AX[1] |
| **Axes Group Variables** | MC://_MC_GRP[] | MC://_MC_GR[1] |

### Precautions for Correct Use

You can assign the same address to more than one variable. However, this is not recommended as it reduces readability and makes the program more difficult to debug. If you do this, set an initial value for only one of the variables. If you set a different initial value for each individual variable, the initial value is not stable.

### Additional Information

You cannot use an AT specification for an EtherCAT slave. Always specify the device variables for EtherCAT slaves.

## Retain

Use the Retain attribute to specify whether a variable should retain its value in the following cases.

- When power is turned ON after power interruption
- When the operating mode is changed
- When a major fault level Controller error occurs

If the Retain attribute is not set, the value of the variable is reset to its initial value in the above situations.

You can specify the Retain attribute when you need to retain the data that is stored in a variable (such as the manufacturing quantities) even after the power to the Controller is turned OFF.

For a variable with an AT specification, the setting of the Retain attribute must agree with address in the memory area where the address is assigned.
(Retained areas: Holding, DM, and EM Areas
Non-retained areas: CIO and Work Areas)

### Conditions Required to Enable the Retain Attribute

The CPU Unit must contain a Battery.

### Using Initial Values for Retain Variables

When you download the user program, select the *Clear the present values of variables with Retain attribute* Check Box.

### Operation with and without the Retain Attribute

The following table shows when variable values are retained or not.

<table>
<tr><th colspan="2" rowspan="2">Case</th><th colspan="2">Values of variables</th></tr>
<tr><th>Retain attribute specified</th><th>Retain attribute not specified</th></tr>
<tr><td colspan="2">When power is turned ON after power interruption</td><td rowspan="4">Retained.</td><td rowspan="5">Not retained.</td></tr>
<tr><td colspan="2">When the operating mode is changed</td></tr>
<tr><td colspan="2">When a major fault level Controller error occurs</td></tr>
<tr><td rowspan="2">When you download the user program</td><td>When the Clear the present values of variables with Retain attribute Check Box is selected.</td></tr>
<tr><td>When the check box is not selected.</td><td>Not retained.</td></tr>
</table>

### Variables for Which You Can Specify the Retain Attribute

AT specifications are made separately for each variable. Set them for all elements and members of array, structure, and union variables.

## Initial Value

The variable is set to the initial value in the following situations.

- When power is turned ON
- When changing between RUN mode and PROGRAM mode
- When you select the *Clear the present value of variables with Retain attribute* Check Box, and download the user program
- When a major fault level Controller error occurs

You can set an initial value for a variable in advance so that you do not have to write a program to initialize all of the variables. For example, you can preset data such as a recipe as initial values. You do not have to set any initial values.

## ● Types of Variables That Can Have Initial Values

You can set initial values for only some types of variables. A list is provided below.

| Type of variable | Initial Value |
|---|---|
| **Global variables** | Supported. |
| **Internal variables** | |
| **Input variables** | |
| **Output variables** | |
| **Return values of functions** | Not supported. |
| **In-out variables** | |
| **External variables** | |

## ● Enabling an Initial Value

You can specify whether a variable has an initial value when you create the variable.

Initial Value Specified

| Initial value |
|---|
| |

(Blank)

Or

| Initial value |
|---|
| 3.14 |

No Initial Value Specified

| Initial value |
|---|
| None |

The following table shows the variables for which you can set an initial value.

| Type | | Example | Enabling an Initial Value |
|---|---|---|---|
| **Basic data type variables** | | **aaa** | Supported. |
| **Array variables** | **Arrays** | **bbb** | Supported. |
| | **Elements** | **bbb[2]** | Not supported. |
| **Structure variables** | **Structures** | **ddd** | Supported. |
| | **Members** | **ddd.xxx** | Not supported. |
| **Union variables** | **Unions** | **eee** | Not supported (initial values are always 0). |
| | **Members** | **eee.word** | Initial values are always 0. |
| **Enumerated variables** | | **ccc** | Supported. |
| **POU instances** | | **instance** | Not supported. |

## ● When Initial Values Are Set

The initial value is assigned to the variable at the following times.

- When power is turned ON
- When the operating mode changes from PROGRAM to RUN mode or from RUN to PROGRAM mode
- When you select the *Clear the present value of variables with Retain attribute* Check Box, and download the user program
- When a major fault level Controller error occurs

### When the Initial Value Specification Is Left Blank

The following initial values are used for variables for which the initial value specification is left blank.

| Data type | | Default initial value |
|---|---|---|
| **Boolean data and bit strings** | **BOOL, BYTE, WORD, DWORD, or LWORD** | 0 |
| **Integers** | **SINT, INT, DINT, LINT, USINT, UINT, UDINT, or ULINT** | 0 |
| **Real numbers** | **REAL and LREAL** | 0.0 |
| **Durations, dates, and times of day** | **TIME** | T#0S |
| | **DATE** | D#1970-01-01 |
| | **TIME_OF_DAY** | TOD#00:00:00 |
| | **DATE_AND_TIME** | DT#1970-01-01-00:00:00 |
| **Text strings** | **STRING** | ‘ ‘(blank character) |

### Initial Value of Array Variables

| Data type | Initial value specifications |
|---|---|
| **Array specifications** | • You can specify an initial value for each element.<br>• To specify initial values, you must specify a value or leave the specification blank for each element. |

### Initial Values for Derivative Data Types

You do not specify an initial value for the data type itself. You set an initial value for each individual variable.

| Data type | Initial value specifications |
|---|---|
| **Structures** | • You can specify an initial value for each member.<br>• To specify initial values, you must specify a value or leave the specification blank for each element. |
| **Unions** | • Initial values cannot be specified. Always zero. |
| **Enumerations** | • Initial values can be specified. |

### Variables That Do Not Apply Initial Values

For the following variables, initial values are not applied when the power is turned ON, and the values before the power interruption are retained.

- Variables with Retain attribute
- Variables with AT specifications (retained areas or DM, Holding, or EM Area specifications only)

**Precautions for Correct Use**

If the CPU Unit has no Battery, the above variables are also initialized.

## Constant

If you specify the Constant attribute, the value of the variable cannot be written by any instructions, ST operators, or CIP message communications. Setting the Constant attribute will prevent any program from overwriting the variable. The values of variables with a Constant attribute cannot be written from instructions after the initial value is set. If there is an instruction in a POU that attempts to write a value to a variable with the Constant attribute, an error will occur when the user program is compiled.

### ● Operation

If there is an instruction or operator in a POU that attempts to write a value to a variable with the Constant attribute, the following operations will occur.

| Source | | Operation for attempts to write the value |
|---|---|---|
| **User program** | | An error is detected during the program check. The Sysmac Studio checks the program when it is complied. A compiling error occurs at that time. |
| **Communications** | **Writing from Sysmac Studio** | Not supported. |
| | **CIP messages** | A command error occurs. |
| | **Tag data links** | An error occurs when a tag data link starts. The tag data link will continue to operate. However, the values of variables with the Constant attribute are not written. |
| **Input refreshing from slaves and Units** | | An error does not occur and the value is written. |
| **Forced refreshing** | | |

### ● Range for Constant Attribute Specification

The Constant attribute is specified separately for each variable. Set them for all elements and members of array, structure, and union variables.

**Additional Information**

You cannot write to variables with the Constant attribute from the user program.

## Network Publish

The Network Publish attribute allows a variable to be read/written from external devices (other Controllers, host computers, etc.) through CIP message communications or tag data links. If this attribute is not set, you can read/write the variable only from the Controller that declared the variable and external devices (other Controllers, host computers, etc.) cannot read/write that variable.

Variables that have been published to the network are called network variables. There are no restrictions on the number of network variables you can have. You can publish as many variables to the network as you need.

### ● Network Publish Specifications

There are three specifications for publishing variables to the network: Publish Only, Input, and Output. The specifications are given in the following table.

| Network Publish | | Specifications |
|---|---|---|
| Do not publish | | You cannot access a variable with this attribute from external devices. However, Support Software can still access the variable regardless of this setting. |
| Publish | Publish Only | You can access a variable with this attribute from external devices through CIP communications. Tag data links are not possible for variables with this attribute setting. |
| | Input | You can access a variable with this attribute from external devices through CIP communications or a tag data link. For tag data links, this will be a variable for data input (from another CPU Unit to the local CPU Unit). |
| | Output | You can access a variable with this attribute from external devices through CIP communications or a tag data link. For tag data links, this will be a variable for data output (from the local CPU Unit to another CPU Unit). |

### Ranges for Published to the Network

The Network publish attribute is specified separately for each variable. Set them for all elements and members of array, structure, and union variables.

## Edge

The Edge attribute makes the variable pass TRUE to a function block when a BOOL variable changes from FALSE to TRUE or from TRUE to FALSE. You can specify the Edge attribute only for BOOL input variables to function blocks.

### Application

Use the Edge attribute when you want the function block to accept the input only when the input parameter changes from FALSE to TRUE or from TRUE to FALSE. For example, you can use this attribute when you want to execute the function block any time there is a change detected in an input parameter.

### Operation

- If you specify a change to TRUE, the input variable changes to TRUE only when the input parameter connected to that input variable changes from FALSE to TRUE.
- If you specify a change to FALSE, the input variable changes to TRUE only when the input parameter changes from TRUE to FALSE.

| Specification | Value of input parameter | Value of variable |
|---|---|---|
| **Change to TRUE** | FALSE to TRUE | TRUE |
| | Other | FALSE |
| **Change to FALSE** | TRUE to FALSE | TRUE |
| | Other | FALSE |
| **None** | --- | Changes according to the input parameter value. |

## 6-3-9 Changes to Variables for Status Changes

The values of variables in the CPU Unit will change as shown in the following table when the power is turned ON, when the operating mode changes, when the variable table is downloaded, when a major fault level Controller error occurs, or during online editing.

<table>
<tr><th rowspan="2">Retain attribute of variable</th><th rowspan="2">Type of variable</th><th rowspan="2">When power is turned ON</th><th>When operating mode changes</th><th colspan="2">After downloading</th></tr>
<tr><th>Change from PROGRAM to RUN mode or RUN to PROGRAM mode</th><th>When the Clear the present values of variables with Retain attribute Check Box is selected.</th><th>When the check box is not selected.</th></tr>
<tr><td rowspan="3">Non-retain</td><td>User-defined variables and device variables</td><td colspan="4">• If initial values are set, the variables change to the initial values.<br>• If initial values are not set, the variables change to 16#00.</td></tr>
<tr><td>Device variables with AT specifications</td><td colspan="4">16#00</td></tr>
<tr><td>CIO, Work, and Timer memory areas for CJ-series Units</td><td colspan="4">16#00</td></tr>
</table>

<table>
<tr><th rowspan="2">Retain attribute of variable</th><th rowspan="2">Type of variable</th><th rowspan="2">When power is turned ON</th><th>When operating mode changes</th><th colspan="2">After downloading</th></tr>
<tr><th>Change from PROGRAM to RUN mode or RUN to PROGRAM mode</th><th>When the Clear the present values of variables with Retain attribute Check Box is selected.</th><th>When the check box is not selected.</th></tr>
<tr><td rowspan="4">Retain</td><td rowspan="2">User-defined variables</td><td rowspan="4">No change (retains value before power interruption).</td><td rowspan="4">No change (i.e., the values in RUN mode are retained).</td><td>When retain condition* is met, retains value before download.</td><td>When retain condition* is met<br>• If initial values are set, the variables change to the initial values.<br>• If initial values are not set, the variables change to 16#00.</td></tr>
<tr><td>When retain condition* is not met<br>• If initial values are set, the variables change to the initial values.<br>• If initial values are not set, the variables change to 16#00.</td><td>• If initial values are set, the variables change to the initial values.<br>• If initial values are not set, the variables change to 16#00.</td></tr>
<tr><td>Device variables for CJ-series Units</td><td>The value in memory at the specified address, regardless of the retain condition*</td><td>• If initial values are set, the variables change to the initial values.<br>• If no initial values are set, the variables retain their value before the download.</td></tr>
<tr><td>Holding, DM, EM, and Counter memory areas for CJ-series Units</td><td>Retains value before download regardless of retain condition.*</td><td>Retains value before download regardless of retain condition.*</td></tr>
</table>

* Retain condition: Indicates that the following conditions are met both before and after transfer.

- The variable name is the same.
- The data type name and data type size are the same.
- The Retain attribute is specified.

| Retain attribute of variable | Type of variable | When a major fault level Controller error occurs | During online editing | |
|---|---|---|---|---|
| | | | Variable added to a POU for online editing. | Variable in a POU for online editing. |
| Non-retain | **User-defined variables and device variables** | • If initial values are set, the variables change to the initial values.<br>• If initial values are not set, the variables change to 16#00. | • If initial values are set, the variables change to the initial values.<br>• If initial values are not set, the variables change to 16#00. | No change |
| | **CIO and Work memory areas for CJ-series Units** | 16#00 | No change | |
| Retain | **User-defined variables and device variables** | No change (retains value before error). | • If initial values are set, the variables change to the initial values.<br>• If initial values are not set, the variables change to 16#00. | |
| | **Holding, DM, and EM memory areas for CJ-series Units** | | No change | |
| Others | **Forced refreshing status** | Cleared. | No change | |

## 6-3-10 Function Block Instances

Function block instances are added to and displayed in the local variable table as a data type.

**Additional Information**

A function block instance is treated as a local variable (i.e., internal variable) of the program in which the instance is created. As such, the instance is added to and displayed in the local variable table of the program. You cannot treat these instances as global variables.

## 6-3-11 Monitoring Variable Values

You can monitor the value of variables from a Watch Tab Page on the Sysmac Studio.

**1** Select ***Watch Tab Page*** from the View Menu. The Watch Tab Page is displayed.

**2** Establish an online connection with the Controller and register the variables in one of the following ways.

**(1) Enter the variable in the name cell in the Watch Tab Page.**

**(2) Drag variables to the Watch Tab Page from an editor or variable table.**

**3** The present values of the variables are displayed.

## 6-3-12 Restrictions on Variable Names and Other Program-related Names

The following is a list of restrictions on program-related names.

### Character Restrictions

| Program-related name | Applicable characters | Reserved words | Multibyte character compatibility | Case sensitivity | Maximum size (not including NULL) | Character encoding |
|---|---|---|---|---|---|---|
| Variable name (including POU instance names) | ● Usable characters<br>• 0 to 9, A to Z, and a to z<br>• Single-byte kana<br>• _ (underlines)<br>• Multibyte characters (e.g., Japanese)<br>Refer to *Reserved Words* below for a list of the reserved words.<br>● Characters that cannot be used together<br>• A text string that starts with a number (0 to 9)<br>• Strings that start with "P_"<br>• A text string that starts in an underline (_) character<br>• A text string that contains more than one underline (_) character<br>• A text string that ends in an underline (_) character<br>• Any text string that consists of an identifier and has a prefix or postfix which contains more than one extended empty space character (i.e., multi-byte spaces or any other empty Unicode space characters) | Refer to *Reserved Words* below. | Supported. | Not case sensitive. | 127 bytes | UTF-8 |
| POU definition names | | | | | | |
| Data type | | | | | | |
| Structure member names and union member names | | | | | | |
| Enumerators | | | | | | |
| Task names | | | | | 63 bytes | |
| Full paths of variable names | | | | | Network variable: 255 bytes<br>Other: 511 bytes | |
| Device names | | | | | 127 bytes | |
| Section names | | | | Case sensitive. | | |
| Axis names | | | | Not case sensitive. | | |
| Axes group names | | | | | | |
| Cam table names | | | | | | |

### Reserved Words

If any names are the same as a reserved word, an error will occur when you check the program.

### Names That Must Be Unique

The following names must be unique. An error is detected during the program check if they are not.

- Global variable names in the same CPU Unit
- Variable names in the same POU
- Section names in the same POU
- Member names in the same union or structure
- Enumerators in the same enumeration
- Local variable names and global variable names
- POU names and data type names
- Data type names and variable names
- Enumerators of an enumeration and enumerators of another enumeration
- Enumerators and variable names

# 6-4 Constants (Literals)

This section describes constants in detail.

## 6-4-1 Constants

The value of a variable changes depending on the data that is assigned to that variable. The value of a constant never changes. Unlike variables, constants are not stored in memory. You can use constants in the algorithm of a POU without the need to declare them. In the NJ-series Controllers, constants have a data type in the same way as variables,

## 6-4-2 Types of Constants

The following types of constants can be used with NJ-series Controllers.

- Bits
- Numbers
- Bit strings
- Times
- Text strings

The following tables show how to express different variables in an NJ-series Controller.

### Bits

| Notation | Example | Remarks |
|---|---|---|
| TRUE or FALSE | TRUE or FALSE | TRUE is equivalent to BOOL#1.<br>FALSE is equivalent to BOOL#0. |
| {*data_type*}#{*numeric_value*] | BOOL#1 or BOOL#0 | |

**Precautions for Correct Use**

You cannot express a BOOL value as 0 or 1. A compiling error will occur.

Example: Wrong: *BOOL_variable*:=1;
Correct: *BOOL_variable*:=TRUE; or *BOOL_variable*:=BOOL#1;

### Numbers

#### ● Integers

| Notation | Example | Remarks |
|---|---|---|
| {*data_type*}#{*base*}#{*numeric_value*] | INT#10#–1 | • Data types: SINT, USINT, INT, UINT, DINT, UDINT, LINT, or ULINT<br>• Base: 2, 8, 10, or 16 |
| {*data_type*}#{*numeric_value*] | INT#–1 | This is interpreted as decimal data. |

**Note** You cannot omit {*data_type*}# and just enter {*base*}#{*numeric_value*]. Any variables that are entered in that form for instruction parameters result in errors.
Example: You cannot enter only *#16#1A*.
You cannot enter just {numeric_value]. Any variables that are entered in that form for instruction parameters result in errors.
Example: You cannot enter only *–1*.

### Real Data

| Notation | Example | Remarks |
|---|---|---|
| {*data_type*}#{*base*}#{*numeric_value*] | LREAL#10#–3.14 | Data types: REAL or LREAL<br>Base: 10 |
| {*data_type*}#{*numeric_value*] | LREAL#–3.14 | This is interpreted as decimal data. |
| {*numeric_value*} | –3.14 | If {*data_type*} is omitted, the value is interpreted as LREAL decimal data. |

**Note** Express real-number variables as *REALnumeric_value*.
Example: Correct: *REAL_variable*:= REAL#3.14
Wrong: *REAL_variable*:=3.14;

## Bit Strings

### Bit String Data

| Notation | Example | Remarks |
|---|---|---|
| {*data_type*}#{*base*}#{*numeric_value*] | WORD#16#0064 | • Data types: BYTE, WORD, DWORD, or LWORD<br>• Base: 2, 8, or 16 |

**Note** Express bit string data as bit_string_data_type#base#numeric_value.
Example: Correct: *bit_string_variable*:=WORD#16#3
Wrong: *bit_string_variable*:=3

**Precautions for Correct Use**

- You cannot compare the sizes of bit string data types (BYTE, WORD, DWORD, and LWORD). You must convert variables of these types to an integer data type with a data conversion instruction (e.g., WORD_TO_UNIT) before you can compare the values.
  Example:
  BCD_data : WORD
  IF WORD_BCD_TO _UNIT(BCD_data)> UINT#1234 THEN
- You cannot perform logic processing on integer data types (SINT, INT, DINT, LINT, USINT, UINT, UDINT, and ULINT). You must convert variables of these types to a bit string data type with a data conversion instruction (e.g., INT_TO_WORD) before you can perform logic operations.
  Example:
  a : INT
  IF INT_TO_WORD(a) AND WORD#16#0001 THEN (*When *a* is odd*)

## Time-related Data

### Durations

| Notation | Example | Remarks |
|---|---|---|
| TIME#{*day*}d{*hour*}h{*minutes*}m{*seconds*}s{*milliseconds*}ms | TIME#61m5s | • You can also include decimal points such as in "T#12d3.5h".<br>• You can also include numerical values that are greater than the valid range of times. For example, T#-61m5s expresses the same time as T#-1h1m5s.<br>• The numerical value is interpreted as a decimal number. If any number that is not a decimal number is used, a compiling error will occur.<br>• You can specify the order of the time any way you want. For example, "TIME#1h_2d" is a valid expression. |
| T#{*day*}d{*hour*}h{*minutes*}m{*seconds*}s{*milliseconds*}ms | T#61m5s | As long as there is at least one of the following: {*day*}, {*hour*}, {*minutes*}, {*seconds*}, {*milliseconds*}, no compiling error will occur. |

### Dates

| Notation | Example | Remarks |
|---|---|---|
| DATE#{*year*}-{*month*}-{*day*} | DATE#2010-1-10 | • You can add one or more zeroes to the beginning of the year, month, and day. For example, D#2010-1-10 expresses the same date as D#2010-01-10.<br>• A compiling error will occur if you specify any numerical value that overflows the valid dates. For example, D#2010-01-35 will cause an error.<br>• The numerical value is interpreted as a decimal number. If any number that is not a decimal number is used, a compiling error will occur. |
| D#{*year*}-{*month*}-{*day*} | D#2010-1-10 | |

### Times of Day

| Notation | Example | Remarks |
|---|---|---|
| TIME_OF_DAY#{*hour*}:{*minutes*}:{*seconds*} | TIME_OF_DAY#23:59:59.999999999 | • You can add one or more zeroes to the beginning of the hour, minute, and second. For example, D#23:1:1: expresses the same date as D#23:01:01.<br>• A compiling error will occur if you specify any numerical value that overflows valid times. For example, D#24:00:00 will cause an error.<br>• The numerical value is interpreted as a decimal number. If any number that is not a decimal number is used, a compiling error will occur. |
| TOD#{*hour*}:{*minutes*}:{*seconds*} | TOD#23:59:59.999999999 | |

### Dates and Times

| Notation | Example | Remarks |
|---|---|---|
| DATE_AND_TIME#{*year*}-{*month*}-{*day*}:{*hour*}:{*minutes*}:{*seconds*} | DATE_AND_TIME#2010-10-10-23:59:59.123 | This is the same as the date data and time data types. |
| DT#{*year*}-{*month*}-{*day*}:{*hour*}:{*minutes*}:{*seconds*} | DT#2010-10-10-23:59:59.123 | |

## Text Strings

### ● Text String Data

| Notation | Example | Remarks |
|---|---|---|
| 'String' | 'This is a string' | • Enclose the string in single-byte single quotation marks (').<br>• If you want to insert tabs, line break codes, or other special characters, you can use a dollar sign ($) as an escape character before them. (Refer to the following table.)<br>• You can also specify a string with 0 characters.<br>• As in the following example, a compiling error will occur if you specify any strings that span across multiple lines.<br>strVar := 'ABC<br>DEF' |

#### Escape Character List

| Escape character | Name | Meaning |
|---|---|---|
| $$ | Single-byte dollar sign | Single-byte dollar sign ($: character code 0x24) |
| $' | Single-byte single quotation mark | Single-byte single quotation mark (': character code 0x27) |
| $L or $l | Line feed | Moves the cursor to the next line.<br>LF control character (line feed: character code 0x0A) |
| $N or $n | Vertical tab | Moves the cursor to the next line.<br>NL control character (vertical tab: character code 0x0B) |
| $P or $p | Form feed | Moves the cursor to the next page.<br>FF control character (form feed: character code 0x0C) |
| $R or $r | Carriage return | Moves the cursor to the start of the line.<br>CR control character (carriage return: character code 0x0D) |
| $T or $t | Horizontal tab | Indicates a tab.<br>Tab character (character code 0x09) |
| $" | Single-byte double quotation mark | Outputs a single-byte double quotation mark (character code 0x22). |
| $(*two-digit hexadecimal number*) | Direct character code specification | Specify the character code as two-digit hexadecimal in parentheses. Character codes are two-digit hexadecimal numbers that range from 00 to FF.<br>For example, "$L" is the same as "$0A". UTF-8 character codes cannot be expressed in a single byte. But, for example, the character code for the Japanese character 'あ' is 0xE38182 which can be represented as '$E3$81$82'. |

# 6-5 Programming Languages

This section describes the programming languages in detail. Refer to the *Sysmac Studio Version 1 Operation Manual* (Cat. No. W504) for details on entering programs with the Sysmac Studio.

## 6-5-1 Programming Languages

The languages used to express the algorithms in a POU (program, function, or function block) are called the programming languages. There are two different programming languages that you can use for an NJ-series Controller: ladder diagram language (LD) and ST (structured text) language.

## 6-5-2 Ladder Diagram Language

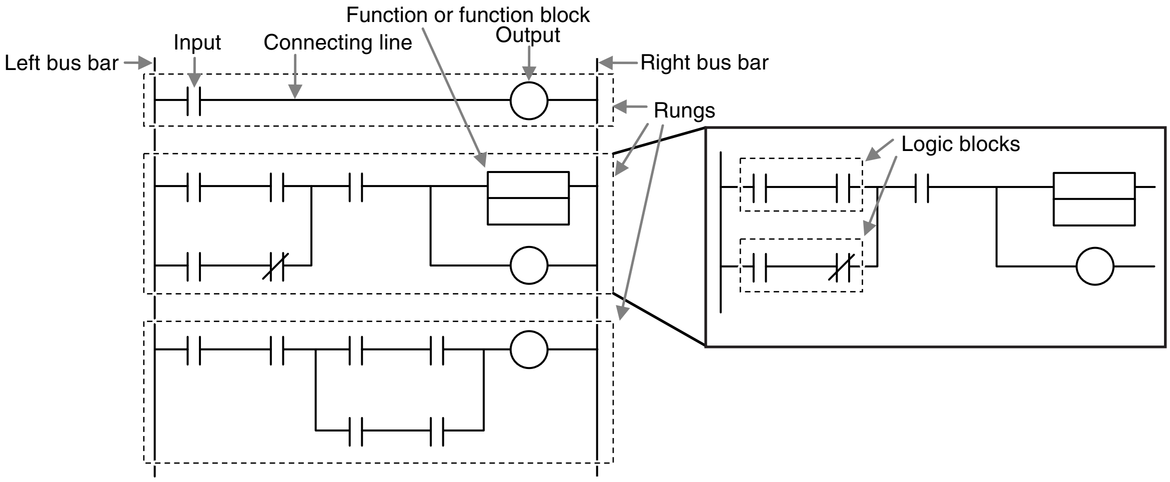
The ladder diagram language (LD) is a graphical programming language that is written in a form that appears similar to electrical circuits. Each object for processing, including functions and function blocks, is represented as a diagram. Those objects are connected together with lines to build the algorithm. Algorithms that are written in the ladder diagram language are called ladder diagrams.

### General Structure of the Ladder Diagram Language

A ladder diagram consists of left and right bus bars, connecting lines, ladder diagram structure elements (e.g., inputs and outputs), functions, and function blocks.*

* Only Jump instructions and Label instructions are expressed with symbols that indicate the jumps and labels.

Algorithms are made of multiple rungs connected together. A rung is a connection of all configuration elements between the left bus bar and the right bus bar. A program rung consists of logic blocks that begin with an LD/LD NOT instruction that indicates a logical start.




- **Bus Bars**

The vertical lines on the left and right sides of a ladder diagram are called the bus bars. These bus bars always have a status of either TRUE or FALSE. If you think of the ladder diagram as an electrical circuit, these states represent the flow of current through the circuit. When a POU that is written as a ladder diagram is executed, the value of the left bus bar changes to TRUE. As a result, all inputs and other configuration elements connected to the left bus bar also become TRUE. Execution progresses as elements to the right are also changed to TRUE based on the operation of these configuration elements. This cascade of the TRUE state is called the "power flow." The left bus bar is the source of this power flow.

- **Connecting line**

The straight horizontal lines that connect the bus bar and the configuration elements are called connecting lines. Connecting lines can be either TRUE or FALSE and can transfer the power flow from the left to the right.

- **Inputs**

Inputs are placed along the connecting line to receive the power flow and operate accordingly. There are several different types of inputs and, depending on their specifications, they will either transfer the power flow from the left to the right or prevent the power flow from passing through. When an input transfers the power flow to the right, the connecting line to the right of the input will become TRUE. If the power flow is inhibited, the connecting line to the right of the input will remain FLASE. For detailed specifications on inputs, refer to the *NJ-series Instructions Reference Manual* (Cat. No. W502).

- **Output**

Outputs are placed along the connecting line to receive the power flow and operate accordingly. An output writes the TRUE or FALSE value to a variable. There are different types of outputs. For detailed specifications on outputs, refer to the *NJ-series Instructions Reference Manual* (Cat. No. W502).

- **Functions and Function Blocks**

Functions and function blocks are placed along the connecting line to receive the power flow and operate accordingly. For detailed instruction specifications, refer to the *NJ-series Instructions Reference Manual* (Cat. No. W502).

## Order of Execution for Ladder Diagrams

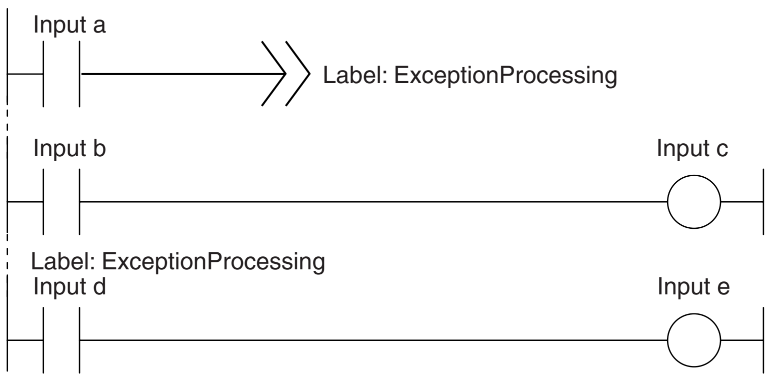
Inputs, outputs, functions, and function blocks are executed when they receive the power flow. The order of execution for a ladder diagram is from top to bottom. Elements at the same level are executed from left to right.

## Ladder Diagram Completion

A ladder diagram is executed in order from top to bottom. When the execution reaches the very bottom, the process is completed. However, the process will also end if an END or RETURN instruction is encountered at any point during the process. No processes after those instructions are executed.

## Controlling Execution of Ladder Diagrams

Ladder diagrams are generally executed from top to bottom, but you can use execution control instructions to change the execution order. In the following example, when the value of program input a changes to TRUE, execution will move to the point labeled ‘ExceptionProcessing.’



## Connecting Functions and Function Blocks in a Ladder Diagram

### ● Connection Configurations

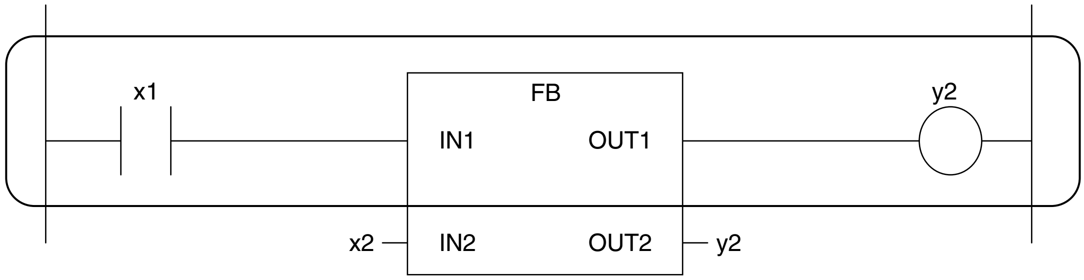
You use the following two types of connections for functions or function blocks.

#### 1) Power Flow Input and Output

In a ladder diagram, the line that connects an input variable of a function or function block and the left bus bar indicates a BOOL input and the line that connects an output variable to the right bus bar indicates a BOOL output.

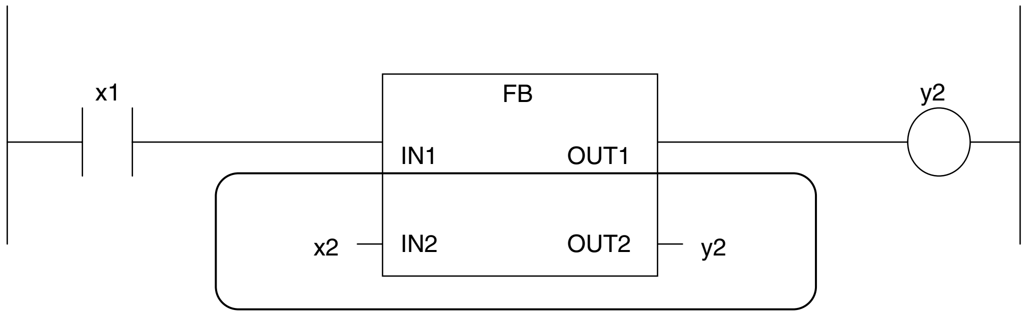
Example:

Inputs are connected in the power flow that connects to the left bus bar. Outputs are connected in the power flow that connects to the right bus bar.




#### 2) Parameter Inputs and Parameter Outputs

In a ladder diagram, parameter inputs and outputs are specified when the input and output variables of a function or function block are not connected to the left and right bus bars.



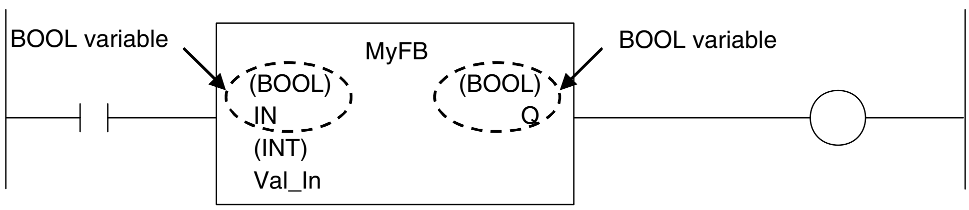

As shown below, you can specify either variables or constants for input and output parameters.

| Function/function block variables | Input parameters | Output parameters |
|---|---|---|
| Input variables | You can specify variables or constants. | --- |
| Output variables | --- | You can specify only variables. |
| In-out variables | You can specify only variables. | You can specify only variables. |

### ● Number of BOOL Variables

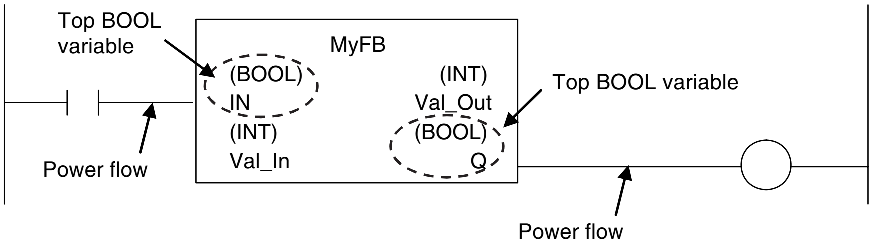
At least one BOOL variable each is required for the input and the output (such as EN and ENO) of a function or function block.

Example:

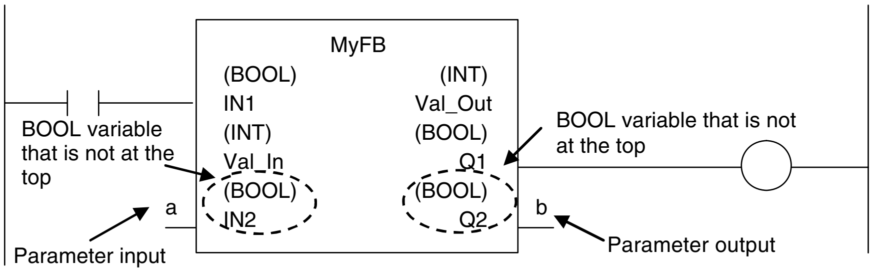


## ● Connections Based on the BOOL Variable Positions

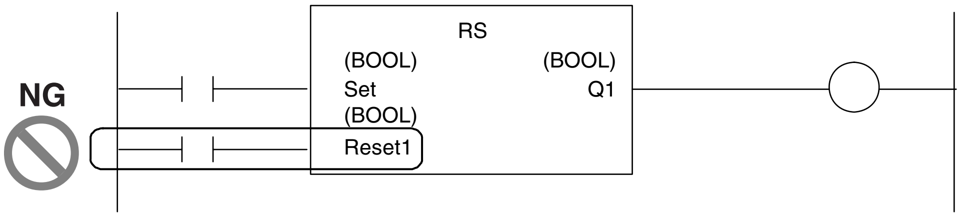
The top BOOL variables are connected to the left and right bus bars. In other words, they become the power flow input and power flow output.

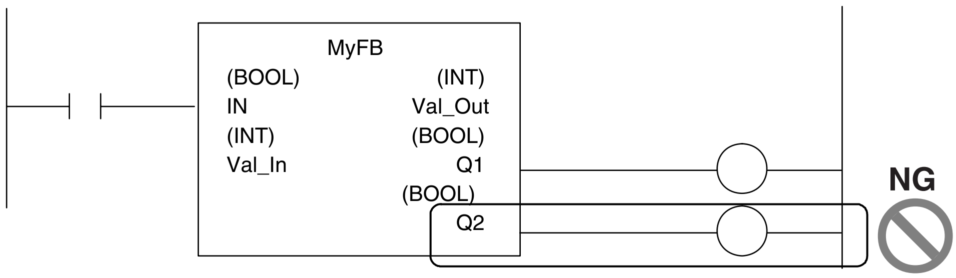



There is only one power flow input and one power flow output for each function or function block. All other BOOL variables that are not at the top are for parameter inputs and parameter outputs.

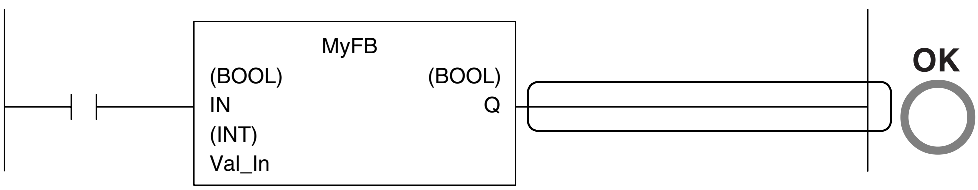



You cannot connect multiple BOOL variables to the left bus bar or the right bus bar as shown below.

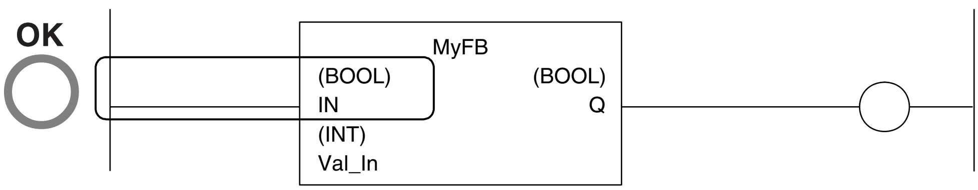



You do not have to connect an OUT instruction to the right bus bar. You can connect the function or function block directly.



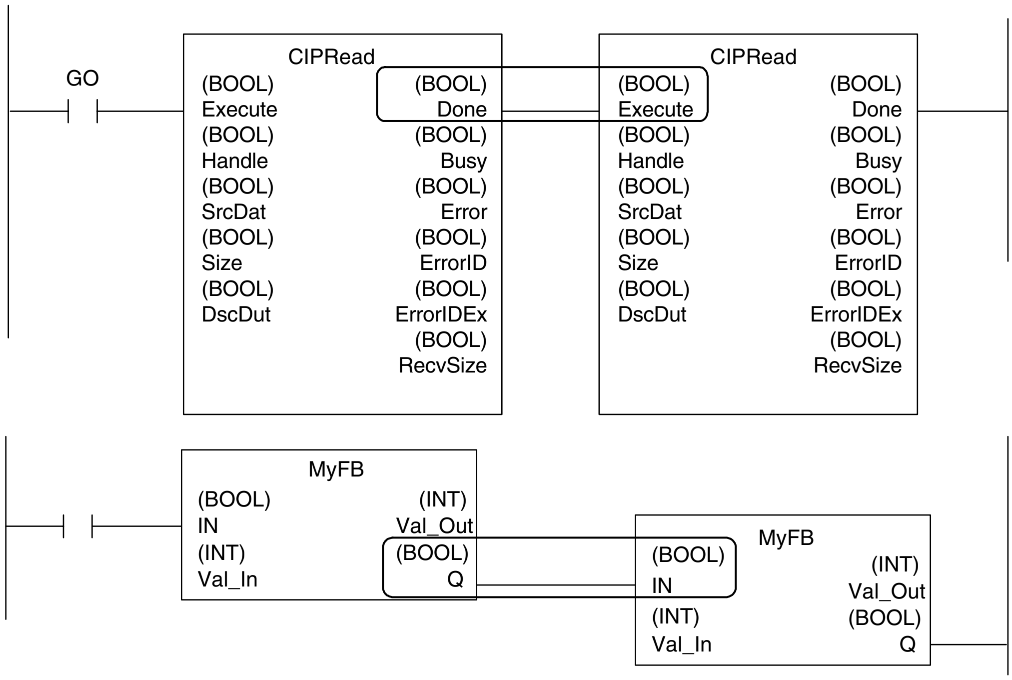

A LD instruction is not necessarily required. You can also connect directly to the left bus bar.



### ● Cascade Connections

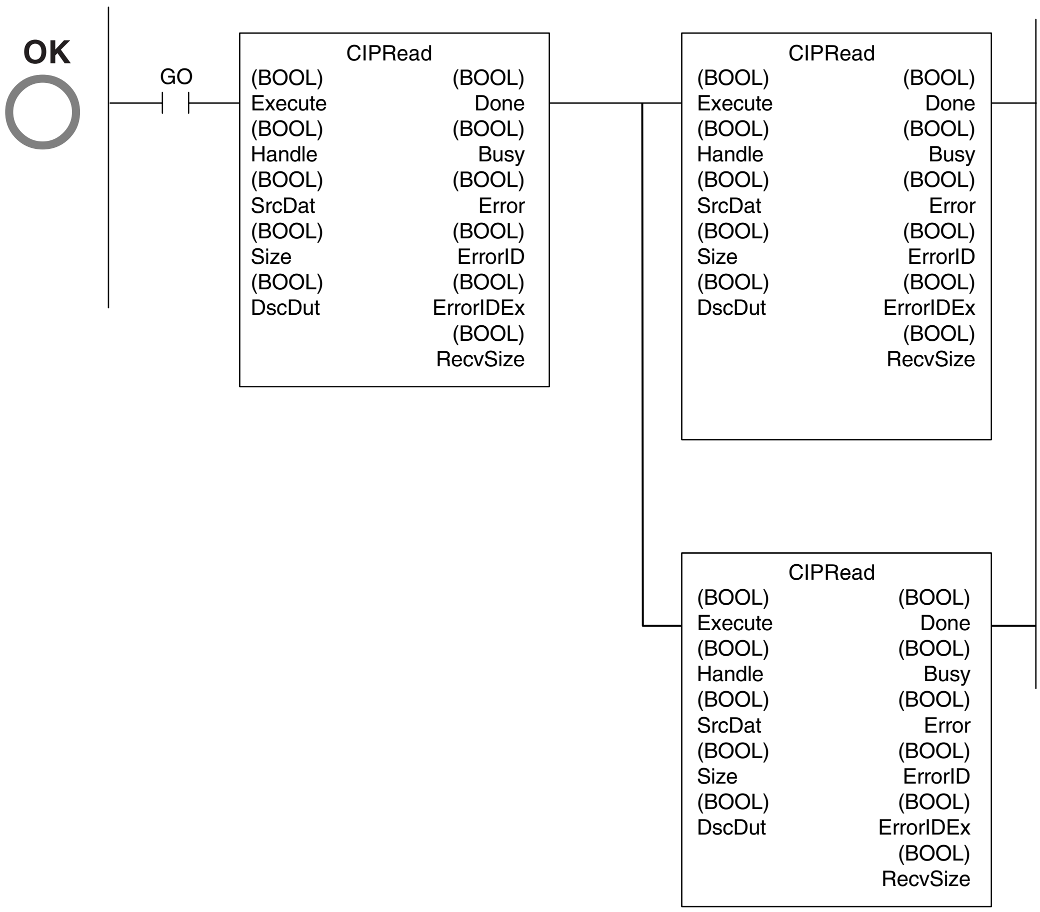
Cascade connections in which the output of a function or function block is connected to the input of another function or function block are allowed only for power flow outputs and inputs.

Example:




### You can branch the power flow output.

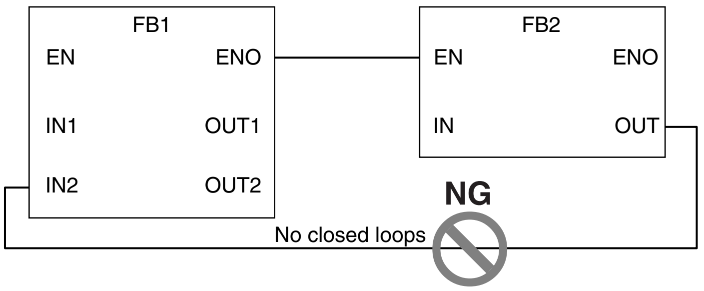
Example:



**Restriction**

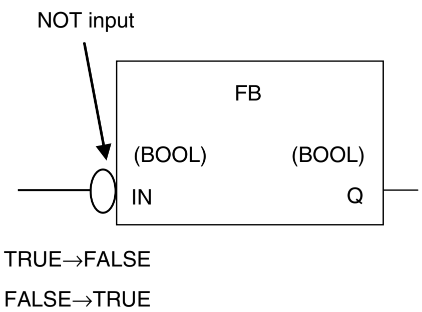
- You cannot create closed loops or intersect connecting lines.

Example:




## ● NOT Inputs

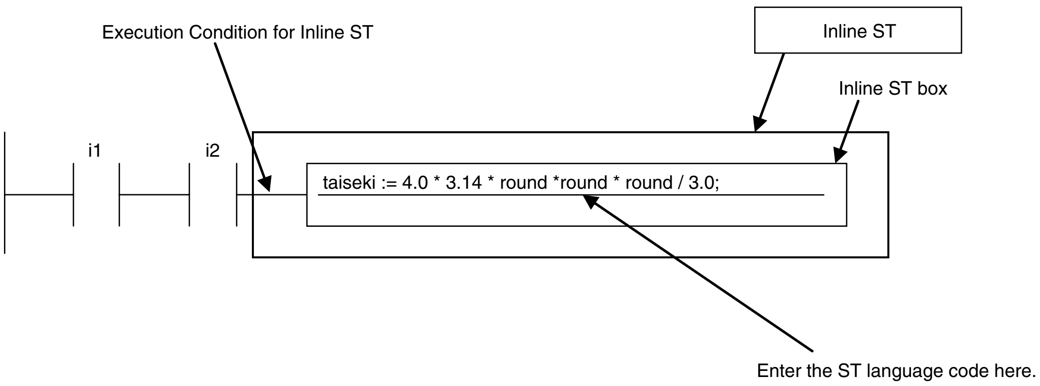
BOOL parameters can be inverted for inputs.




# Inline ST

## ● Introduction

Inline ST is a ladder diagram programming element in which you can write ST language code in a box called an inline ST box (a blank text input area) within a ladder diagram. This allows you to easily code numeric data processing and text string processing within ladder diagrams. The connecting line to an inline ST box becomes its execution condition. The ST code inside of the box is executed based on that connecting line. Refer to the following figure.




Inline ST is treated as a rung element in a ladder diagram. Therefore, unlike functions and function blocks, they have no input, output, or in-out variables.

## ● Restrictions for Inline ST

You can write ST language code in inline ST boxes.

## ● Execution Conditions for Inline ST

The execution conditions for inline ST are shown in the following table.

| Status | Operation |
|---|---|
| TRUE execution condition | Operation follows the execution condition. You can use the execution condition at any point in the power flow (e.g., you can connect the inline ST directly to the left bus bar). To specify a change to TRUE or a change to FALSE, specify it for an input in the execution condition. |
| FALSE execution condition | Nothing is done. |
| Resetting in a master control region | Nothing is done. |

## ● Scope of Variables in Inline ST

The scope of variables that you can access from inline ST is the same as the POU of the ladder diagram that contains the inline ST.

## ● Restrictions for Inline ST

| Item | Description |
|---|---|
| Number of inline ST boxes per rung | 1 |

# 6-5-3 Structured Text Language

The ST (structured text) language is a high-level language code for industrial controls (mainly PLCs) defined by the IEC 61131-3 standard. The standard control statements, operators, and functions make the ST language ideal for mathematical processing that is difficult to write in ladder diagrams. The features of ST are described below.

- Loop constructs and control constructs such as IF THEN ELSE are provided.
- You can write programs like high-level languages such as C, and you can include comments to make the program easy to read.

```

// Determine TableNo
FOR i:=0 TO ItemNum DO

    IF (MinNo[i] <= ItemBox[i]) AND (ItemBox[i] <= MaxNo[i]) THEN   // Normal
        TableNo[i] := ItemBox[i];
        RangeOK[i] := TRUE;

    ELSIF (ItemBox[i] > MaxNo[i]) THEN                              // Upper
        TableNo[i] := MaxNo[i];
        RangeOK[i] := FALSE;

    ELSE                                                            // Lower
        TableNo[i] := MinNo[i];
        RangeOK[i] := FALSE;

    END_IF;

END_FOR;
```

## Structure of ST

ST code consists of one or more statements. One statement is the equivalent of one process. Statements are executed from top to bottom, one line at a time, until the process is completed. Statements are made up of keywords and expressions. A keyword is a symbol or string that expresses assignment or execution control. An expression is a code that calculates a value from variables, constants, function return values, and/or a combination of those, along with various operators. A statement represents a process that completes by itself. Expressions form a statement by using a combination of values and keywords.

Example of an Assignment Statement:

Assignment keyword Variables Operators Constant Return value of function

Comment

A:= B + 100 * ABC (10, 20) ; (*Assign A to B + 100 * ABC (10, 20)*)

Expression

Example of an IF Construct:

IF keyword IF keyword

IF D = E + 100 * DEF(10,20) THEN

Expression

(*TRUE if *D* and E+100*DEF(10,20) are equal, otherwise FALSE*)

G := H ;

Statement IF keyword

END_IF ;

## ST Language Expressions

### Statement Separators

- Statements must end with a single-byte semicolon (;). Statements are not considered complete with only a carriage return at the end. This allows you to write long statements across multiple lines.
- One statement must end with one single-byte semicolon (;). In the following example, the IF construct contains a single assignment statement. Each statement must be ended with a single-byte semicolon (;).

IF A=B THEN

C := D; Assignment statement

END_IF

IF construct

### Comment

- You can write comments in your program to make the code easier to understand.
- Statements written as comments are not executed.

- The two methods to insert comments are described below.

| Comment notation | Examples | Remarks |
|---|---|---|
| Enclose the comment in single-byte parenthesis and asterisks, for example, "(*This is a comment*)". | (* Commenting out multiple lines<br>IF ErrCode = 3 THEN<br>Value := 1000;<br>END_IF;<br>down to here. *) | This type of comment can span over multiple lines. Comments cannot be nested. |
| Begin the comment with two forward slashes (//) and end it with a carriage return. | // Comment<br>// A := SIN(X)^2; | You can comment out only single lines. |

## ● Spaces, Carriage Returns, and Tabs

- You can place any number of spaces, carriage returns, and tabs in your code at any location. This allows you to add spaces or tabs before statements and carriage returns between operators/keywords and expressions in order to make your code easier to read.
- Always enter a token separator, such as a space, carriage return, or tab, between operators/keywords and variables.

Example: The square boxes indicate where you must insert a token separator, such as a space, carriage return, or tab.

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

## ● Lowercase/Uppercase, Single-byte/double-byte Characters

- Operators, keywords, and variable names are not case sensitive.
- Operators, keywords, and variable names must always be in single-byte characters. A syntax error will occur if you input double-byte characters.

## ● Variables and Prohibited Characters

Refer to *6-3-12 Restrictions on Variable Names and Other Program-related Names* for restrictions on variable names.

## ● Text Strings

Refer to *6-3-12 Restrictions on Variable Names and Other Program-related Names* for restrictions on text strings.

## ST Keywords and Operators

### Statement Keywords

| Keyword | Meaning | Example |
|---|---|---|
| := | Assignment | d := 10; |
| | Calling functions and function blocks | FBname(para1 := 10, para2 := 20);<br>Refer to *Function Block Calls* on page 6-94. |
| RETURN | Return | |
| IF | If | IF d < e THEN f := 1;<br>ELSIF d = e THEN f :=2;<br>ELSE f := 3;<br>END_IF; |
| CASE | Case | CASE f OF<br>1: g :=11;<br>2: g :=12;<br>ELSE g :=0;<br>END_CASE; |
| FOR | For | FOR i = 100 TO 1 BY -1 DO<br>    Val[ i ] := i;<br>END_FOR; |
| WHILE | While | WHILE Val < MaxVal DO<br>  Val := Val + 1;<br>END_WHILE; |
| REPEAT | Repeat | REPEAT<br>    Val := Val + 1;<br>UNTIL( Val > 4 )<br>END_REPEAT; |
| EXIT | Exit the loop. | FOR i := 1 TO 100 DO<br>   FOR j := 1 TO 10 DO<br>        IF Val[ i, j ]>100 THEN EXIT;<br>        END_IF;<br>    END_FOR;<br>END_FOR; |
| ; | Empty statement | Val[ i ] := i<br>  ; (* Empty statement *)<br><br>WHILE(Var <>0) DO<br>  ; (* Empty statement *)<br>END_WHILE; |
| (* Text *) | Comments | (* Commenting out multiple lines<br>IF MyFun (ErrorCode) = 3<br>  THEN  ReturnValue := GetDetail();<br>END_IF;<br>down to here. *) |
| //Text | Comment | A := SIN( X ) ^ 2 + COS ( Y ) ^2 + 10;<br>// A := SIN( X ) ^ 2 + COS ( Y ) ^2 + 5; |

## ● Operators

| Operation | Operator | Notation example and evaluated value | Priority<br>1: Highest<br>11: Lowest |
|---|---|---|---|
| Parentheses | () | (1+2)*(3+4)<br>Value: 21 | 1 |
| Function/function block call | | CONCAT('ABC','DEFG') | 2 |
| Exponent | ** | 1**2<br>Value: 1 | 3 |
| NOT | NOT | NOT TRUE<br>Value: FALSE | 4 |
| Multiplication | * | 100*200<br>Value: 20,000 | 5 |
| Division | / | 100/200<br>Value: 0.5 | |
| Remainder | MOD | 10 MOD 7<br>Value: 3<br><br>–17 MOD 6<br>Value: –5<br><br>–17 MOD (–6)<br>Value: –5<br><br>17 MOD 6<br>Value: 5<br><br>17 MOD (–6)<br>Value: 5 | |
| Addition | + | 100+200<br>Value: 300 | 6 |
| Subtraction | – | 100-200<br>Value: –100 | |
| Comparison | <, >, <=, >= | 100<200<br>If the comparison result is TRUE, the value is set to TRUE. Otherwise, the value is set to FALSE. In the above example, 100 is less than 200, so the value is TRUE. | 7 |
| Matches | = | 100=200<br>If the two values match, the value is set to TRUE. Otherwise, the value is set to FALSE. In the above example, 100 does not equal 200, so the value is FALSE. | 8 |
| Does not match | < > | 100<>200<br>If the two values do not match, the value is set to TRUE. Otherwise, the value is set to FALSE. In the above example, 100 does not equal 200, so the value is TRUE. | |

| Operation | Operator | Notation example and evaluated value | Priority 1: Highest 11: Lowest |
|---|---|---|---|
| Logical AND | AND,& | Applies 1-bit AND logic to all bits.<br>The results of 1-bit AND logic are as follows:<br>0 AND 0 = 0<br>0 AND 1 = 0<br>1 AND 0 = 0<br>1 AND 1 = 1<br><br>0101 AND 1100<br>Value: 0100 | 9 |
| Logical exclusive OR | XOR | Applies 1-bit exclusive OR logic to all bits.<br>The results of 1-bit exclusive OR logic are as follows:<br>0 XOR 0 = 0<br>0 XOR 1 = 1<br>1 XOR 0 = 1<br>1 XOR 1 = 0<br><br>0101 XOR 1100<br>Value: 1001 | 10 |
| Logical OR | OR | Applies 1-bit OR logic to all bits.<br>The results of 1-bit OR logic are as follows:<br>0 OR 0 = 0<br>0 OR 1 = 1<br>1 OR 0 = 1<br>1 OR 1 = 1<br><br>0101 OR 1100<br>Value: 1101 | 11 |

### If operators with different priorities are mixed, the operators with the highest priorities are executed first.

Example: X:=(1+2)–3*4; In this case, X is assigned a value of –9.

Calculations are performed based on the data types. For example, the result of calculations with INT data will be INT data. If the expression *A/B* is calculated with INT variables *A*=3 and *B*=2, the result would not be 1.5 because all values after the decimal point are truncated. Thus, in this case the expression (A/B)*2 would evaluate to 2 instead of 3. Use it with caution.

## ● Data Types for Operator Operands

If all the operands for an operator have the same data type, any data type given as “Supported” in the following table can be set as operands. However, if an operand with a different data type is set for the operator, an implicit cast is required. Refer to *Implicit Casts*, following the table, for details on implicit casting.

| Data type | Assignment operator | Argument setting operator | Numeric operators | Modulo-division operator | Power operator | Comparison operators | Equality operators | Logic operators | Positive/negative signs |
|---|---|---|---|---|---|---|---|---|---|
| | := | :=<br>=> | +<br>–<br>*<br>/ | MOD | ** | <<br><=<br>=><br>> | =<br><> | NOT<br>AND<br>&<br>OR<br>XOR | +<br>– |
| Boolean | OK | OK | --- | --- | --- | --- | OK | OK | --- |
| Bit string | OK | OK | --- | --- | --- | --- | OK | OK | --- |
| Integer | OK | OK | OK | OK | OK | OK | OK | --- | OK |
| Real number | OK | OK | OK | --- | OK | OK | OK | --- | OK |
| Duration | OK | OK | --- | --- | --- | --- | --- | --- | OK |
| Date | OK | OK | --- | --- | --- | --- | --- | --- | --- |
| Time of day | OK | OK | --- | --- | --- | --- | --- | --- | --- |
| Date and time | OK | OK | --- | --- | --- | --- | --- | --- | --- |
| Text string | OK | OK | --- | --- | --- | ---* | ---* | --- | --- |
| Enumeration | OK | OK | --- | --- | --- | --- | OK | --- | --- |
| Structure parent | OK | OK | --- | --- | --- | --- | --- | --- | --- |
| Array parent | OK | OK | --- | --- | --- | --- | --- | --- | --- |

OK: Possible

---: A compiling error will occur.

* Do not use operators to compare text string variables. Use instructions (such as EQascii) instead.

## ● Implicit Casts

If the data types of the operands do not match, as shown below, the data types are converted automatically according to the implicit cast rules. If the implicit cast rules are not satisfied, a compiling error occurs.

**(1) When the data types of the operands in the expression on the right side of the assignment statement are not the same**

**(2) When the data types of the operands on the right and left sides of the assignment statement are not the same**

Example: Assignment Statement Where the Right Side is an Arithmetic Expression

$$A := \underbrace{B + C - D}_{(1)}$$

(2)

**(3) When the data types of the operands in statement are not the same**

Example: Integer Expression in a Statement

```
CASE A+B OF
  INT#1:          (3)
  def:=INT#10
```

## Casting Rules When the Right-hand Side of an Assignment Statement Is an Arithmetic Expression

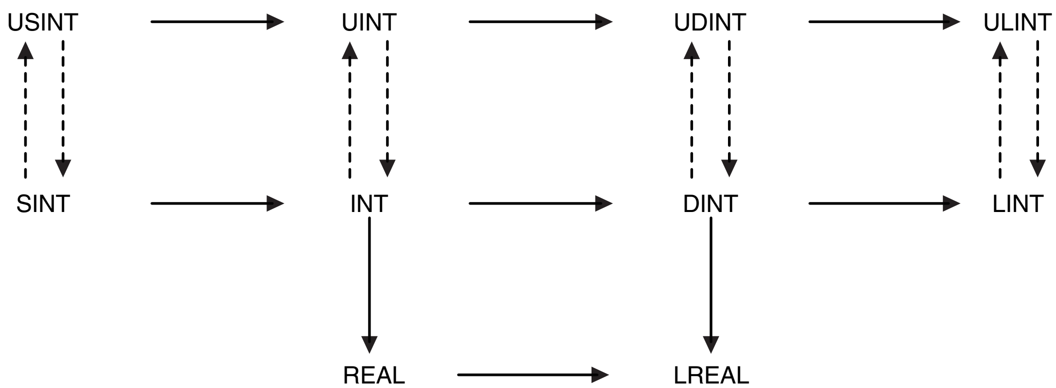
- For the right-hand operand, you can use any combination of the data types that are supported for the operator operand.
- Of the operands on the right side, the operand with the highest rank is considered the data type of the entire side. (Refer to the *Data Type Ranking Table* given below for the data type ranks.)
- If both an unsigned integer and a signed integer with the same ranks exist on the right side, the data type of the right side is considered to be unsigned.

Data Type Ranking Table:
The higher the rank, the larger the range (absolute values and precision) of numerical values that the data type can express.

| Rank | Data type |
|---|---|
| 1 | USINT, SINT, and BYTE |
| 2 | UINT, INT, and WORD |
| 3 | REAL |
| 4 | DINT, UDINT, and DWORD |
| 5 | LREAL |
| 6 | LINT, ULINT, and LWORD |

## Casting Rules When You Assign the Right-hand Value to the Left-hand Side

In the following chart, a cast is performed if an arrow connects the data type of the source to the data type of the assignment destination. Any combination that is not connected will cause a compiling error.




When you assign the value, the sign and absolute value of the number do not change.

When you assign the value, the sign and absolute value of the number may change.
Example: intVar := -1; (* intVar := 16#FFFF *)
uintVar := 1;
uintVar := intVar; (* uintVar:= 16#FFFF, or –1 was assigned but the result is 65535 *)

Even if the arrow does not connect directly to a data type, you can still perform assignments for the data types. For example, SINT->USINT->UINT->UDINT->ULINT are all connected, so you can write an assignment such as ULINT:=SINT.

### Casting Rules in Expressions in Statements

The implicit cast rules for right-hand arithmetic expressions in assignment statements and for assigning the value of the right-hand side to the left-hand side also apply to expressions in statements.

Example:

```
CASE (A+B+C) OF
    Result1:
        to
    ResultN:
        to
END_CASE;
```

## ST Language Statements

- **Assignment**

### Overview:

This statement assigns the right side (i.e., the value of the expression) to the left side (i.e., the variable).

### Reserved Words:

:=

Combination of a colon (:) and an equals sign (=)

### Statement Structure:

```
<variable>:=<expression>;
<variable>:=<variable>;
<variable>:=<constant>;
```

### Application:

Use this statement to assign a value to a variable. For example, use it to set initial values or to store the results of a calculation.

### Description:

This statement assigns (or stores) the <*expression_value*> to the <*variable*>.

### Example:

Example 1: The following statement assigns the result of the expression *X*+1 to variable *A*.

```
A:=X+1;
```

Example 2: The following statement assigns the value of variable *B* to variable *A*.

```
A:=B;
```

Example 3: The following statement assigns a value of 10 to variable *A*.

```
A:=10;
```

### Precautions:

- Either the source data type must match the destination data type, or the combination of data types must allow implicit casting. Otherwise, a compiling error will occur.

- If the value that is assigned is STRING data, make the size of the destination STRING variable larger than that of the source string. Otherwise, an error will occur.
- For STRING variables, assignment is allowed if the size of left-hand variable is greater than the size of the text string stored in right-hand variable.
  Example:
  Assignment is allowed in the following case.
  - Variable Table:

| Variable name | Data type | Size |
|---|---|---|
| Var1 | STRING | 10 |
| Var2 | STRING | 20 |

  - User Program:
    Var2 :='ABC';
    Var1 := Var2;

You cannot make assignments to union variables. You must make the assignments to individual members of the unions.

## ● RETURN

### Overview:

The following actions occur depending on where the ST statement is used.

**ST**

The ST program is ended during operation and the next program is executed.

**ST in a Function Inside a Function Block Instance**

The function or function block is ended during operation and the next instruction after the calling instruction is executed.

**Inline ST**

The POU that contains inline ST with a RETURN statement is ended.

### Reserved Words:

RETURN

### Statement Structure:

```
RETURN;
```

### Application:

Use this statement to force the current program, function, or function block to end.

## ● IF with One Condition

### Overview:

The construct executes the specified statement when a condition is met. If the condition is not met, another statement is executed. The following expressions are used to specify whether the condition is met.

TRUE: The condition is met.

FALSE: The condition is not met.

### Reserved Words:

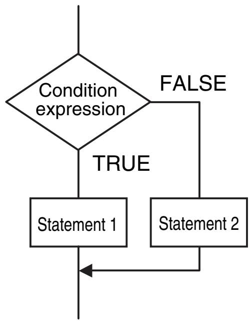
IF, THEN, (ELSE), END_IF

**Note** You can omit ELSE.

### Construct Structure:

```
IF <condition_expression> THEN
  <statement_1>;
ELSE
  <statement_2>;
END_IF;
```

### Process Flow Diagram:




### Application:

Use this construct to perform one of two processes depending on evaluation of a condition (condition expression).

### Description:

If <*condition_expression*> is TRUE, <*statement_1*> is executed.

If <*condition_expression*> is FALSE, <*statement_2*> is executed.

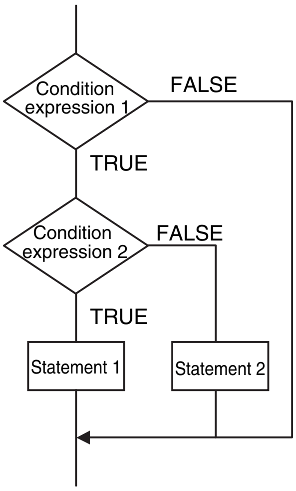
### Precautions:

- IF must always be used together with END_IF.
- Write a statement that evaluates to TRUE or FALSE (for example *IF A>10*) or a BOOL variable (for example *IF A*) for the condition expression.
- You can write <*statement_1*> and <*statement_2*> on multiple lines. Separate statements with a semicolon (;).

Example: Another IF Statement before <*statement_1*>

```
IF <condition_expression_1> THEN
    IF <condition_expression_2> THEN
        <statement_1>;
    ELSE
        <statement_2>;
    END_IF;
END_IF;
```

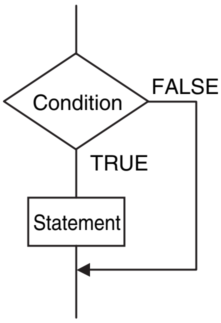
Process Flow Diagram:




ELSE corresponds to the previous THEN statement, as shown above.

- You can execute more than one statement for both <*statement_1*> and <*statement_2*>. Separate statements with a semicolon (;).
- You can omit the ELSE statement. If it is omitted, nothing is executed when <*condition_expression*> is FALSE.

Process Flow Diagram:




Example:

Example 1: A value of 10 is assigned to variable *X* when the statement *A* > 0 is TRUE. A value of 0 is assigned to variable *X* when the statement A > 0 is FALSE.

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

Example 2: A value of 10 is assigned to variable *X* and a value of 20 is assigned to variable Y when the statements A > 0 and B > 1 are both TRUE. A value of 0 is assigned to variable *X* and variable *Y* when the statements *A* > 0 and *B* > 1 are both FALSE.

```
IF A>0 AND B>1 THEN
    X:=10;Y:=20;
ELSE
    X:=0;Y:=0;
END_IF;
```

Example 3: A value of 10 is assigned to variable *X* when the BOOL variable *A* is TRUE. A value of 0 is assigned to variable *X* when variable *A* is FALSE.

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

## ● IF with Multiple Conditions

### Overview:

The construct executes the specified statement when a condition is met. If a condition is not met but another condition is met, another statement is executed. If neither condition is met, another statement is executed.

The following expressions are used to specify whether the condition is met.

TRUE: The condition is met.

FALSE: The condition is not met.

### Reserved Words:

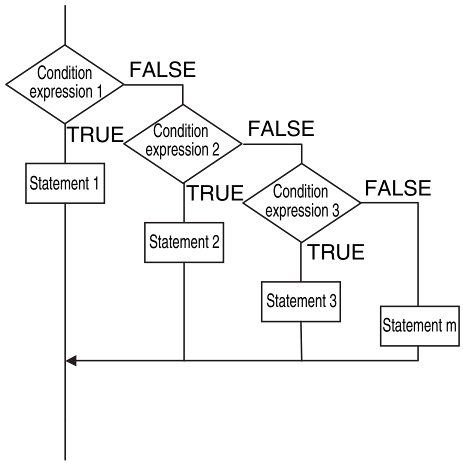
IF, THEN, ELSIF, (ELSE), END_IF

**Note** You can omit ELSE.

### Construct Structure:

```
IF <condition_expression_1> THEN <statement_1>;
    ELSIF <condition_expression_2> THEN <statement_2>;
    ELSIF <condition_expression_3> THEN <statement_3>;
            .
            .
            .
    ELSIF <condition_expression_n> THEN <statement_n>;
ELSE<statement_m>;
END_IF;
```

### Process Flow Diagram:



## Application:

Use this construct to perform a process depending on evaluation of multiple conditions (condition expressions).

## Description:

If <*condition_expression_1*> is TRUE, <*statement_1*> is executed.

If <*condition_expression_1*> is FALSE and <*condition_expression_2*> is TRUE, then <*statement_2*> is executed.

If <*condition_expression_2*> is FALSE and <*condition_expression_3*> is TRUE, then <*statement_3*> is executed.

.
.
.

If <*condition_expression_n*> is TRUE, <*statement_n*> is executed.

If none of the conditions is TRUE, <*statement_m*> is executed.

## Precautions:

- IF must always be used together with END_IF.
- Write statements that can be TRUE or FALSE for the condition expressions. Example: IF(A>10)
  You can also specify BOOL variables (including functions that return a BOOL value) for the condition expressions instead of an actual expression. In that case, when the variable is TRUE, the evaluated result is TRUE and when the variable is FALSE, evaluated result is FALSE.
- You can write any of the statements on multiple lines. Separate statements with a semicolon (;).
- You can omit the ELSE statement. If it is omitted, and none of the conditions produces a match, nothing is done.

### Example:

A value of 10 is assigned to variable *X* when the statement *A* > 0 is TRUE.

A value of 1 is assigned to variable *X* when the statement A > 0 is FALSE and statement B = 1 is TRUE.

A value of 2 is assigned to variable *X* when the statement A > 0 is FALSE and statement B = 2 is TRUE.

If none of the conditions is TRUE, a value of 0 is assigned to the variable *X*.

```
IF A>0 THEN X:=10;
    ELSIF B=1 THEN X:=1;
    ELSIF B=2 THEN X:=2;
ELSE X:=0;
END_IF;
```

## CASE

### Overview:

This construct executes a statement that corresponds to an integer set value that matches the value of an integer expression.

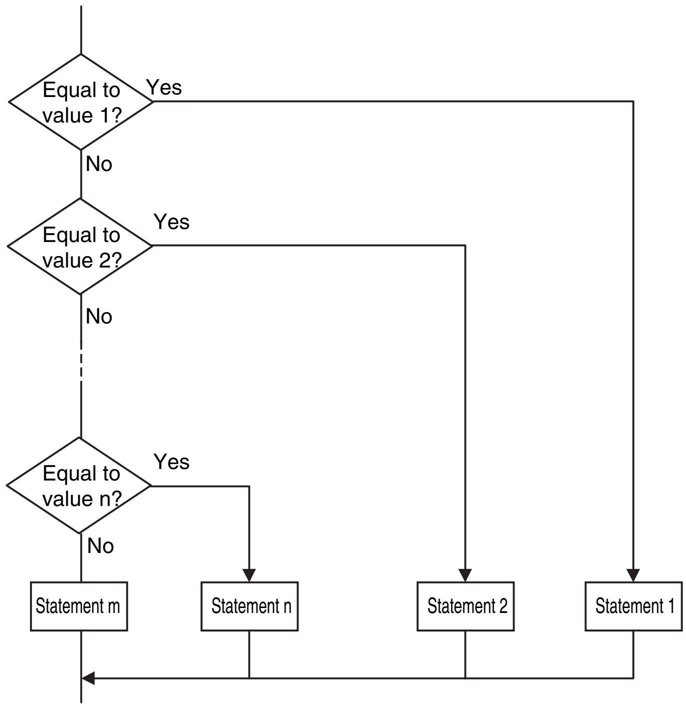
### Reserved Words:

CASE

### Construct Structure:

```
CASE <integer_expression> OF
    <integer_expression_value_1>:<statement_1>;
    <integer_expression_value_2>:<statement_2>;
              .
              .
              .
    <integer_expression_value_n>:<statement_n>;
ELSE<statement_m>;
END_CASE;
```

### Process Flow Diagram:



### Application:

Use this construct to perform different actions based on the value of an integer.

### Description:

If <*integer_expression*> matches <*integer_expression_value_n*>, <*statement_n*> is executed.
If <*integer_expression*> does not match any of the integer values, <*statement_m*> is executed.

### Precautions:

- CASE must always be used together with END_CASE.
- Use one of the following for the <*integer_expression*>:
    - An integer or enumeration variable (example: *abc*)
    - An integer expression (example *abc+def*)
    - A function that returns an integer value (example: *xyz()*)
- You can write any of the statements on multiple lines. Separate statements with a semicolon (;).
- To specify OR logic of multiple integers for <*integer_expression_value_n*>, separate the values with commas. To specify a continuous range of integers, separate the start integer and the end integer with two periods (..).

Example 1: You can specify a condition for a specific integer value, or the same condition for multiple integer values.

| Code | |
|---|---|
| CASE A OF | |
| 1: X:=1; | A value of 1 is assigned to variable *X* when variable *A* is 1. |
| 2: X:=2; | A value of 2 is assigned to variable *X* when variable *A* is 2. |
| 3: X:=3; | A value of 3 is assigned to variable *X* when variable *A* is 3. |
| ELSE | |
| X:=0; | If none of the values is matched, a value of 0 is assigned to the variable *X*. |
| END_CASE; | |

| Code | |
|---|---|
| CASE A OF | |
| 1: X:=1; | A value of 1 is assigned to variable *X* when variable *A* is 1. |
| 2,5: X:=2; | A value of 2 is assigned to variable *X* when variable *A* is 2 or 5. |
| 6..10: X:=3; | A value of 3 is assigned to variable *X* when variable *A* is between 6 and 10. |
| 11,12,15..20: X:=4; | A value of 4 is assigned to variable *X* when variable *A* is 11, 12, or between 15 and 20. |
| ELSE | |
| X:=0; | If none of the values is matched, a value of 0 is assigned to the variable *X*. |
| END_CASE; | |

Example 2: You can give an integer variable, integer expression, integer function return value, enumeration variable, or enumeration function return value for the <*integer_expression*>. An example is shown below.

- Example for an Integer Enumeration Variable

```
CASE ColorVar OF
    RED:
        X := 0;
    BLUE:
        X := 1;
    ELSE
        X := 2;
END_CASE;
```

- Example for an Integer Expression

```
CASE (a1 + a2) OF
    0:
        X := 0;
    1:
        X := 1;
    ELSE
        X := 2;
END_CASE;
```

- Example of an Integer Enumeration Function Return Value

```
CASE FUN( ) OF
    0:
        X := 10;
    1:
        X := 11;
    ELSE
        X := 12;
END_CASE;
```

Branches depending on the return value of FUN( ).

### Data Types That You Can Use in CASE Constructs

| Classification | Data type | | <integer_expression> |
|---|---|---|---|
| **Basic data types** | **Integers** | | Supported. |
| | **Boolean, bit string, real, duration, date, time of day, date and time, or text string data** | | Not supported. |
| **Data type specifications** | **Array specifications** | **Arrays** | Not supported. |
| | | **Elements** | Supported for integers and enumerations only. |
| **Derivative data types** | **Structures** | **Structures** | Not supported. |
| | | **Members** | Supported for integers and enumerations only. |
| | **Unions** | **Unions** | Not supported. |
| | | **Members** | Supported for integers and enumerations only. |
| | **Enumerations** | | Supported. |

## ● FOR

### Overview:

This construct repeatedly executes the same statements until a variable (called the FOR variable) changes from one value to another value.
The following expressions are used to specify whether the condition is met.

TRUE: The condition is met.

FALSE: The condition is not met.

### Reserved Words:

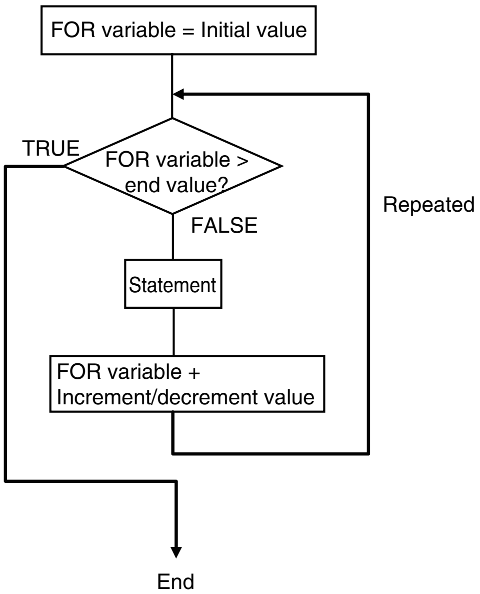
FOR, TO, (BY), DO, END_FOR

**Note** You can omit BY.

### Construct Structure:

```
FOR <FOR_variable>:= <initial_value> TO <end_value> BY <increment/decrement> DO
    <statement>;
END_FOR;
```

### Process Flow Diagram:




### Application:

Use this construct when you know in advance how many times you want to repeat a process.

This type of repeat construct is particularly effective to specify each element of an array variable based on the value of a FOR variable.

### Description:

A decision is made based on the evaluation of <*initial_value*>, <*end_value*>, and <*increment/decrement*>.
When <*FOR_variable*> is <*initial_value*>, <*statement*> is executed.
After execution, the value of <*increment/decrement*> is added to <*FOR_variable*> and <*statement*> is executed again if <*FOR_variable*> is less than the value of the <*end_value*>.
After execution, the value of <*increment/decrement*> is added to <*FOR_variable*> and <*statement*> is executed again if <*FOR_variable*> is less than the value of the <*end_value*>.
This process is repeated.
The loop ends when <*FOR_variable*> > <*end_value*>.
If <*increment/decrement*> is negative, the directions of the comparison symbols in the above statements are reversed.

### Precautions:

- If the FOR variable is signed, <*increment/decrement*> can be a negative number.
- FOR must always be used together with END_FOR.
- You cannot use addition or other arithmetic expressions in the <*end_value*> and <*increment/decrement*>.
- The FOR variable becomes the end value plus increment/decrement after execution of the process is completed for the end value. This ends the FOR construct.

Example: When the FOR construct is completed in the following ST statements, the value of *i* is 101.

```
FOR i:=0 TO 100 DO
    X[i]:=0;
END_FOR;
// Here, i is 101.
    a:=FALSE;
END_IF;
```

- Do not write code that directly modifies the FOR variable inside the FOR construct. Unintended operation may result.

  Example:

```
FOR i:=0 TO 100 BY 1 DO
    X[i]:=0;
    i:=i+INT#5;
END_FOR;
```

- You can write any of the statements on multiple lines. Separate statements with a semicolon (;).
- You can omit BY<*increment/decrement*>. If it is omitted, the statement is executed with an increment value of 1.
- You can specify any expression that returns an integer (SINT, INT, DINT, LINT, USINT, UINT, UDINT, or ULINT) variable or integer value for the <*initial_value*>,<*end_value*>, and <*increment/decrement*>. You can also specify a function that returns an integer value.

  Example 1: A value of 100 is assigned to array variable elements *SP[n]*. The FOR variable is variable n, the initial value is 0, the end value is 50, and the increment is 5.

```
FOR n := 0 TO 50 BY 5 DO
    SP[n] := 100;
END_FOR;
```

  Example 2: The total of elements *DATA[1]* through *DATA[50]* of array variable elements *DATA[n]* is calculated and the result is assigned to the variable *SUM*.

```
IF a THEN
    FOR n := 0 TO 50 BY 1 DO
        DATA[n]:= 1 ;
    END_FOR;

    FOR n := 0 TO 50 BY 1 DO
        SUM:= SUM + DATA[n] ;
    END_FOR;

    a:=FALSE;
END_IF;
```

  Example 3: The maximum and minimum values of elements *DATA[1]* through *DATA[50]* of array variable elements *DATA[n]* are found. The maximum value is assigned to the *MAX variable*, and the minimum value is to the *MIN variable*. The value of *DATA[n]* is from 0 to 1,000.

```
MAX :=0;
MIN :=1000;
FOR n :=1 TO 50 BY 1 DO
    IF DATA[n] > MAX THEN
        MAX :=DATA[n];
    END_IF;
    IF DATA[n] < MAX THEN
        MIN :=DATA[n];
    END_IF;
END_FOR;
```

- If the total execution time of the statements in the FOR construct from when the FOR variable is incremented/decremented from the initial value until it reaches the end value exceeds the task period, a Task Period Exceeded Error occurs.
  - When the FOR Variable Cannot Logically Reach the End Value

    Example:

```
FOR i := 0 TO 100 BY 1 DO
    intArray[i] := i;
    i := INT#50;
END_FOR;
```

An infinite loop occurs and results in a Task Period Exceeded Error.

Example:

```
FOR i := 0 TO 100 BY 0 DO
    ;
END_FOR;
```

An infinite loop occurs and results in a Task Period Exceeded Error.

- When an Overflow or Underflow Occurs Because the FOR Variable Exceeds the End Value

Example:

```
FOR i := 0 TO 254 BY 2 DO
    INTArray[i] := i;
END_FOR;
```

### Data Types That You Can Use in FOR Constructs

| Classification | Data type | | *<initial_value>*, *<end_value>*, and *<increment/decrement>** |
|---|---|---|---|
| **Basic data types** | **Boolean, bit string, real, duration, date, time of day, date and time, or text string data** | | Not supported. |
| | **Integers** | | Supported. |
| **Data type specifications** | **Array specifications** | **Arrays** | Not supported. |
| | | **Elements** | Supported for integers and enumerations only. |
| **Derivative data types** | **Structures** | **Structures** | Not supported. |
| | | **Members** | Supported for integers and enumerations only. |
| | **Unions** | **Unions** | Not supported. |
| | | **Members** | Supported for integers and enumerations only. |
| | **Enumerations** | | Supported. |

* You must use the same data type for the <*FOR_variable*>, <*end_value*> and <*increment/decrement*>. Otherwise, an error occurs when the program is built on the Sysmac Studio.

## ● WHILE

### Overview:

This construct repeatedly executes the specified statements as long as a condition expression is TRUE.

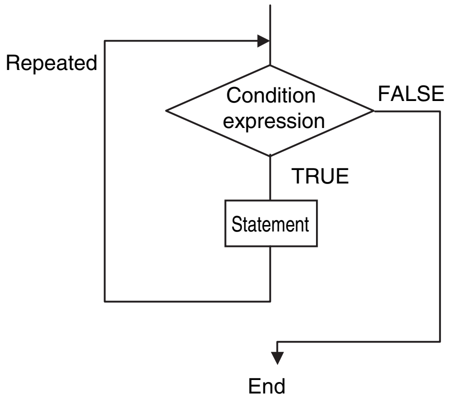
### Reserved Words:

WHILE, DO, END_WHILE

### Construct Structure:

```
WHILE <condition_expression> DO
    <statement>;
END_WHILE;
```

### Process Flow Diagram:




### Application:

Use this type of repeat construct when you do not know how many times to repeat a process (i.e., when you do not know how many times based on the condition) and you want to repeat a process for as long as a certain condition is met. You can also use this type of repeat construct to execute a process only when a condition expression is TRUE (pre-evaluation repeat construct).

### Description:

The <*condition_expression*> is evaluated before <*statement*> is executed.

If <*condition_expression*> is TRUE, <*statement*> is executed. Then the <*condition_expression*> is evaluated again. This process is repeated.

If the <*condition_expression*> is FALSE, <*statement*> is not executed and the <*condition_expression*> is no longer evaluated.

### Precautions:

- WHILE must always be used together with END_WHILE.
- If the <*condition_expression*> is FALSE before <*statement*> is executed, the WHILE construct is exited and <*statement*> is not executed.
- You can write <*statement_1*> and <*statement_2*> on multiple lines. Separate statements with a semicolon (;).
- You can execute more than one statement for <*statement*>. Separate statements with a semicolon (;).
- You can also specify a BOOL variable (including functions that return a BOOL value) for the condition expressions instead of an actual expression.

**Example:**

Example 1: The first multiple of 7 that exceeds 1,000 is calculated and assigned to variable *A*.

```
A := 0;
WHILE A <= 1000 DO
    A := A+INT#7;
END_WHILE;
```

Example 2: The value of variable *X* is doubled if *X* is less than 3,000 and the value is assigned to array variable element *DATA[1]*. Next, the value of *X* is doubled again and the value is assigned to the array variable element *DATA[2]*. This process is repeated.

```
n := 1;
X := 1;
WHILE X < 3000 DO
    X:= X*INT#10#2;
    DATA[n]:= X;
    n := n+INT#1;
END_WHILE;
```

- If you do not write correct condition expressions, the program execution time increases and may cause a Task Period Exceeded Error.

  Example:

  ```
  boolVar := TRUE;
  WHILE boolVar DO
  intVar := intVar + INT#1;
  END_WHILE;
  ```

## ● REPEAT

The following expressions are used to specify whether the condition is met.

TRUE: The condition is met.

FALSE: The condition is not met.

### Overview:

This construct repeatedly executes one or more statements until a condition expression is TRUE.

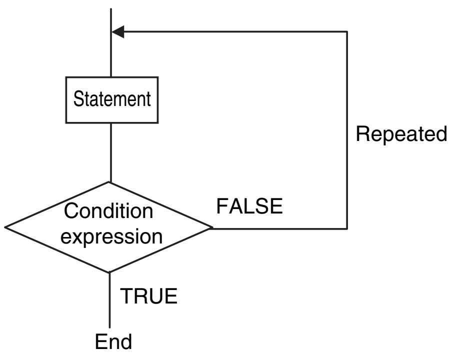
### Reserved Words:

REPEAT, UNTIL, END_ REPEAT

### Construct Structure:

```
REPEAT
    <statement>;
UNTIL <condition_expression>
END_REPEAT;
```

### Process Flow Diagram:




### Application:

Use this type of repeat construct when you do not know how many times to repeat a process (i.e., when you do not know how many times based on the condition) and you want to repeat a process for as long as a certain condition is met after processing. Use this type of repeat construct to determine whether to repeat execution based on the result of the execution of a process (post-evaluation repeat construct).

### Description:

First, <*statement*> is executed unconditionally. Then the <*condition_expression*> is evaluated.

If <*condition_expression*> is FALSE, <*statement*> is executed.

If <*condition_expression*> is TRUE, <*statement*> is not executed and the REPEAT construct is exited.

### Precautions:

- REPEAT must always be used together with END_REPEAT.
- Even if the <*condition_expression*> is TRUE before <*statement*> is executed, <statement> is executed.
  In other words, <*statement*> is always executed at least one time.
- <*statement*> can contain multiple lines of code for the statement. Separate statements with a semicolon (;).
- You can also specify a BOOL variable (including functions that return a BOOL value) for the condition expressions instead of an actual expression.

  **Example:**

  Example 1: Numbers from 1 to 10 are added and the values are assigned to the variable *TOTAL*.

```
A := 1;
TOTAL := 0;
REPEAT
    TOTAL := TOTAL + A;
    A := A+INT#1;
UNTIL A>10
END_REPEAT;
```

- If you do not write correct condition expressions, the program execution time increases and may cause a Task Period Exceeded Error.

  Example:

```
intVar := INT#1;
REPEAT
intVar := intVar + INT#1;
UNTIL intVar = INT#0
END_REPEAT;
```

## ● EXIT

### Overview:

Use this statement only inside a repeat construct (FOR construct, WHILE construct, or REPEAT construct) to exit the repeat construct.

Use this statement inside an IF construct to exit from the repeat construct when a condition is met.

### Reserved Words:

EXIT

### Construct Structure (e.g., in an IF Construct):

```
FOR (WHILE, REPEAT) <statement>
          .
          .
          .
IF <condition_expression> THEN EXIT;
END_IF;
          .
          .
          .
END_FOR (WHILE, REPEAT);
```

### Application:

Use EXIT to end a repeating process before the end condition is met.

### Description (e.g., in an IF Construct):

If the <condition_expression> is TRUE, the repeat construct (FOR construct, WHILE construct, or REPEAT construct) is ended and all code inside the repeat construct after the EXIT statement is ignored.

**Note 1** You can also specify a BOOL variable instead of an expression for the condition expressions.

**2** Even if the <*condition_expression*> is TRUE before <*statement*> is executed, <statement> is executed.

### Example:

Variable n is repeatedly incremented by 1 from 1 to 50 while the value of n is added to array variable elements *DATA[n]*. However, if *DATA[n]* exceeds 100, the repeat construct is exited.

```
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;
```

## ● Function Block Calls

### Overview:

This statement calls a function block.

### Reserved Words: None

### Statement Structure:

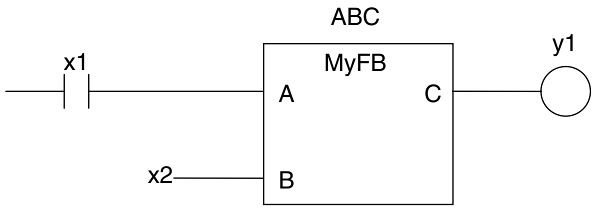
Give the argument specifications (to pass the values of the specified variables to the input variables of the called function block) and the return value specification (to specify the variable that will receive the value of the output variable of the called function block) in parenthesis after the instance name of the function block. There are two methods of writing this statement, as shown in (1) and (2) below. We recommend method 1 for program readability.

### Notation Method 1:

Give both the variable names of the called function block and the parameter names of the calling POU.

ABC(A:=x1, B:=x2, C=>y1);
*ABC*: Function block instance name
A and B: Input or in-out variable names of called function block
*x1* and *x2*: Input or in-out parameter of calling POU (can be a constant)
C: Output variable of called function block
*y1*: Output parameter of calling POU

- Ladder Diagram Expression



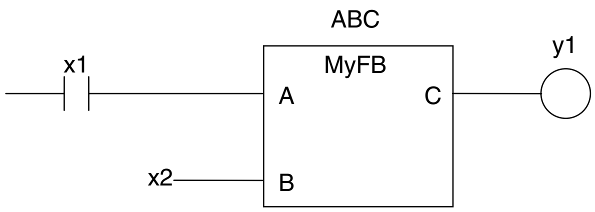

- You can give the arguments and return values in any order.
- You can omit the input variable names and input parameter names. If you omit these names, the values assigned to the input variables for the previous call are assigned to the input variables again. If this is the first time that the function block is called, the input variables are set to their initial values.
- You can omit the output variables and output parameters. If they are omitted, the value of the output variable is not assigned to anything.

### Notation Method 2:

Omit the variable names of the called function block and give the parameter names of the calling POU.

ABC(x1, x2, y1);
*ABC*: Function block instance name
A and B: Omitted. (Input or in-out variable of called function block)
*x1* and *x2*: Input or in-out parameter of calling POU (can be a constant)
C: Omitted. (Output variable of called function block or constant)
*y1*: Omitted. (Output parameter of calling POU)

- Ladder Diagram Expression




- The order of parameters is based on the function block definition. The order is the same as the local variable definition for the function block, from top to bottom.

### Application:

This statement calls a function block.

## Example

- Programming

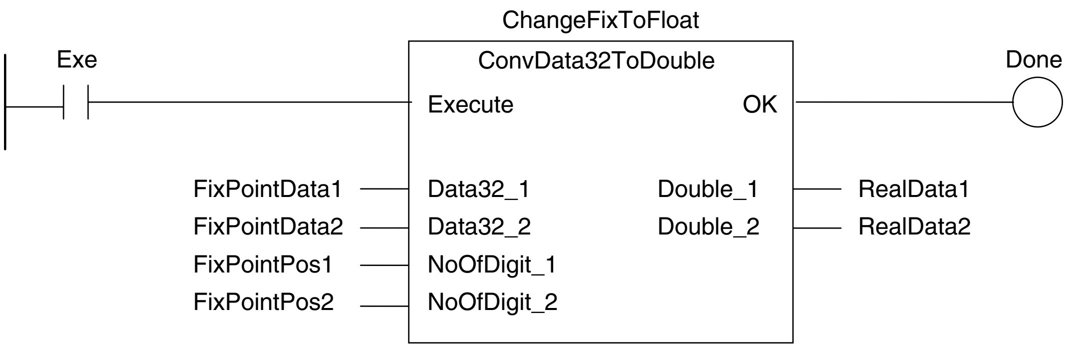
Notation 1

ChangeFixToFloat(Execute:=Exe,Data32_1:=FixPointData1, Data32_2:=FixPointData2,
NoOfDigit_1:=FixPointPos1,
NoOfDigit_2:=FixPointPos2,OK=>Done,Double_1=>RealData1,
Double_2=>RealData2);

Notation 2

ChangeFixToFloat(Exe, FixPointData1, FixPointData2, FixPointPos1, FixPointPos2,
Done, RealData1, RealData2);

- Ladder Diagram Expression




- Function Block Definition

Function block name: ConvData32ToDouble

Function Block Variables

| I/O | Variable name | Data type |
|---|---|---|
| Input variables | Execute | BOOL |
| | Data32_1 | DINT |
| | Data32_2 | DINT |
| | NoOfDigit_1 | INT |
| | NoOfDigit_2 | INT |
| Output variables | OK | BOOL |
| | Double_1 | LREAL |
| | Double_2 | LREAL |

- Program Variables

| Variable name | Data type | Comments |
|---|---|---|
| ChangeFixToFloat | ConvData32ToDouble | Convert from fixed-point to floating-point. |
| Exe | BOOL | Execution trigger |
| FixPointData1 | DINT | Decimal point position specification data 1 |
| FixPointPos1 | INT | Number of digits below decimal point 1 |
| FixPointData2 | DINT | Decimal point position specification data 2 |
| FixPointPos2 | INT | Number of digits below decimal point 2 |
| Done | BOOL | Normal end |
| RealData1 | LREAL | Floating-point data 1 |
| RealData2 | LREAL | Floating-point data 2 |

### Omitting Parameters

When you call a function block, you can omit parameters that are not required. The following table shows when you can omit parameters.

| POU type | Variables for the called POU | Notation pattern | | Omission |
|---|---|---|---|---|
| | | Parameters included | Examples | |
| FB | Given (notation method 1) | All parameters given | instance(x:=a,y:=b,z:=c); | OK |
| | | More than one parameter given | instance(x:=a,y:=b); | |
| | | One parameter given | instance(y:=b); | |
| | | No parameters given | instance(x:=); | --- |
| | Given (notation method 2) | All parameters given | instance(a,b,c); | OK |
| | | All parameters not given | instance(); | |
| | | Only the first parameter given | instance(a); | --- |
| | | One parameter given | instance(a, , ); | |
| | | More than one parameter given | instance(a,b); | |

OK: Possible (initial used), ---: Compiling error.

## ● Function Calls

### Overview:

This statement calls a function.

### Reserved Words: None

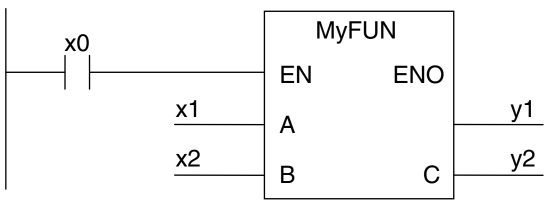
### Statement Structure:

Give the output parameter to which the return value is assigned on the left side of the assignment keyword (:=). On the right side, give the argument specifications (to pass the values of the specified variables to the input variables of the called function) inside the parenthesis after the function name. There are two methods of writing this statement, as shown in (1) and (2) below.
We recommend method (1) for program readability.

### Notation Method 1:

```
IF (x0=TRUE) THEN
    y1 := MyFUN(A:=x1, B:=x2, C=>y2);
END_IF;
```

- Ladder Diagram Expression




MyFUN: Function name

x0: Specifies whether to call the function.

A and B: Input variable names of the called function

x1 and x2: Input parameters of the called function

C: Output variable name of the called function

y1: Storage location for the return value from the called function

y2: Output parameters of the called function

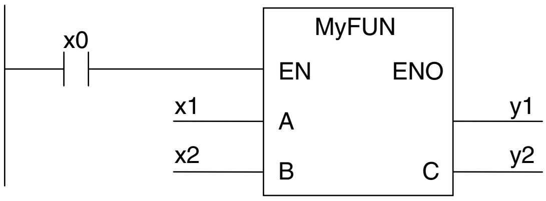
- You can give the arguments in any order.

- You can omit the input variable names and input parameter names. If they are omitted, the input variables are assigned their initial values.
- You can omit *EN* as well. If it is omitted, *EN* is assigned a value of TRUE.

### Notation Method 2:

```
IF (x0=TRUE) THEN
    y1 := MyFUN(x1, x2, y2);
END_IF;
```

- Ladder Diagram Expression




MyFUN: Function name

x0: Specifies whether to call the function.

A and B: Input variable names of the called function

x1 and x2: Input parameters of the called function

C: Output variable name of the called function

y1: Storage location for the return value from the called function

y2: Output parameters of the called function

- The order of parameters is based on the function definition. The order is the same as the local variable definition for the function, from top to bottom.

### Example:

- Programming

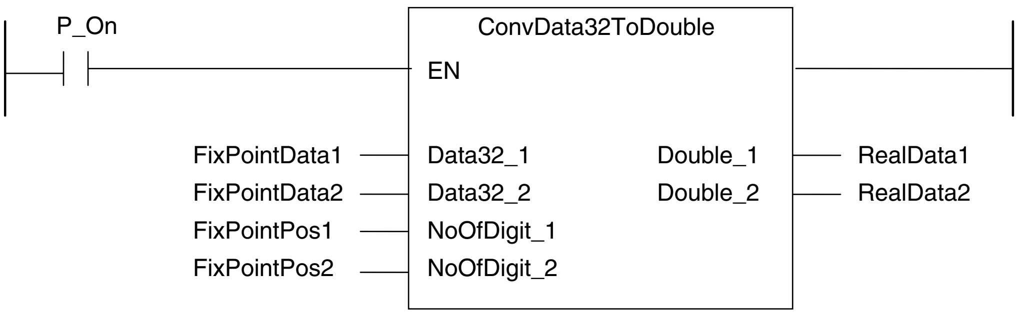
Notation 1

```
ConvData32ToDouble(Data32_1:=FixPointData1,Data32_2:=FixPointData2,
NoOfDigit_1:=FixPointPos1, NoOfDigit_2:=FixPointPos2,
Double_1=>RealData1, Double_2=>RealData2);
```

Notation 2

```
ConvData32ToDouble(FixPointData1, FixPointData2, FixPointPos1, FixPointPos2,
RealData1, RealData2);
```

- Ladder Diagram Expression



- Function Definition
  Function name: ConvData32ToDouble
  Function Variables

| I/O | Variable name | Data type |
|---|---|---|
| Input variables | Execute | BOOL |
| | Data32_1 | DINT |
| | Data32_2 | DINT |
| | NoOfDigit_1 | INT |
| | NoOfDigit_2 | INT |
| Output variables | Double_1 | LREAL |
| | Double_2 | LREAL |
| Return value | --- | BOOL |

- Program Variables

| Variable name | Data type | Comment |
|---|---|---|
| ChangeFixToFloat | ConvData32ToDouble | Convert from fixed-point to floating-point. |
| Exe | BOOL | Execution trigger |
| FixPointData1 | DINT | Decimal point position specification data 1 |
| FixPointPos1 | INT | Number of digits below decimal point 1 |
| FixPointData2 | DINT | Decimal point position specification data 2 |
| FixPointPos2 | INT | Number of digits below decimal point 2 |
| Done | BOOL | Normal end |
| RealData | LREAL | Floating-point data 1 |
| RealData | LREAL | Floating-point data 2 |

## Application:

This statement calls a function.

## Omitting Parameters

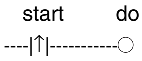
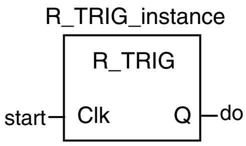
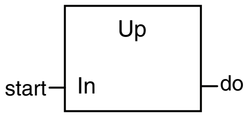
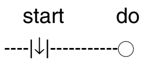
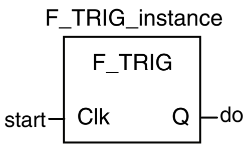
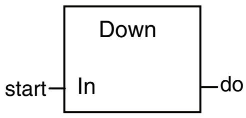
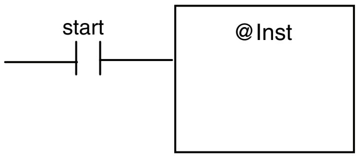
When you call a function, you can omit parameters that are not required. The following table shows when you can omit parameters.

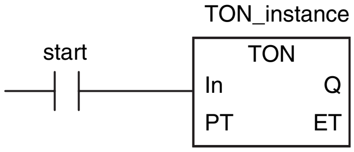
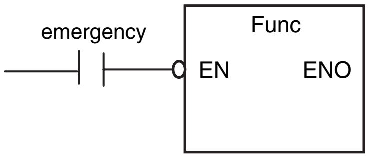
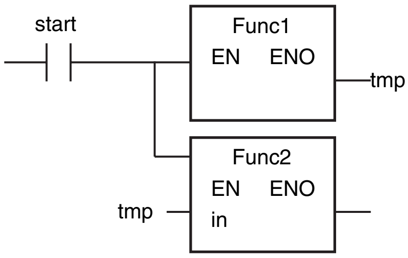
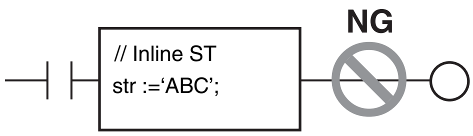
| POU type | Variables for the called POU | Notation pattern | | Omission |
|---|---|---|---|---|
| | | Parameters included | Example | |
| FUN | Given (notation method 1) | All parameters given | FUN(x:=a,y:=b,z:=c); | OK |
| | | More than one parameter given | FUN(x:=a,y:=b); | |
| | | One parameter given | FUN(y:=b); | |
| | | No parameters given | FUN(x:=); | --- |
| | Given (notation method 2) | All parameters given | FUN(a,b,c) | OK |
| | | No parameters given | FUN(); | |
| | | Only the first parameter given | FUN(a); | --- |
| | | One parameter given | FUN(a, , ); | |
| | | More than one parameter given | FUN(a,b); | |

OK: Possible (initial used), ---: Compiling error.

## Differences between ST and Ladder Diagrams

The differences between ST and ladder diagrams are described below.

| Item | Ladder diagram | ST (including inline ST) |
|---|---|---|
| Input differentiation | ● **Change to TRUE**<br>• Method 1<br><br>• Method 2<br><br>• Method 3<br> | ● **Change to TRUE**<br>• **Method 1**<br>R_TRIG_instance (Clk:=start, Q=>do);<br>* R_TRIG_instance is an instance of the R_TRIG instruction. |
| | ● **Change to TRUE**<br>• Method 1<br><br>• Method 2<br><br>• Method 3<br> | ● **Change to TRUE**<br>• **Method 1**<br>F_TRIG_instance (Clk:=start, Q=>do);<br>* F_TRIG_instance is an instance of the F_TRIG instruction. |
| Instruction differentiation | ● **Change to TRUE**<br> | ● **Change to TRUE**<br>There is no equivalent in ST. You must create it in logic.<br>Example:<br>• Method 1<br>R_TRIG_instance (Clk:=start, Q=>do);<br>IF (do = TRUE) THEN Inst();<br>END_IF;<br>• Method 2<br>IF (start = TRUE) THEN<br>IF (pre_start = FALSE) THEN Inst();<br>END_IF;<br>END_IF;<br>pre-start:=start;// Update previous value. |

| Item | Ladder diagram | ST (including inline ST) |
|---|---|---|
| Instructions that last multiple task periods | With the TON instruction, multiple cycles are required from the start of instruction execution to the end and the instruction is reset when the power flow is FALSE. Therefore, you need to declare only one instance to both execute the instruction and reset it.<br><br> | You must declare two instances, one for execution and one to reset, as shown below.<br>IF (start = TRUE) THEN<br>TON_instance(In:=TRUE, *omitted*);<br>// Start timer.<br>ELSE<br>TON_instance(In:=FALSE, *omitted*);<br>// Reset timer.<br>END_IF; |
| Function/function block argument NOT specifications | Add a circle to indicate NOT at the intersection of the BOOL argument and the function/function block.<br><br> | Add a NOT operator to the argument.<br>* You can add NOT operators to any BOOL variable, not just arguments.<br>IF (NOT emergency) THEN<br>Func();<br>END_IF; |
| Multi-stage connections | <br> | IF(start=TRUE) THEN<br>Func2( in := Func1());<br>END_IF; |
| Post-connecting ladder instructions | You can connect only other Out instructions after an Out instruction.<br> | You cannot continue the ladder diagram after inline ST.<br><br> |
| Program divisions | You can create sections. | You cannot create sections. |

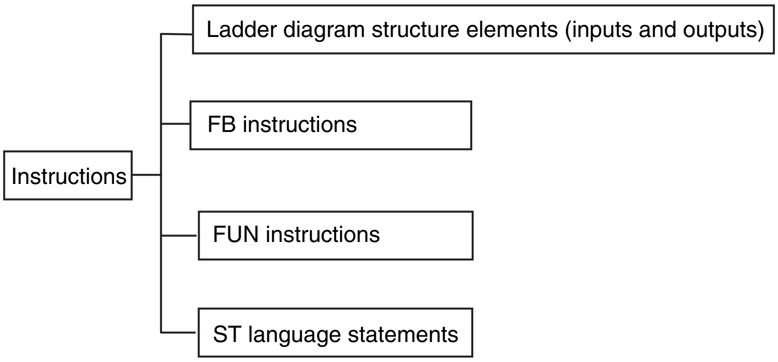
# 6-6 Instructions

This section describes the instructions pre-defined by the NJ-series system.

For details on these instructions, refer to the *NJ-series Instructions Reference Manual* (Cat. No. W502) and *NJ-series Motion Control Instructions Reference Manual* (Cat. No. W508).

## 6-6-1 Instructions

Instructions are the smallest unit of the processing elements that are provided by OMRON for use in POU algorithms. Instructions are classified as shown below.




Programs, user-defined functions, and user-defined function blocks consist of these instructions.

## 6-6-2 Basic Understanding of Instructions

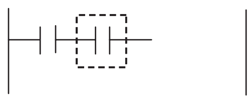
The fundamental specifications of the instructions follow the specifications of functions and function blocks.

This section describes specifications that are unique to instructions.

### Ladder Diagram Structure Elements (Inputs and Outputs)

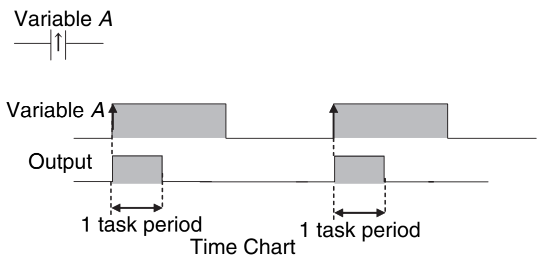
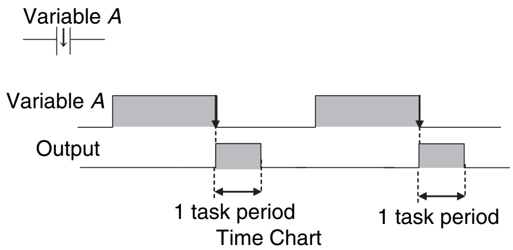
#### ● Locations

Instructions for ladder diagram inputs and outputs have certain positions where they can be placed, as shown below.

| Classification | | Locations | Diagram |
|---|---|---|---|
| Input instructions | Logical start | Connected directly to the left bus bar or is at the beginning of an instruction block. |  |
| | Intermediate instructions | Between a logical start and the output instruction. |  |
| Output instructions | | Connected directly to the right bus bar. |  |

● **Instruction Options**

Some ladder diagram instructions for inputs also detect changes to TRUE or changes to FALSE if you add an upward arrow or downward arrow to them.

| | | |
|---|---|---|
| Change to TRUE (↑) |  | The instruction reads input status, makes comparisons, tests bits, or performs other types of processing every task period and outputs the power flow when result changes from FALSE to TRUE.<br>The output power flow changes to FALSE in the next task period (after it is TRUE for one task period). |
| Change to FALSE (↓) |  | The instruction reads input status or performs other types of processing every task period and outputs the power flow when result changes from TRUE to FALSE. The output power flow changes to FALSE in the next task period (after it is TRUE for one task period). |

## Function Block Instructions

● **Execution Conditions**

The operation of the execution condition for an FB instruction depends on the instruction.

A specific input variable for the execution condition is defined for each instruction.

Examples: *Execute* specifies a change to TRUE or a change to FALSE in the execution condition.

*Enable* causes the instruction to be executed each task period according to the current execution condition.

Function block instructions are unconditionally executed for as long as the POU that called them is executed.

● **Instruction Options**

Instruction options cannot be specified.

## FUN Instructions

### ● Execution Conditions

All FUN instructions have *EN* inputs as execution conditions. The FUN instruction is executed each task period as long as *EN* is TRUE.

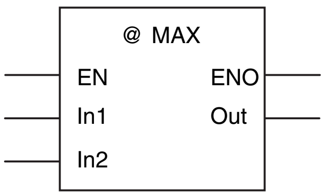
### ● Instruction Options

In a ladder diagram, you can add the following instruction options to specify a change to TRUE or a change to FALSE as the execution condition for that instruction. ST statements do not have options.

| Instruction Options | | Symbol | |
|---|---|---|---|
| Differentiation option | Change to TRUE | @ | This option creates an upwardly differentiated instruction.<br>The instruction is executed only once when *EN* changes to TRUE. |

To add an instruction option, add one of the option symbols listed in the table above before the instruction.

Example:




## Information That Applies to Both FB Instructions and FUN Instructions

### ● Condition Flags

System-defined variables that are assigned values that represent the result of instruction processing are called Condition Flags. The only Condition Flag for an NJ-series Controller is the Carry Flag (P_CY).

The Carry Flag serves the following purposes.

- It shows whether the result of processing an instruction exceeds the range that can be expressed by the data type of the output variable.
- It shows whether an overflow occurred in a bit string data or bit shift instruction. For details, refer to the *NJ-series Instructions Reference Manual* (Cat. No. W502).

## 6-6-3 Operation for Instruction Errors

### Instruction Errors

An instruction error indicates that instruction execution was not possible due to a problem that was found when input parameters and other values were checked by the CPU Unit before instruction execution.

Operation When an Instruction Error Occurs

- For instructions with *ENO*, *ENO* changes to FALSE (however, it is also FALSE when the instruction is not executed).
- For FB instructions that are processed across multiple task periods, the *Error* output variable changes to TRUE and an error code that gives the cause of the error is output to *ErrorID*.

In both of these cases, the *P_PRGER* (Instruction Error Flag) system-defined variable changes to TRUE to indicate that an instruction error occurred in that program.

The following section describes the operations that are performed when an error occurs.

### Operation for Instruction Errors

When the CPU Unit executes an instruction, it checks the input parameter values and other information.

As a result of that check, one of the following actions is taken.

#### ● Ladder Diagrams

| Type | Output variable | Normal operation | Error operation |
|---|---|---|---|
| **Instruction** | **ENO** | Changes to TRUE. | Changes to FALSE. |
| | **P_PRGER** | Retained (nothing is done). | Changes to TRUE. |
| | **Updating output parameters** | Power flow output: Value is updated according to the internal algorithm.<br>BOOL parameter output: Value is updated according to the internal algorithm.<br>Non-BOOL parameter output: Value is updated according to the internal algorithm. | Power flow output: FALSE<br>BOOL parameter outputs: Retained<br>Non-BOOL parameter outputs: Retained |
| **User-created functions and function blocks** | **ENO** | Use *ENO* in the same way as for standard instructions. | Same as at the left. |
| | **Updating output parameters** | Power flow output: Value is updated according to the internal algorithm.<br>BOOL parameter output: Value is updated according to the internal algorithm.<br>Non-BOOL parameter output: Value is updated according to the internal algorithm. | Power flow output: FALSE<br>BOOL parameter outputs: Retained<br>Non-BOOL parameter outputs: Retained |

#### ● ST

| Type | Output variable | Normal operation | Error operation |
|---|---|---|---|
| ST | ENO | Changes to TRUE. | Changes to FALSE. |
| | P_PRGER | Retained (nothing is done). | TRUE |

## Operation When a Syntax Error Occurs in a POU Written in ST

### ● Errors in Assignment Statements

When an error occurs in an assignment statement written in ST, that line is not executed.

```
5   a = b / (c + d) + e * f + ABS(g);
6   x := 1;
```

For example, if a division by zero error occurs in (b/(c+d)) on line 5, execution of line 5 is cancelled (the value of a is not changed) and line 6 is executed.

This operation is the same as when the output *ENO* of a user-created function is FALSE.

```
5   a = User-created_function_block (b) + c;
6   x := 1;
```

When the *ENO* output from the user-created function is FALSE, execution of line 5 is cancelled (the value of a is not changed) and line 6 is executed.

### ● Errors in IF Constructs

If a syntax error occurs in ST, perform error processing for the syntax error.
When the value of (*c+d*), below, is zero, the lines between the IF and END_IF are not executed.

```
POU"AA"
 5   IF a = b / (c + d) THEN
 6     x := 1;
 7   ELSE
 8     x := 2;
 9   END_IF;
10   y := 10;
 :   :
     IF P_PRGER = TRUE THEN
       x:= initial_value; (*Processing when an error occurs*)
       y:= initial_value;
     END_IF;
```

The user must include a safety processing for possible errors.

### ● Syntax Errors in ST

The following syntax errors can occur in ST.

- Exceeding the number of elements in an array.
- No parameter set for in-out variable.
- STRING assignment: When the text string size (bytes) of the left side is less than the text string length (bytes) of the right side
- Division by zero (excluding floating-point number calculations)

* When the value of a floating-point number is nonnumeric, the result of the calculation will also be nonnumeric. This is not considered an error.

### ● Operation for Structure Errors

The *P_PRGER* Flag changes TRUE and the following occurs.

| Syntax | Error location | Operation |
|---|---|---|
| **Assignment statement** | | The line is not executed. |

| Syntax | Error location | Operation |
|---|---|---|
| Control constructs | IF condition expression | No statements between IF and END_IF are executed. |
| | CASE condition expression | No statements between CASE and END_CASE are executed. |
| | FOR condition expression | No statements between FOR and END_FOR are executed. |
| | WHILE condition expression | No statements between WHILE and END_WHILE are executed. |
| | REPEAT condition expression | No statements between REPEAT and END_REPEAT are executed. |

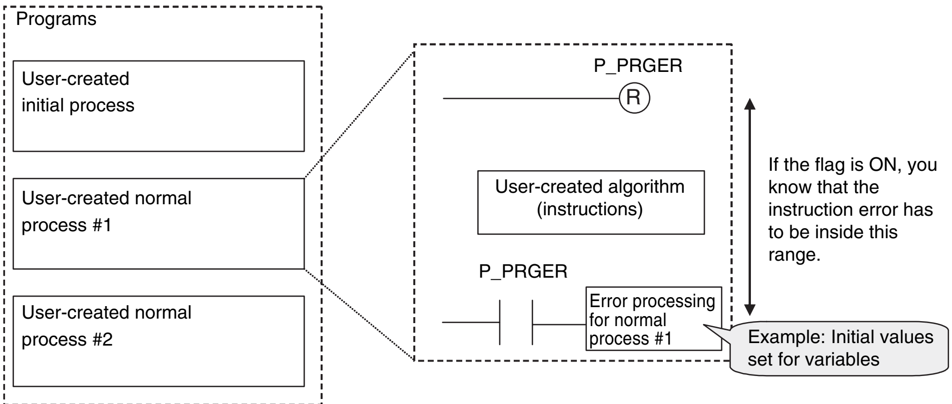
## Instruction Error Flag

When an instruction error occurs in a ladder algorithm or when a syntax/function error occurs in an ST algorithm, the *P_PRGER* (Instruction Error Flag) system-defined variable changes to TRUE. The *P_PRGER* Flag is a local variable (i.e., internal variable) for the program. This flag changes to TRUE when an instruction error occurs in the program, and remains TRUE during the next task period.

| Variable name | Meaning | Function | Data type | Range of values | Initial value | Read /write |
|---|---|---|---|---|---|---|
| P_PRGER | Instruction Error Flag | This flag changes to and remains TRUE when an instruction error occurs. After this flag changes to TRUE, it stays TRUE until the program changes it back to FALSE. | BOOL | TRUE or FALSE | FALSE | Read /write |

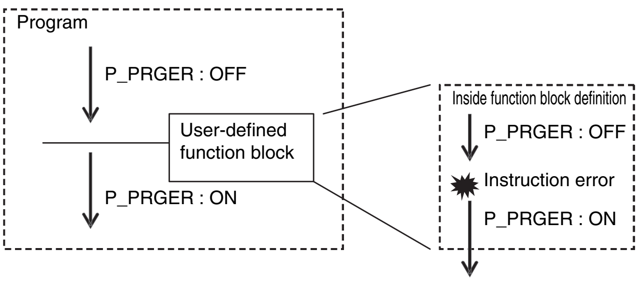
The user can write the P_PRGER Flag. You can temporarily set the value of this flag to FALSE through a user operation to determine if the error occurs within a specific range, for example. After this flag changes to TRUE, it remains TRUE until the operating mode is changed or the flag is overwritten by a program.

Example:




The *P_PRGER* Flag also changes to TRUE when an instruction error occurs inside a user-created function block that is used by the program.

Example:



# 6-7 Programming Precautions

This section describes precautions for developing a user program.

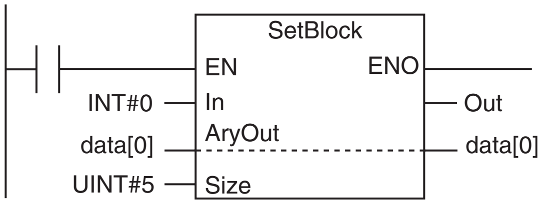
## 6-7-1 Array Specifications for Input Variables, Output Variables, In-Out Variables

Some instructions handle array variables.

Example:

Data Type Table

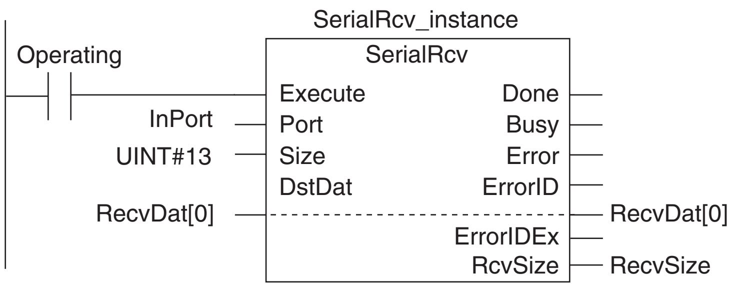
| Variable name | Data type |
|---|---|
| data | ARRAY[0..4] OF INT |




## 6-7-2 Structure Variables for Input Variables, Output Variables, In-Out Variables

Some instructions have structure variables for input, output, or in-out variables.

Example:

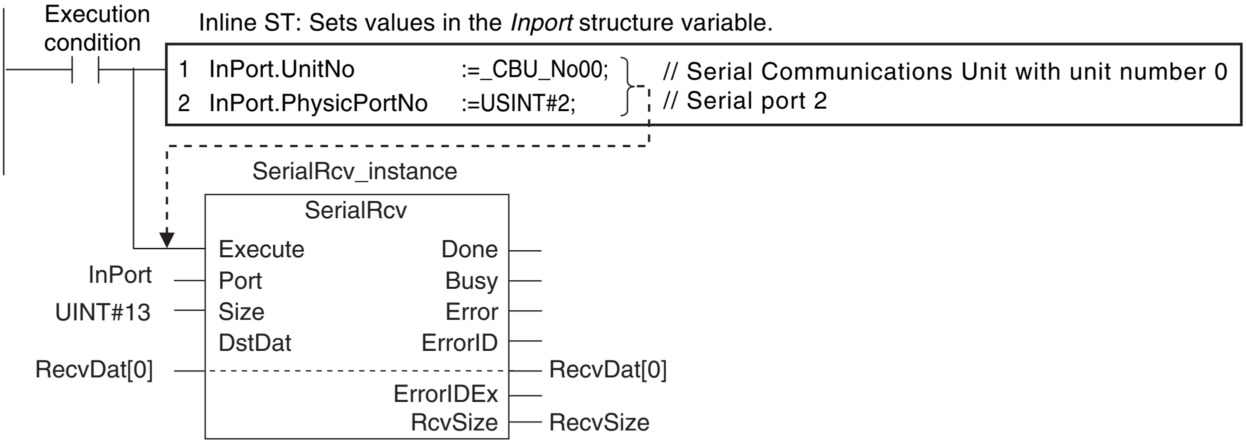


In this case, you must create a structure variable for the input, output, and in-out parameters, then use the MOVE instruction to set the values.

Example:

Variable Table

| Variable name | Data type |
|---|---|
| InPort | _sPORT |




## 6-7-3 Master Control

### Introduction

Master control is used to make output FALSE for all processing between the MC (Master Control Start) instruction and the MCR (Master Control End) instruction. Master control is useful to control the execution conditions of a relatively long series of instructions.

Refer to information on the MC and MCR instructions in the *NJ-series Instructions Reference Manual* (Cat. No. W502) for details.

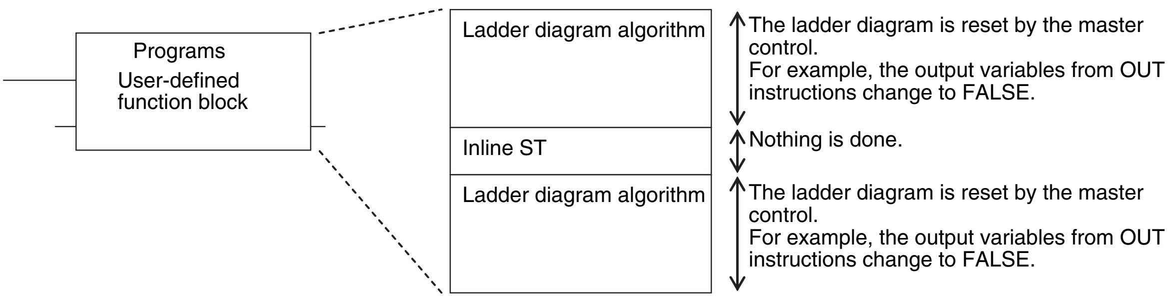
### Master Control Programming Languages

You can use master control in ladder diagrams.

You cannot use master control with ST. You also cannot use master control for inline ST inside a ladder diagram.

Example:

Inside a Master Control Region:




### Operation of Instructions That Are Reset in a Master Control Region

Refer to information on the MC and MCR instructions in the *NJ-series Instructions Reference Manual* (Cat. No. W502) for the operation of other instructions in the master control region when master control is reset.

# 7

# Simulation, Transferring Projects to the Physical CPU Unit, and Operation

This section describes simulation of Controller operation and how to use the results of simulation.


**7-1 Simulation . . . 7-2**

7-1-1 Differences between the Simulator and the Physical CPU Unit . . . 7-3
7-1-2 Simulation Programs . . . 7-3
7-1-3 Executing a Simulation . . . 7-4
7-1-4 Sysmac Studio Online Operations . . . 7-4
7-1-5 Simulation Debugging . . . 7-5
7-1-6 Estimation of Execution Times . . . 7-6
7-1-7 Servo Drive Signal Processing Emulation . . . 7-6

**7-2 Transferring the Project to the CPU Unit and Test Run . . . 7-7**

7-2-1 Transferring the Project . . . 7-7
7-2-2 Checking I/O Wiring . . . 7-7
7-2-3 MC Test Run . . . 7-7

**7-3 Starting Operation . . . 7-8**

# 7-1 Simulation

This section describes simulation of the NJ-series Controller in the Sysmac Studio. Refer to the *Sysmac Studio Version 1 Operation Manual* (Cat. No. W504) for details.

The shaded steps in the overall procedure that is shown below are related to the simulation.

**Step 1. Software Design**

- Step 1-1 Designing I/O and Processing
- Step 1-2 Designing Tasks
- Step 1-3 Designing Programs

↓

**Step 2. Software Setups and Programming**

- Step 2-1 Slave and Unit Configurations
- Step 2-2 Controller Setup
- Step 2-3 Programming
- Step 2-4 Offline Debugging

↓

**Step 3. Mounting and Setting Hardware**

↓

**Step 4. Wiring**

↓

**Step 5. Confirming Operation and Starting Actual System Operation**

Refer to *1-3 Overall Operating Procedure for the NJ-series Controller* for details.

You can simulate the following operations of the NJ-series Controller on the Sysmac Studio.

- Simulation Program
- Executing simulations (Simulations use a virtual controller that has the same functions as the physical CPU Unit.)
- Debugging
- Simulation Monitor
- Estimation of Execution Times
- Servo Drive Signal Processing Emulation

## 7-1-1 Differences between the Simulator and the Physical CPU Unit

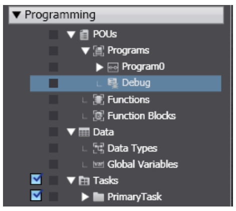
The differences between the functions of the Simulator and the physical CPU Unit are given below according to the divisions of test functions.

| Item | Simulator | Physical CPU Unit |
|---|---|---|
| Algorithm verification<br>Normal operation<br>Operation for errors | • Data monitoring<br>• 3D motion monitoring<br>• Debugging | Simulation provides more functions, such as step execution. |
| Checking task execution times | • Task execution time monitoring<br>You can display both the execution time and the actual processing time. | You can see only the execution time. |
| Checking wiring | Not supported. | • Forced refreshing<br>• Changing the values of variables |
| Verification of connections with other Controllers and host applications | Not supported. | • Data links |
| Sysmac Studio online operations<br>• Monitoring present values of variables<br>• Operating status displays<br>• Data tracing | The functions are the same. | |

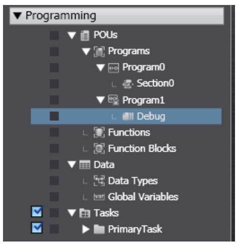
## 7-1-2 Simulation Programs

A simulation program is a program or a program section of a ladder diagram that you can execute only on the Simulator. Simulation programs are treated as normal programs by the Simulator. Assign them to a task to execute them.

Program



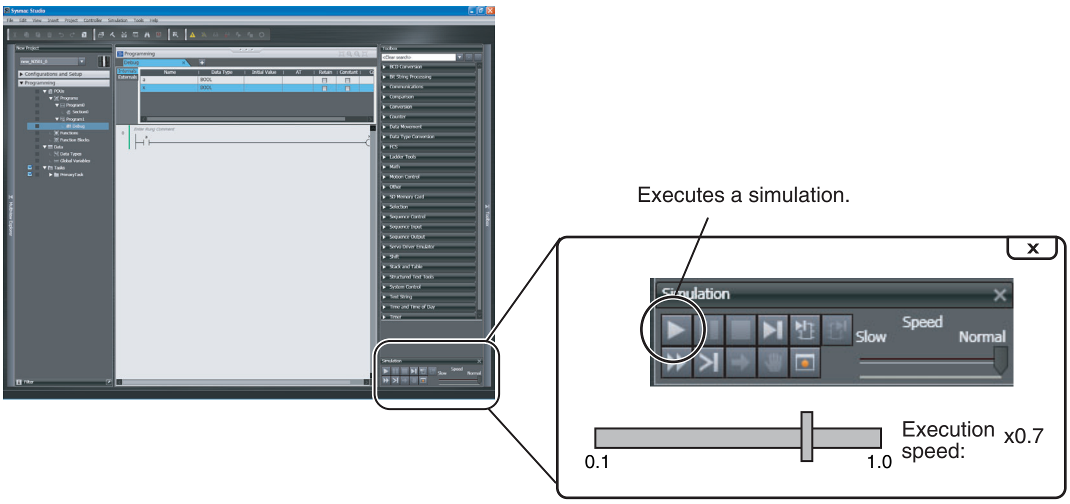

Sections



## 7-1-3 Executing a Simulation

### Starting and Stopping Simulation

Select ***Simulation Pane*** from the View Menu on the Sysmac Studio to open the Simulation Pane. Click the **RUN** Button to transfer the program and execute the simulation. When the simulation starts, the Editor and other Sysmac Studio panes are the same as when connected to the physical CPU Unit.




Click the **Stop** Button in the Simulation Pane to stop the simulation.

### Executing a Partial Simulation

You can select what to simulate in the Multiview Explorer to execute a specific task, a specific section, or a program.

### Setting the Simulation Speed

Drag the *Simulation Speed Slider* in the Simulation Pane. You can change the simulation speed from 0.1x to 1x. You can change the speed during a simulation.

## 7-1-4 Sysmac Studio Online Operations

The Simulator provides the same online operations as those supported when the Sysmac Studio is connected to a physical NJ-series Controller.

- Monitoring the present value of variables
- Changing the present value of variables
- Forced-refreshing variables
- Operating status displays
- Data tracing

## 7-1-5 Simulation Debugging

You can use simulation debugging to stop the operation of the Simulator or to execute a program one step at a time to check the validity of the program logic.

### ● Step Execution

This function stops execution after only one step is executed. You can use step execution for ladder diagrams, ST, and inline ST.


### ● Continuous Step Execution

This function continually performs step execution at a specified interval.

### ● Step-In Execution

This function performs step execution into a function block.

### ● Step-out Execution

This function performs step execution from a function block to the next instruction.

### ● One-period Execution

This function executes the current task for one period. Execution pauses at the beginning of the program in the next period.

### ● Breakpoints

This function is used to specify a location in the program and pause the Simulator at that location during execution.

### ● Pausing

This function pauses operation of the Simulator.

### ● Conditional Breaks

This function stops the execution of the program at a breakpoint when the specified stopping condition is met. You can combine multiple conditions with OR logic as the condition.

### ● Cycling Power

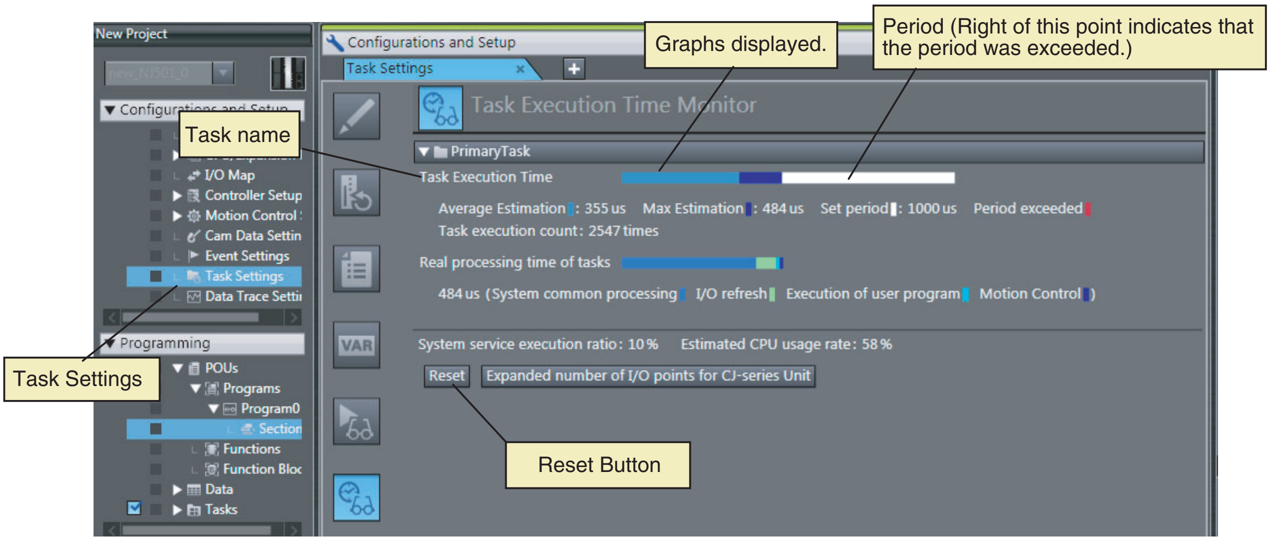
This function simulates turning the power OFF and ON (resetting).

## 7-1-6 Estimation of Execution Times

This function adds the program execution time, refreshing time, and other required times to display estimated processing time for each task based on the times computed during simulations.

### Task Execution Time Monitor Display

The display is the same as when connected to a physical CPU Unit. Only the task execution time is displayed when you are connected to a physical CPU Unit.




## 7-1-7 Servo Drive Signal Processing Emulation

You can emulate the signal processing of the Servo Drive, and move the Servo axes in the Simulator with actual axis settings. This provides virtual outputs of the Servo status and other signals (e.g., waiting for in-position state signal and Servo ON signal) to perform a simulation without changing the program.

# 7-2 Transferring the Project to the CPU Unit and Test Run

This section describes how to use the Sysmac Studio to transfer the user program to the physical CPU Unit and perform an MC Test Run.

## 7-2-1 Transferring the Project

Use the Sysmac Studio to transfer the project to the physical Controller.

1. Go online with the Controller, and then select ***Synchronization*** from the Controller Menu.

   The data on the computer and the data in the physical Controller are compared automatically.

2. Click the **Transfer to Controller** Button.

**Note** Use the Synchronization Menu of the Sysmac Studio to upload and download data.

## 7-2-2 Checking I/O Wiring

You can check the wiring by using forced refreshing of real I/O from the I/O Map or Watch Tab Page.

## 7-2-3 MC Test Run

MC Test Run is used mainly to perform the following operations from the Sysmac Studio without a user program.

- Checking wiring: You can monitor Servo Drive connector I/O signals and Servo Drive status.
- Checking the operation and direction of the motor: You can turn ON the Servo and jog axes.
- Checking electronic gear settings: You can perform relative positioning, and check and change travel distances.
- Checking homing: You can check the homing operation.

Connect online to the CPU Unit from the Sysmac Studio and perform the MC Test Run on the MC Test Run Tab Page. Refer to the *NJ-series CPU Unit Motion Control User's Manual* (Cat. No. W507) for details.

Use the following procedure.

1. After you complete the necessary wiring, connect the Sysmac Studio online to the CPU Unit.

2. Create axes, assign the axes, and set the following axis parameters.

   Axis parameter settings required for MC Test Run operation:
   Unit of Display, Command Pulse Count Per Motor Rotation, Work Travel Distance Per Motor Rotation, Maximum Velocity, Maximum Jog Velocity, Maximum Acceleration Rate, Maximum Deceleration Rate, Software Limit Function Selection, Software Limits, and Count Mode

3. Open the MC Test Run Tab Page and perform the following.

   Example:

   - Monitor and check wiring.
   - Jogging to check the direction of the motor
   - Check travel distances for relative positioning (electronic gear settings).
   - Confirming the homing operation

# 7-3 Starting Operation

This section describes how to use the Sysmac Studio to operate the NJ-series Controller.

Use the Sysmac Studio to start operation of the CPU Unit.

# 8

# CPU Unit Status

This section describes CPU Unit status.


**8-1 Overview of CPU Unit Status . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8-2**

**8-2 State Changes . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8-3**

8-2-1 When Power Is Turned ON . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8-3

8-2-2 Operating Mode Changes . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8-3

8-2-3 When Downloading Data from the Sysmac Studio to CPU Unit . . . . . . . . . . . 8-6

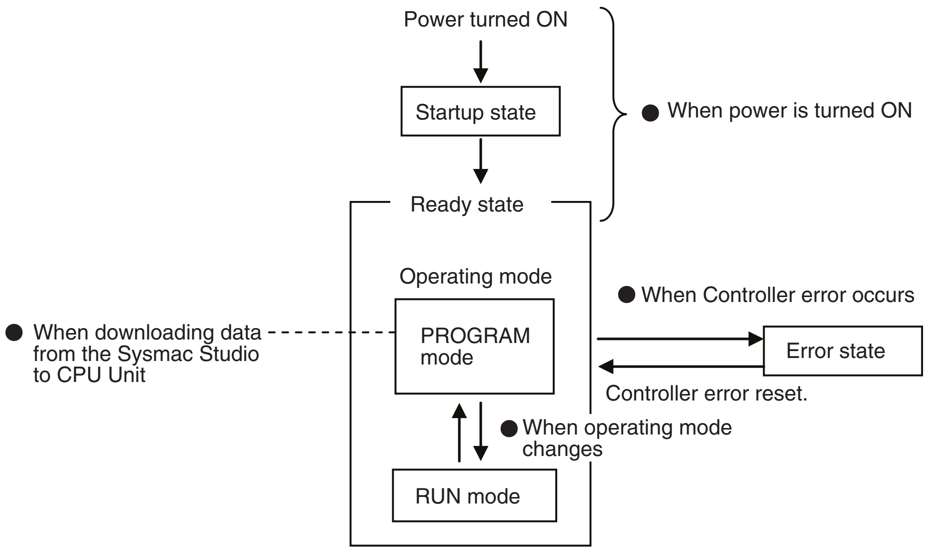
8-2-4 Status for Controller Errors . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 8-7

# 8-1 Overview of CPU Unit Status

This section provides an overview of the states of an NJ-series CPU Unit.

An NJ-series CPU Unit can be in any of three states: startup state, ready state, or error state. The CPU Unit changes between these states for the following events.

- When power is turned ON
- When operating mode changes
- When downloading data from the Sysmac Studio to CPU Unit
- When Controller error occurs



# 8-2 State Changes

This section describes the changes in states that can occur for an NJ-series CPU Unit.

## 8-2-1 When Power Is Turned ON

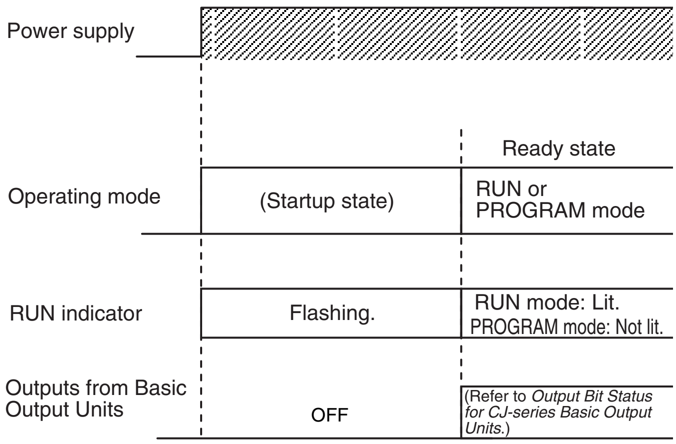
### Status until Ready State

The CPU Unit is ready to operate 10 to 20 seconds after the power supply to the Controller is turned ON. All outputs from Basic Output Units are OFF during this time. External communications are not performed and the RUN indicator flashes. (This is called the startup state.)

### Status after Ready State

#### ● Operating Modes

When the CPU Unit enters the ready state, it will change to the operating mode that you specify in the Controller Configurations and Setup (*Startup Mode* setting in the Basic Settings in **Configurations and Setup** – **Controller Setup** – **Operation Settings**). You can set the operating mode at startup to RUN mode or PROGRAM mode. Refer to *8-2-2 Operating Mode Changes* for information on the operating modes.




#### ● Status of Output Bits for EtherCAT Slaves

The status of slave outputs before the start of EtherCAT communications depends on settings in the slaves. After EtherCAT communications start, the slaves output the values of the device variables. The values of device variables in RUN mode depend on the results of user program execution. These values then determine the output values of slaves.

## 8-2-2 Operating Mode Changes

You can start and stop the execution of the user program when the CPU Unit is in Ready State.
You change the operating mode to start and stop user program execution.

### Operating Modes

There are two operating modes: RUN mode and PROGRAM mode.

- **RUN Mode**

The user program is executed in RUN mode. The default setting of the operating mode at startup is RUN mode.

- **PROGRAM Mode**

The user program is not executed in PROGRAM mode. Use this mode to transfer the project (with the user program) and check I/O wiring.

## Operating Modes and Functions

| Function | RUN mode | PROGRAM mode |
|---|---|---|
| **Program execution** | Yes | None |
| **I/O refreshing of CJ-series Units and EtherCAT slaves** | Yes | |
| **Synchronizing from the Sysmac Studio** | Not supported. | Supported. |
| **Online editing** | Supported. | |
| **Forced refreshing** | Supported. | |
| **Changing the values of variables and values in memory used for CJ-series Units from the Sysmac Studio** | Supported. | |
| **Changing the values of variables and values in memory used for CJ-series Units from an HMI.** | Supported. | |
| **Communications** | Supported. | |

## Operating Mode at Startup

You can set the operating mode that is used at startup in the Controller Setup under the Configurations and Setup on the Sysmac Studio, as shown below.

| Access point | Setting group | Setting | Description | Set values | Default | Update timing | Changes in RUN mode |
|---|---|---|---|---|---|---|---|
| Operation Settings, Operation Settings Tab, Basic Settings | Operation Settings | Startup Mode | Sets the CPU Unit's operating mode at startup. | RUN or PROGRAM mode | RUN mode | When downloaded to CPU Unit | Not allowed. |

## Operation for Operating Mode Changes

- **Changes in Values of Variables**

When the operating mode changes between RUN and PROGRAM mode, the values of variables and the status of errors are affected as given in the following table.

| Mode change | Values of user-defined variables | |
|---|---|---|
| | Variables without Retain attribute | Variables with Retain attribute |
| RUN to PROGRAM | • If initial values are set, the variables change to the initial values.<br>• If initial values are not set, the variables change to 0. | No change<br>(The values before the operating mode changed are retained.) |
| PROGRAM to RUN | | |

**Precautions for Safe Use**

Always confirm the safety of the controlled system before you change the operating mode or the setting of the Startup Mode.

### ● Status of Output Bits for EtherCAT Slaves

The output data sent from the EtherCAT Master Function Module is used regardless of the operating mode of the CPU Unit.

### ● Servo Drive Status

If the operating mode changes from RUN to PROGRAM mode during a motion control operation, the axes will decelerate to a stop at the maximum deceleration rate.

## Checking the Operating Mode

You can check the operating mode on the front-panel indicators, from the Sysmac Studio, or from system-defined variables.

### ● Checking Operating Mode on Indicators on Front of CPU Unit

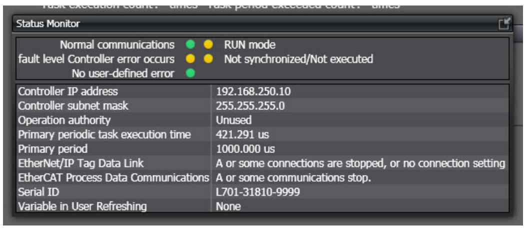
The RUN indicator on the front of the CPU Unit indicates the operating mode as described below.

| Operating modes | RUN indicator on CPU Unit | |
|---|---|---|
| | During startup | In ready status |
| PROGRAM mode | Flashing. | Not lit. |
| RUN mode | | Lit green. |

### ● Checking the Operating Mode from the Sysmac Studio

You can check the operating mode from the Controller Status Pane of the Sysmac Studio.

#### Controller Status Pane




**Additional Information**

Use the RUN output on the Power Supply Unit to externally output a signal in RUN mode.

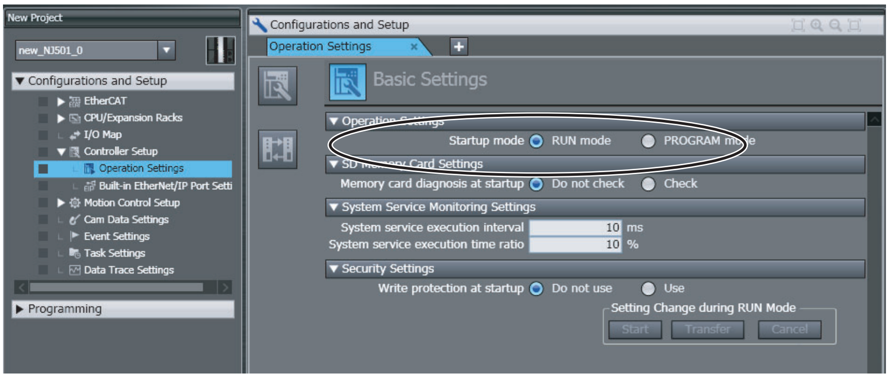
## Changing the Operating Mode

### ● Changing the Operating Mode

You can change the operating mode from the Sysmac Studio.

#### Changing the Operating Mode at Startup

When the power supply to the Controller is turned ON, the CPU Unit enters RUN mode by default. Change the setting of the *Startup mode* in the Basic Settings to PROGRAM mode in **Configurations and Setup** – **Controller Setup** – **Operation Settings** on the Sysmac Studio.




### Changing the Operating Mode from the Sysmac Studio

Use the following procedure.

- Select ***Mode - Run*** from the Controller Menu.

## 8-2-3 When Downloading Data from the Sysmac Studio to CPU Unit

The operation that occurs when you download the project data from the Sysmac Studio to the CPU Unit is described below.

## Operation during Downloads

### ● Status of Output Bits for EtherCAT Slaves

The output status is controlled by the settings in the EtherCAT slave.

### ● Output Bit Status for CJ-series Basic Output Units

When you change from RUN mode to PROGRAM mode, the memory used for CJ-series Units is initialized to all zeros (16#0000). I/O refreshing is performed with those values.

## Operation after Downloads

### ● Status of Output Bits for EtherCAT Slaves

The EtherCAT slaves perform initial processing after the download is completed. In the same way as for the download process, the operation of the slaves during this time depends on the settings in the EtherCAT slaves. Guidelines for the time required for initial processing after the download are given in the following table.

| Number of slaves | Time for initial processing after a download (guideline) |
|---|---|
| **1** | 3.8 s |
| **48** | 11 s |
| **192** | 45 s |

The status is as follows after initial processing:

| Settings at user program transfer | Device variables in CPU Unit | Status of outputs from EtherCAT slaves |
|---|---|---|
| When variable values are initialized or not initialized | Initial value of variable set to TRUE | Output is turned ON. |
| | Initial value of variable set to FALSE | Output is turned OFF. |
| | Variable for which no initial value is set | Output is turned OFF. |

### ● Output Bit Status for CJ-series Basic Output Units

| Settings at user program transfer | Device variables in CPU Unit | Status of outputs from CJ-series Basic Output Units |
|---|---|---|
| When variable values are initialized or not initialized | Initial value of variable set to TRUE | Output is turned ON. |
| | Initial value of variable set to FALSE | Output is turned OFF. |
| | Variable for which no initial value is set | Output before the download is retained. |

## 8-2-4 Status for Controller Errors

An error that is defined by the NJ-series system is called a Controller error. The following tables give the operation of function modules and the CPU Unit itself when a Controller error occurs.

### Function Module Operation for Controller Errors in RUN Mode

The following table lists function module operations when a Controller error occurs in RUN mode.

| Error type | Operation |
|---|---|
| **Minor fault level Controller error** | The function module where the error occurred does not stop. |
| **Partial fault level Controller error** | The function module where the error occurred stops. |
| **Major fault level Controller error** | All function modules stop. |

Refer to *12-1-3 Non-fatal error in CPU Unit* for details on Controller errors.

9

# CPU Unit Functions

This section describes the functionality provided by the CPU Unit.


**9-1 Data Management, Clock, and Operating Functions . . . . . . . . . . . . . . . . . 9-3**
9-1-1 Clearing All Memory . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9-3
9-1-2 Clock . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9-3
9-1-3 RUN Output . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 9-6

**9-2 Management Functions for CJ-series Units . . . . . . . . . . . . . . . . . . . . . . . . 9-7**
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# 9-1 Data Management, Clock, and Operating Functions

This section describes the data management, clock, and operating functions.

## 9-1-1 Clearing All Memory

You can initialize the user program, Controller Configurations and Setup, and variables in the CPU Unit to the defaults from the Sysmac Studio. This is called the Clear All Memory operation.

**Precautions for Correct Use**

- The Clear All Memory operation can be performed only in PROGRAM mode.
- You cannot execute the Clear All Memory operation when write protection is set in the security functions.
- Do not turn OFF the power supply to the Controller during the Clear All Memory operation.

After you clear the memory, the CPU Unit operates in the same way as immediately after you create the system configuration with the CPU Unit in the factory default condition.

The absolute encoder home offset is not cleared.

### ● Operations from the Sysmac Studio

Connect the Sysmac Studio to the CPU Unit online, and select ***Clear All Memory*** from the Controller Menu.

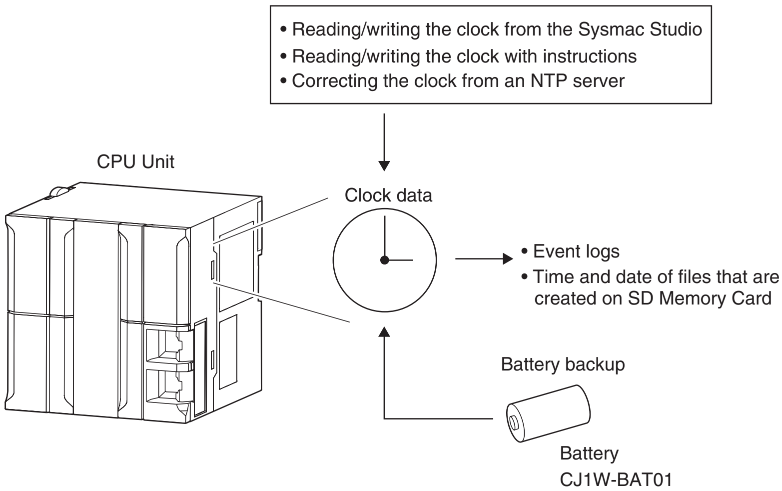
## 9-1-2 Clock

### Introduction

A clock (RTC) is built into the CPU Unit. The clock data from this clock is used for timestamps in the event logs and for the time and date of files that are created on the SD Memory Card.

The following functions are supported.

- Reading/writing the clock from the Sysmac Studio
- Reading/writing the clock with instructions
- Reading the clock from system-defined variables (Writing is not possible.)
- Correcting the clock from an NTP Server




**Precautions for Correct Use**

The clock data is retained by the Battery when the power is turned OFF. The clock data is not correct when the power is turned ON. You can reset the clock data from an NTP server over an EtherNet/IP network after the power is turned ON.

### Clock Data Range

The range of the clock is 1970-01-01 to 2106-02-06 (January 1, 1970 to February 6, 2106).

### Setting the Time Zone and the Local Time

You must set the time zone and local time for use outside of Japan. You can set the time zone from the Sysmac Studio in the Controller Clock Dialog Box. You can still use the CPU Unit's internal clock even if you do not set the time zone. Clock data that is read by the CPU Unit from an external device and the clock data that is set are the local time based on the time zone.

**Additional Information**

When a Battery is not mounted or when the Battery voltage is low, the time zone setting is retained, but the clock data is not retained and will not be correct.

## Setting the Clock Data

Use one of the following methods.

### Changing Clock Data from the Sysmac Studio

You can use the Sysmac Studio to synchronize the clock data of the built-in clock with the clock on the computer.

### Changing Clock Data with Instructions

You can use the SetTime instruction to set the clock data.

### Changing the Clock Data from an NTP Server

You can use an NTP server on EtherNet/IP to set the clock data.

## Correcting the Clock from an NTP Server

### ● Application

In a network system, the clock data must be shared by the entire system. NTP is supported to enable easy time synchronization.

### ● Specifications

An NTP client is provided.

Refer to the *NJ-series Built-in EtherNet/IP User's Manual* (Cat. No. W506) for details.

## Reading the Clock Data

If the clock data is incorrect, the incorrect value is read.

### ● Reading the Clock Data from Instructions

You can use the GetTime instruction to read the clock data from the user program.

### ● Reading the Clock from System-defined Variables (Writing Is Not Possible)

You can use the following system-defined variable to read the clock data.
*_CurrentTime* (System Time)

### ● Sysmac Studio Procedure

You can select ***Controller Clock*** from the Controller Menu of the Sysmac Studio to display the clock data.

## Logging

When you change the clock data, an event is recorded in the event log. However, nothing is recorded in the event log if the time is corrected for the NTP.

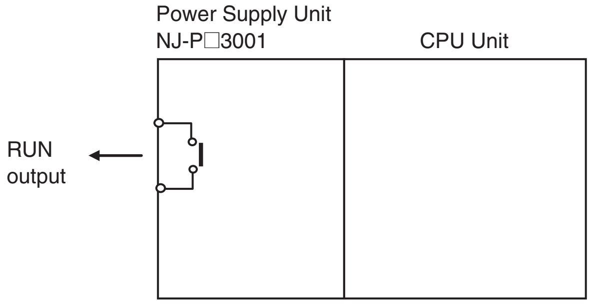
## Related System-defined Variables

| Variable name | Meaning | Description | Data type | R/W |
|---|---|---|---|---|
| _CurrentTime | System Time | This variable contains the CPU Unit's internal clock data. | DATE_AND_TIME | R |

## 9-1-3 RUN Output

### Introduction

The RUN output on the NJ-P□3001 Power Supply Unit is ON while the CPU Unit is operating.




The RUN output operates as shown in the following table.

| Status | Operation |
|---|---|
| **During RUN mode** | ON |
| **Startup state (until RUN mode is entered according to the Startup Mode setting).** | OFF |
| **During PROGRAM mode** | |
| **When a major fault level Controller error occurs** | |

The ratings of the RUN output on an NJ-P□3001 Power Supply Unit are as follows:

| Item | Description |
|---|---|
| **Contact form** | SPST-NO |
| **Switching capacity** | 2 A at 250 VAC for resistive load<br>0.5 A at 120 VAC for inductive load<br>2 A at 24 VDC for resistive load |

### Application

You can use the RUN output for the following purposes:

- Obtain a signal to notify the host that the CPU Unit is functioning normally and is currently operating.
- Synchronize the completion of startup of more than one CPU Unit
- Release interlocks when the CPU Unit starts operation.

**Precautions for Safe Use**

It takes up to approximately 10 to 20 s to enter RUN mode after the power is turned ON. During that time, outputs will be OFF and external communications are not performed. Use the RUN output on the Power Supply Unit, for example, to implement fail-safe circuits so that external devices do not operate incorrectly.

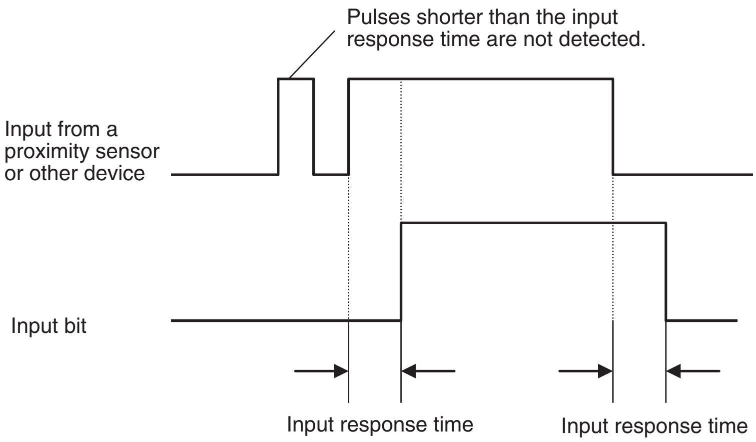
# 9-2 Management Functions for CJ-series Units

This section describes the management functions used for Units in the Controller.

## 9-2-1 Basic I/O Units

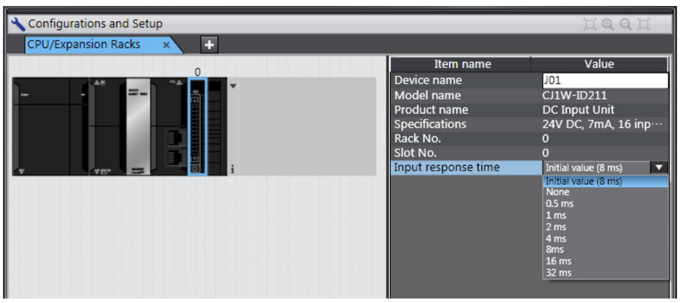
### Introduction

You can increase the input response time to reduce chattering and the effects of external noise. You can decrease the input response time to enable detection of shorter input pulses. Do not set the ON response time or OFF response time to less than the refresh time.




### Setting Methods

From the Multiview Explorer of the Sysmac Studio, double-click **CPU/Expansion Racks** under **Configurations and Setup**. Then select the input response times in the Unit information for the Basic I/O Units.




You must do either of the following to enable the settings.

- Cycle the power supply to the Controller.
- Reset the Controller (the entire CPU Unit) from the Sysmac Studio.

## Related System-defined Variables

The set values for the input response times of the Basic Input Units are output to the following system-defined variable.

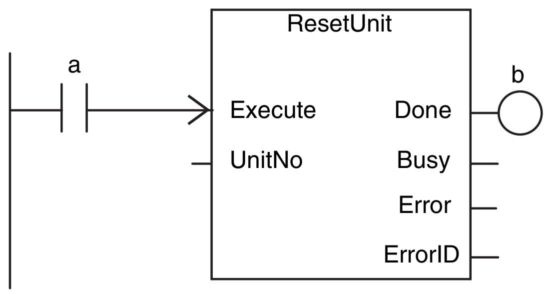
| Variable name | Meaning | Description | Data type |
|---|---|---|---|
| _CJB_InRespTm | Basic Input Unit Input Response Times | Contains the response times of the Basic I/O Units in 0.1-ms increments. | ARRAY[0..3, 0..9]OF UINT |

# 9-2-2 Special Units

## Restarting Special Units

You can restart a Special Unit (Special I/O Unit or CPU Bus Unit) to enable values that are set for it. If you restart a Special Unit, you do not have to cycle the power supply to the Controller. Execute the following ResetUnit (Restart Unit) instruction to restart Special Units.

| Instruction name | Instruction | Description |
|---|---|---|
| Restart Unit | ResetUnit | Restarts the CPU Bus Unit or Special I/O Unit. |




The ResetUnit instruction restarts a Special Unit across multiple task periods when execution condition *a* changes to TRUE. If the restart ends normally, the output variable *Done* (normal end) changes to TRUE and variable *b* therefore changes to TRUE.

If Special Unit settings are changed in any of the following ways, you must restart the Special Unit or cycle the power supply to the Controller.

- Editing from the Special Unit Setting Pane of the Sysmac Studio
- Editing from the I/O Map or Watch Tab Page
- Setting the user program

### ● Related System-defined Variables

| Variable name | Meaning | Description | Data type |
|---|---|---|---|
| _CJB_CBU00InitSta to _CJB_CBU15InitSta | CPU Bus Unit Initializing Flags | The corresponding variable is TRUE during initialization of the CPU Bus Unit. The corresponding variable changes to FALSE when the initialization is completed. The numbers in the variables indicate the unit numbers of the applicable Units. | BOOL |
| _CJB_SIO00InitSta to _CJB_SIO95InitSta | Special I/O Unit Initializing Flags | The corresponding variable is TRUE during initialization of the Special I/O Unit. The corresponding variable changes to FALSE when the initialization is completed. The numbers in the variables indicate the unit numbers of the applicable Units. | BOOL |

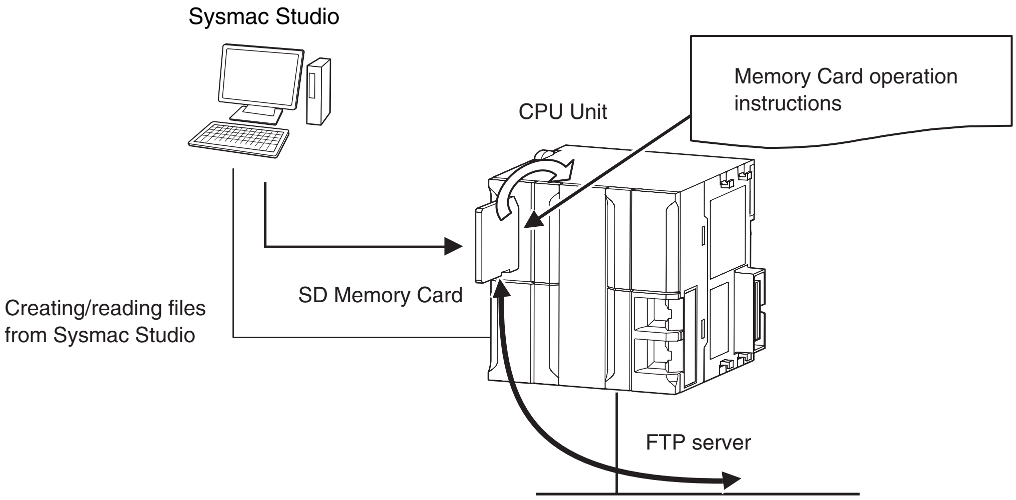
| Variable name | Meaning | Description | Data type |
|---|---|---|---|
| _CJB_CBU00 Restart to _CJB_CBU15 Restart | CPU Bus Unit Restart Bits | The CPU Bus Unit is restarted when the corresponding variable changes to TRUE. (It is changed to FALSE by the system after the CPU Bus Unit is restarted.) The numbers in the variables indicate the unit numbers of the applicable Units. If you change the Restart Bit to TRUE with an instruction, the restart process begins from refresh processing in the next task period after the instruction is executed. | BOOL |
| _CJB_SIO00 Restart to _CJB_SIO95 Restart | Special I/O Unit Restart Bits | The Special I/O Unit is restarted when the corresponding variable changes to TRUE. (It is changed to FALSE by the system after the Special I/O Unit is restarted.) The numbers in the variable names indicate the unit numbers of the applicable Units. If you change the Restart Bit to TRUE with an instruction, the restart process begins from refresh processing in the next task period. | BOOL |

# 9-3 SD Memory Card Operations

This section describes the functions that you can use for SD Memory Cards.

## 9-3-1 SD Memory Card Operations

The NJ-series CPU Unit supports the following functions for SD Memory Cards.




| Function | Introduction |
|---|---|
| **SD Memory Card operation instructions** | You can access SD Memory Cards from instructions in the user program. |
| **FTP server** | You can use FTP commands from an FTP client on the Intranet to read and write large files in the SD Memory Card through EtherNet/IP. |
| **File operations from the Sysmac Studio** | You can perform file operations from the Sysmac Studio for the SD Memory Card inserted in the CPU Unit.<br>You can perform file operations for Controller files in the SD Memory Card and save standard document files on the computer. |
| **SD Memory Card life expiration detection** | Notification of the expiration of the life of the SD Memory Card is provided in a system-defined variable and event log. |

## 9-3-2 Specifications of Supported SD Memory Cards, Folders, and Files

### SD Memory Card Specifications

You can use any SD or SDHC Memory Card, but operation has been verified only for the following OMRON SD Memory Card. Normal operation may not be possible with any other SD Memory Cards.

| Item | Description |
|---|---|
| **Model number** | HMC-SD291 |
| **Capacity** | 2 GB |
| **Number of overwrites** | 100,000 |
| **Formatting** | FAT16 |
| **Write protection** | You can write-protect the SD Memory Card with a hardware switch on the Card. |

The system-defined variable *_Card1Err* (SD Memory Card Error Flag) changes to TRUE (observation level) in the following cases.

- When there is a format error

If an error occurs, the SD PWR indicator on the front of the CPU Unit goes out, and accessing the SD Memory Card will not be possible.

### Folder and File Specifications

#### Character Restrictions

| Object named by user | Usable characters | Reserved words | Multibyte character compatibility | Case sensitivity | Maximum size (without NULL) |
|---|---|---|---|---|---|
| Volume label | 0 to 9, A to Z, and a to z, as well as % - _ @ ! ‘ ( ) ~= # & + ^ [ ] { } , . ; and single-byte kana*1 | CON, PRN, AUX, CLOCK$, NUL, COM0, COM1, COM2, COM3, COM4, COM5, COM6, COM7, COM8, COM9, LPT0, LPT1, LPT2, LPT3, LPT4, LPT5, LPT6, LPT7, LPT8, LPT9 | Not supported.*2 | Case insensitive | 11 bytes |
| Directory name | 0 to 9, A to Z, and a to z, as well as $ % ’ - _ @ ! ‘ ( ) ~= # & + ^ [ ] { } , . ; and single-byte kana | | | | 65 bytes |
| File name | | | | | 65 bytes |

*1 You cannot begin volume label names with a space.

*2 Even if the computer supports multibyte characters (e.g., for Japanese), you cannot use them in the CPU Unit.

#### Subdirectory Levels

You can create up to 5 levels (example: f1/f2/f3/f4/f5/abc.txt)

#### Number of Files in the Root Directory

511 max.

## 9-3-3 SD Memory Card Operation Instructions

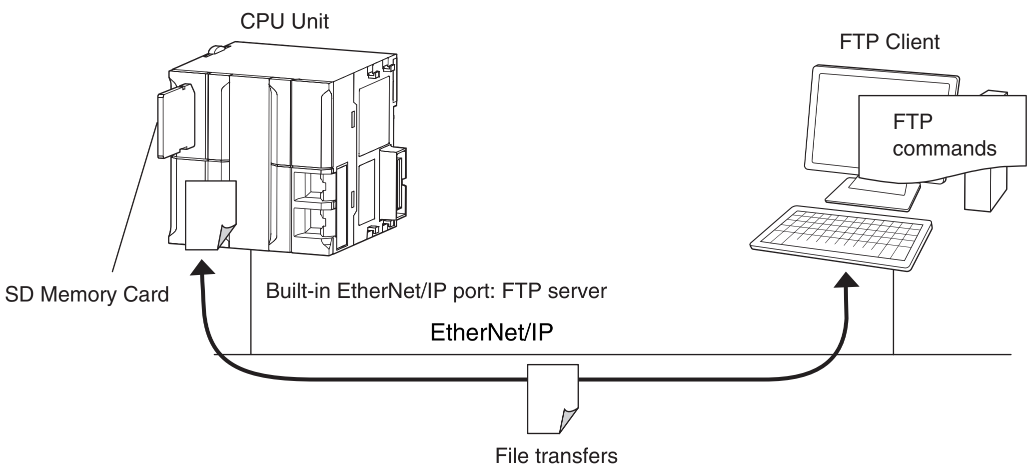
You can perform various operations on the SD Memory Card by using the following instructions.

| Instruction name | Instruction | Description |
|---|---|---|
| **Read Variable from File** | **FileReadVar** | The FileReadVar instruction reads the contents of a binary file on the SD Memory Card and writes it to the specified variable. You can specify array and structure variables. |
| **Write Variable to File** | **FileWriteVar** | The FileWriteVar instruction writes the value of a specified variable to a binary file in the SD Memory Card. You can specify array and structure variables. If the directory specified for the file name does not exist, it is created. |
| **Open File** | **FileOpen** | The FileOpen instruction opens the specified file. |
| **Close File** | **FileClose** | The FileClose instruction closes the specified file. |
| **Seek File** | **FileSeek** | The FileSeek instruction sets a file position indicator in the specified file. |
| **Read File** | **FileRead** | The FileRead instruction reads the data from the specified file. |
| **Write File** | **FileWrite** | The FileWrite instruction writes data to the specified file. |
| **Get Text String** | **FileGets** | The FileGets instruction reads a text string of one line from the specified file. |
| **Put Text String** | **FilePuts** | The FilePuts instruction writes a text string of one line to the specified file. |
| **Delete File** | **FileRemove** | The FileRemove instruction deletes the specified file from the SD Memory Card. |
| **Change File Name** | **FileRename** | The FileRename instruction changes the name of the specified file or directory. |
| **Copy File** | **FileCopy** | The FileCopy instruction copies the specified file to a different file. |
| **Create Directory** | **DirCreate** | The DirCreate instruction creates a directory in the SD Memory Card. |
| **Delete Directory** | **DirRemove** | The DirRemove instruction deletes a directory from the SD Memory Card. |

## 9-3-4 FTP Server

You can read and write files on the SD Memory Card via EtherNet/IP by sending FTP commands to the built-in EtherNet/IP port from an FTP client.

Refer to the *NJ-series CPU Unit Built-in EtherNet/IP User's Manual* (Cat. No. W506) for details.



## 9-3-5 File Operations from the Sysmac Studio

You can perform file operations from the Sysmac Studio for the SD Memory Card inserted in the CPU Unit. In addition to Controller files, you can also store document files or other files on the SD Memory Card.

## 9-3-6 SD Memory Card Life Expiration Detection

You can determine the remaining life of the SD Memory Card before the Card becomes physically deteriorated.

You can determine the remaining life of the SD Memory Card with the following functions.

- System-defined variable *_Card1Deteriorated* (SD Memory Card Life Warning Flag)
- SD Memory Card Life Exceeded (Observation) record in the event log

The life of the SD Memory Card is checked when the power is turned ON and periodically while the SD Memory Card is inserted.

When the end of the life of the SD Memory Card is detected, save the data on the SD Memory Card and replace the SD Memory Card.

## 9-3-7 List of System-defined Variables Related to SD Memory Cards

The following system-defined variables show the status of the SD Memory Card.

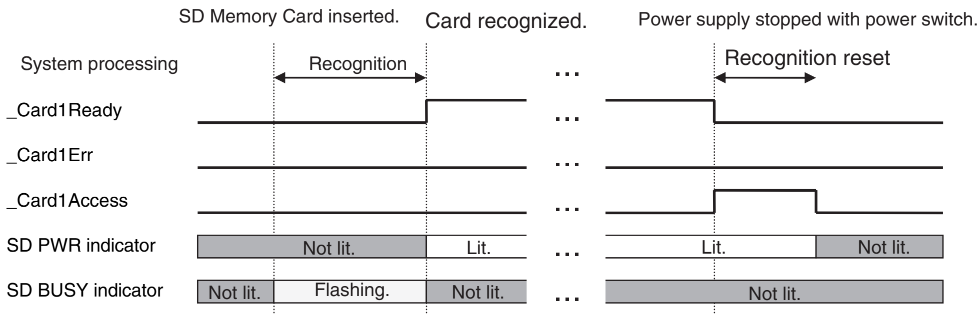
| Variable name | Meaning | Description | Data type |
|---|---|---|---|
| _Card1Ready | SD Memory Card Ready Flag | TRUE when the SD Memory Card is recognized. It is FALSE when an SD Memory Card is not recognized.<br>TRUE: The Card can be used.<br>FALSE: The Card cannot be used. | BOOL |
| _Card1Protect | SD Memory Card Write Protected Flag | TRUE when the SD Memory Card is write-protected.<br>TRUE: Write protected.<br>FALSE: Not write protected. | BOOL |
| _Card1Err | SD Memory Card Error Flag | TRUE when an unusable SD Memory Card is inserted or a format error occurs.<br>TRUE: There is an error<br>FALSE: There is no error | BOOL |
| _Card1Access | SD Memory Card Access Flag*1 | TRUE during SD Memory Card access.<br>TRUE: Card is being accessed.<br>FALSE: Card is not being accessed. | BOOL |
| _Card1Deteriorated | SD Memory Card Life Warning Flag | TRUE when the end of the life of the SD Memory Card is detected.<br>TRUE: The end of the life of the Card is detected.<br>FALSE: The end of the life of the Card was not detected. | BOOL |
| _Card1PowerFail | SD Memory Card Power Interruption Flag*2 | TRUE when the power supply to the Controller was interrupted during access to the SD Memory Card.<br>TRUE: Power was interrupted during SD Memory Card access.<br>FALSE: Operation is normal. | BOOL |

*1 Precaution When Using SD Memory Card Access Flag (*_Card1Access*)
The SD Memory Card Access Flag is intended for use in notifying external devices. The status of access to the SD Memory Card is not updated in realtime. Because of this, do not use the flag in the user program. Because the status of access to the SD Memory Card is not shown in realtime, it may cause unexpected Controller operation if you use it in the user program.

*2 Precautions When Using the SD Memory Card Power Interruption Flag ( *_Card1PowerFail*)
If the SD Memory Card Power Interruption Flag is TRUE, check to see if the correct file is in the SD Memory Card and to see if the SD Memory Card operates properly. If the correct file is missing or the SD Memory Card does not operate properly, download the correct file to the SD Memory Card again. Cycle the power supply to the Controller or reset the Controller, and then see if the SD Memory Card operates properly. When you are finished, change SD Memory Card Power Interruption Flag to FALSE. (*_Card1PowerFail* does not change to FALSE automatically.)

**Additional Information**

SD Memory Card Recognition and Unmounting Timing Chart




## 9-3-8 SD Memory Card Self-diagnostic Functions

You can perform self-diagnosis on the inserted SD Memory Card when the power supply is turned ON.

You can select whether to perform self-diagnosis when the power is turned ON in the Operation Settings of the Controller Setup under the Configurations and Setup from the Sysmac Studio as shown below.

- File system check
- Check equivalent to CHKDSK
- Restoration attempt when check fails

| Access point | Setting group | Setting | Description | Set values |
|---|---|---|---|---|
| Operation Settings, Operation Settings Tab, Basic Settings | SD Memory Card Settings | Memory Card Diagnosis at Startup (See note.) | Sets whether to execute self-diagnosis (file system check and restoration) on the inserted SD Memory Card when the power is turned ON. | Do not check.<br>Check. |

**Note** Self-diagnosis is not executed if write protection is set on the SD Memory Card itself.

## ● Results of Self-diagnosis

| Case | Indicators | | | Error type | Correction | Remarks |
|---|---|---|---|---|---|---|
| | RUN | SD PWR | SD BUSY | | | |
| Self-diagnosis in progress | Flashing. | Not lit. | Lit. | --- | --- | --- |
| 1. When self-diagnosis found no problems | --- | Lit. | Not lit. | Normal | None | --- |
| 2. The format of the SD Memory Card is not correct. | --- | Not lit. | Not lit. | Observation | Use the Sysmac Studio to format the SD Memory Card. | --- |
| 3. An error was detected during the file system check and the file system was automatically restored. | --- | Not lit. | Flashes during restore operation.<br>Not lit after restore operation is completed. | Observation | Use file operations in the Sysmac Studio or insert the SD Memory Card into the computer to check whether any files were deleted by the restore operation. | If a corrupted file is detected, an attempt is made to restore the file. |
| 4. The SD Memory Card failed. | --- | Not lit. | Not lit. | Observation | Replace the SD Memory Card. | --- |

**Precautions for Correct Use**

Never interrupt the power supply to the Controller during SD Memory Card access. That includes when SD Memory Card self-diagnosis at startup is enabled. An attempt is made by the SD Memory Card restoration function to restore any corrupted files. If the restore fails, these files may be deleted automatically at startup.

**Precautions for Safe Use**

If the recovery function is activated at startup, time is required to enter RUN mode. During that time, outputs will be OFF and external communications are not performed. Use the RUN output on the Power Supply Unit, for example, to implement fail-safe circuits so that external devices do not operate incorrectly.

## 9-3-9 Exclusive Control of Access to the SD Memory Card

Access to files on the SD Memory Card is possible with the following methods.

- FTP server
- SD Memory Card operation instructions
- File operations from the Sysmac Studio

However, exclusive control is required when you access the same file on the SD Memory Card from different sources. This is to prevent reading or writing a file while it is being written, or writing a file while it is being read.

### Exclusive Control of Access to a File on the SD Memory Card

The CPU Unit automatically performs exclusive control only for the following combinations of instructions.

For the other combinations shown below, perform exclusive control by using file operation instructions (Change File Name, Copy File, etc.) or communications commands.

<table>
<tr><th colspan="2" rowspan="2">Access already underway<br>Later access</th><th colspan="2">Instructions</th><th colspan="2">FTP</th></tr>
<tr><th>Read</th><th>Write</th><th>Read</th><th>Write</th></tr>
<tr><th rowspan="2">Instructions</th><th>Read</th><td colspan="2" rowspan="2">Exclusive control is performed automatically, and an error occurs for the instruction that is executed later.</td><td>(Exclusive control is not required.)</td><td rowspan="4">Perform exclusive control.</td></tr>
<tr><th>Write</th><td>Perform exclusive control.</td></tr>
<tr><th rowspan="2">Communications commands</th><th>Read</th><td>(Exclusive control is not required.)</td><td>Perform exclusive control.</td><td>(Exclusive control is not required.)</td></tr>
<tr><th>Write</th><td colspan="3">Perform exclusive control.</td></tr>
</table>

# 9-4 Security

This section describes security functions.

The NJ-series Controller provides the following security functions.

- Verification of operation authority
- CPU Unit names and serial IDs
- Protection
- Restriction of user program operation with user program execution IDs

## 9-4-1 Verification of Operation Authority

### Introduction

Online operations are restricted by operation rights to prevent damage to equipment or injuries that may be caused by operating mistakes. Examples are shown below.

- I/O Monitor: Writing, forced refreshing, etc.
- Controller operations: Changing the operating mode, online editing, MC Test Run, etc.

You can register passwords for operation authority for each CPU Unit in the Sysmac Studio. If a correct password is entered when an online connection is made to a Controller, the online operations for the operation authority category for the password that was entered will be allowed.

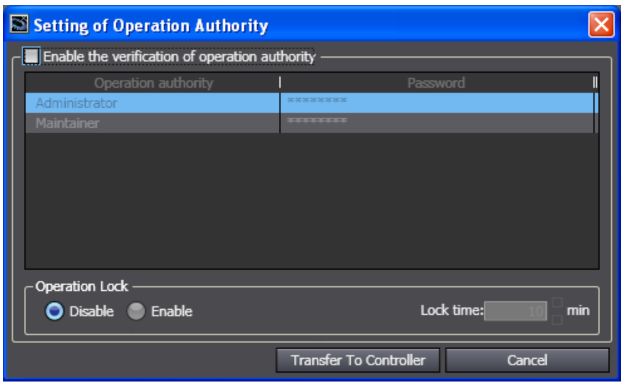
The Administrator sets a password for each operation authority. Users are notified of the operation authority name and password according to their skills.

### Operation

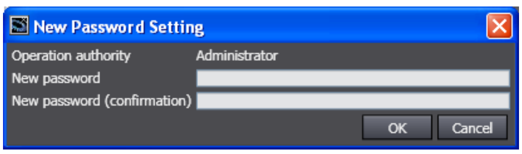
#### ● Enabling Operation Authority Authentication

Select ***Security*** – ***Setting of Operation Authority*** from the Controller Menu on the Sysmac Studio. Settings are made in the following dialog box.

**1** Select ***Security*** – ***Setting of Operation Authority*** from the Controller Menu. The Setting of Operation Authority Dialog Box is displayed.




**2** Select the *Enable the verification of operation authority* Check Box and double-click *Administrator* in the *Operation authority* Column.




9-4 Security

9

9-4-1 Verification of Operation Authority

**3** Enter the Administrator's password in the *New password* Box. Enter the same password in the confirmation box, and click the **OK** Button.

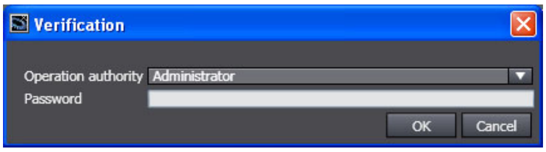
**4** Set the Maintainer's password in the same way.

The user can perform operations only if the correct password is entered.

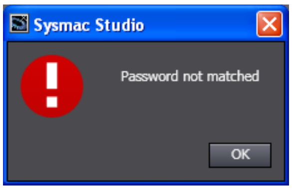
| Setting | Description |
|---|---|
| **Enable the verification of operation authority** | Select this check box to enable verification of operation authority. Set a password for each operation authority level. |
| **Operation Lock** | When the operation lock is enabled, operation is locked if you do not perform any actions for the specified period of time when the Sysmac Studio is online. To reset the lock, enter the password in the Verification of Operation Authority Dialog Box that is displayed. This prevents an operator with different authority from mistakenly performing operations. The operation lock is intended to prevent misuse by operators of different operation authority levels. Execution of internal Sysmac Studio operations, such as monitoring and transfer processes, is still possible even when operation is locked. |

### ● Going Online

**1** Go online. The Verification Dialog Box is displayed.




**2** Select the operation authority, enter the password, and click the **OK** Button. The following warning is displayed if the password does not match. Click the **OK** Button, and then try to go online again.




## Specifications

### ● Types of Operation Authorities

You can use the following two operation authorities on the Sysmac Studio.

| English name |
|---|
| Administrator |
| Maintainer |

### ● Examples of Online Operations for Operation Rights

Examples of the online operations that are allowed for each operation authority are given below. Refer to the *Sysmac Studio Version 1 Operation Manual* (Cat. No. W504) for details.

OK: Operation possible, VR: Verification required for each operation, NP: Operation not possible

| Status monitor (example) | Administrator | Maintainer |
|---|---|---|
| Monitoring errors for troubleshooting | OK | OK |

| I/O monitor operations (examples) | Administrator | Maintainer |
|---|---|---|
| I/O monitor: Reading | OK | OK |

| Status monitor (example) | Administrator | Maintainer |
|---|---|---|
| I/O monitor: Writing | OK | OK |
| Controlling BOOL variables (SET/RESET) | OK | OK |
| Forced refreshing | OK | OK |

| Controller operations (examples) | Administrator | Maintainer |
|---|---|---|
| RUN mode/PROGRAM mode | OK | VR |
| Online editing | OK | VR |
| Resetting the Controller | OK | NP |
| Resetting errors (troubleshooting) | OK | OK |
| Starting or restarting an MC Test Run | OK | VR |
| User program execution IDs for Controllers | OK | NP |
| CPU Unit write protection | OK | OK |

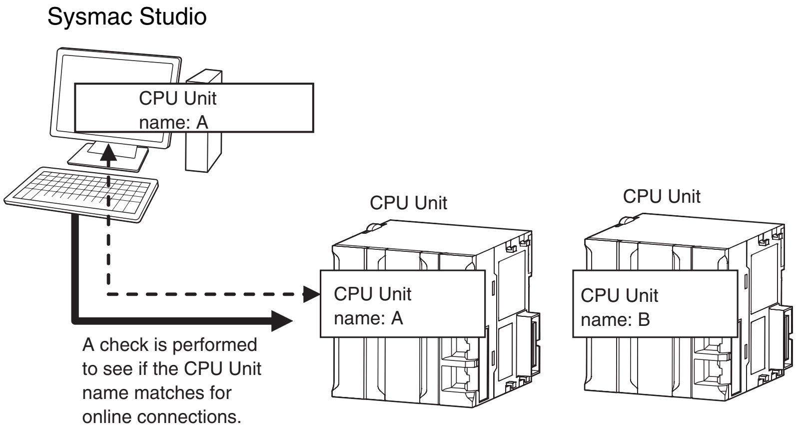
### ● Password Specifications

| Item | Description |
|---|---|
| **Valid number of characters** | 8 to 32 |
| **Applicable characters** | Single-byte alphanumeric characters (case sensitive) |

## 9-4-2 CPU Unit Names and Serial IDs

### Introduction

Register a CPU Unit name in the CPU Unit. When going online to a CPU Unit from the Sysmac Studio, the CPU Unit name in the project is compared to the name of the CPU Unit being connected to. This helps prevent incorrect connections to the CPU Unit from the Sysmac Studio. It is particularly effective for operations performed over an EtherNet/IP network.

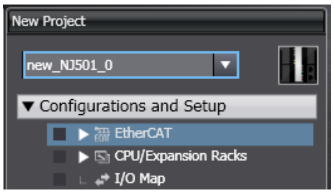



In addition to the CPU Unit name, it is also possible to use serial ID identification based on the CPU Unit production information (optional).

## Setting Methods

**1** Set the CPU Unit name when you create a project on the Sysmac Studio.

The CPU Unit name is displayed as shown below.




To change the name, right-click the Controller icon and select ***Rename***.

**2** When you first connect to the CPU Unit online, the Sysmac Studio prompts you to store the CPU Unit name in the CPU Unit.

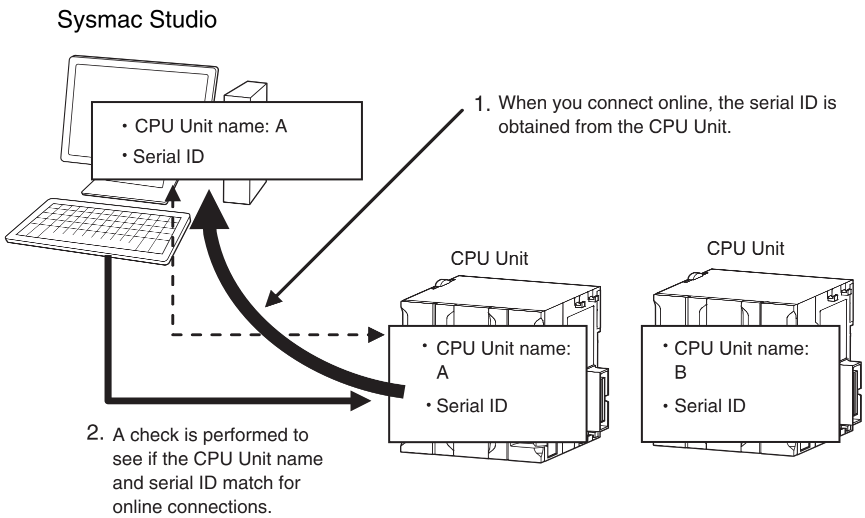
**3** After that, when you connect to the CPU Unit online, the Sysmac Studio refers to the CPU Unit name in the project and the CPU Unit name of the CPU Unit you connect to. A warning dialog box is shown if they do not match, and you are asked whether to continue to connect.

**Additional Information**

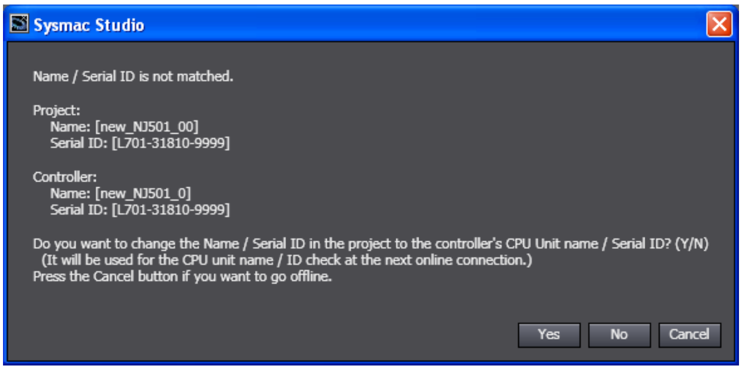
You can name EtherNet/IP ports in the Network Configurator.

## Serial IDs (Optional Function)

When the Sysmac Studio first connects online, you can obtain the serial ID from the CPU Unit's production information and store it in the project. After that, when the Sysmac Studio connects online, both the CPU Unit name and the serial ID are compared. This enables stricter verification of the CPU Unit.



**The following dialog box is displayed on the Sysmac Studio when the CPU Unit name and the serial ID are compared.**




## 9-4-3 Protection

### Introduction

This function disables the ability to write data to CPU Units and SD Memory Cards to protect user program assets and prevent misuse. The NJ-series Controller provides the following protection functions.

#### ● Protection for Online Operations from the Sysmac Studio

| Protection | Description | Target data in the CPU Unit | | |
|---|---|---|---|---|
| | | User program | Cam tables | Configurations and Setup |
| **User program transfers with no restoration information** | **Prevents reading data in the CPU Unit from the Sysmac Studio. This protects the user program and other data.** | Possible | Possible | --- |
| **CPU Unit write-protection** | **Prevents writing data to the CPU Unit from the Sysmac Studio. Use this function to prevent incorrect operation.** | Possible | Possible | Possible |

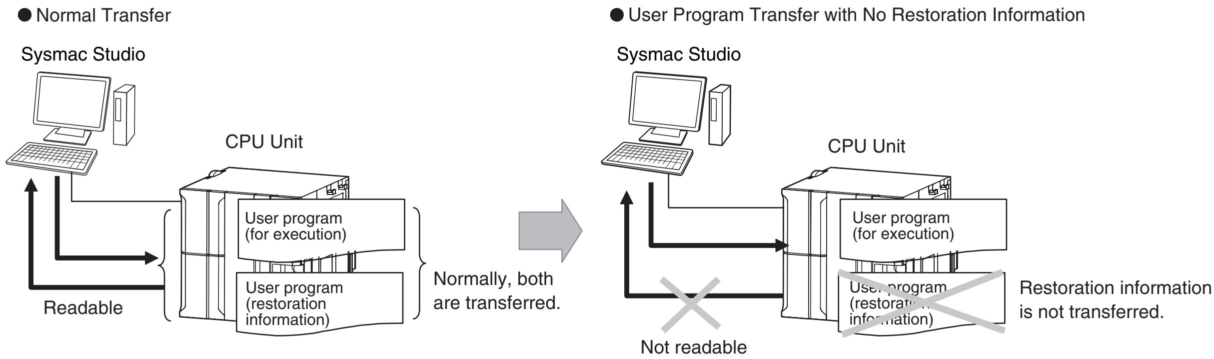
#### ● Protection for Offline Operations from the Sysmac Studio

| Protection | Description | Protection |
|---|---|---|
| **Protection of all project files** | **Codes the project file by using a password when the project is exported (when an .smc file is created).** | Project file |

## Protection for Online Operations from the Sysmac Studio

### ● User Program Transfers with No Restoration Information

Normally, when you transfer the user program from the Sysmac Studio to the CPU Unit, information is transferred to restore it. This function does not transfer information for restoration to prohibit reading the user program.



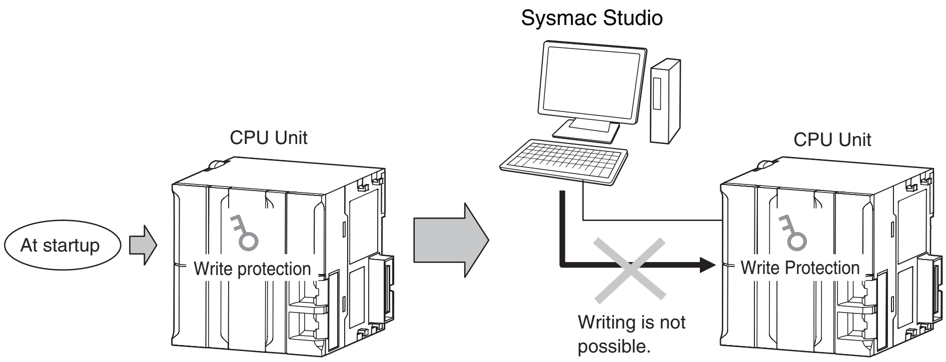

This function is used to prevent theft of user program data when on-site maintenance of the user program is not required. In the Sysmac Studio, select the *Do not transfer program source* Check Box and click the **Transfer to Controller** Button when you transfer the user program to the CPU Unit.

### ● CPU Unit Write-protection

The following two types of protection are supported.

**1) Controller Write Protection at Startup**

This setting automatically enables write protection when you turn ON the power supply to the Controller.

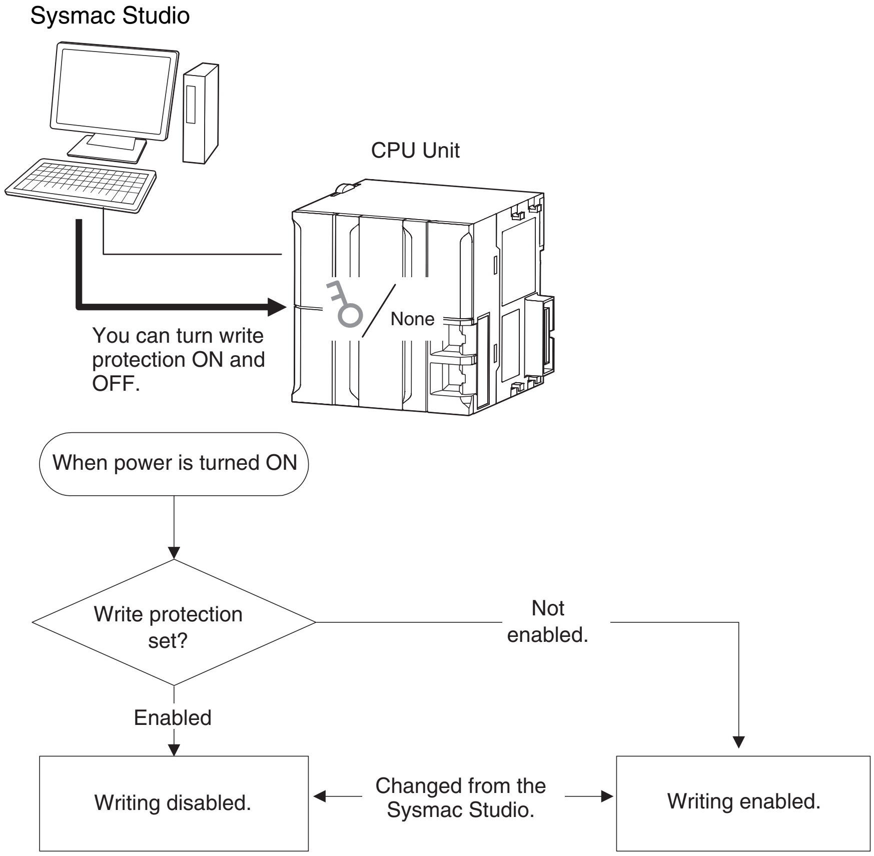



Set whether to automatically enable write protection when the power supply is turned ON in the **Controller Setup** under the **Configurations and Setup** of the Sysmac Studio.

| Access point | Setting group | Setting | Description | Set values |
|---|---|---|---|---|
| Operation Settings, Operation Settings Tab, Basic Settings | Security Settings | Write Protection at Startup | Sets whether to enable write protection. | Do not use.<br>Use. |

### 2) Setting and Removing Write Protection from the Sysmac Studio

In the Sysmac Studio, go online and select ***Security*** – ***Write Protect Setting Switch*** from the Controller Menu to toggle write protection.



## Write-protected Items

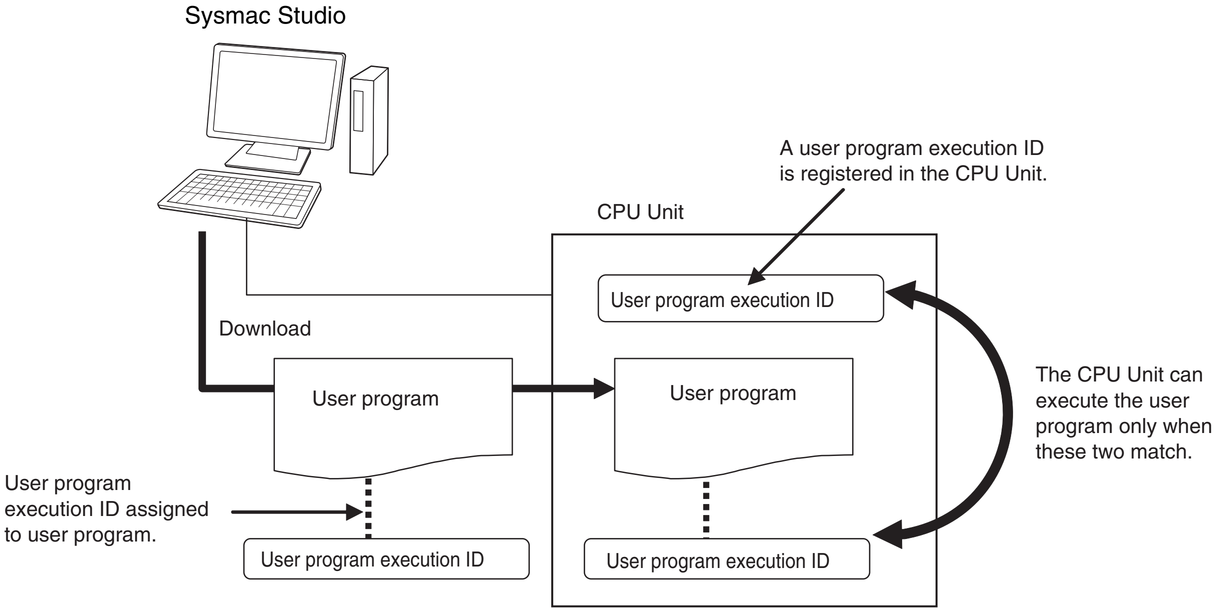
The data and write operations in 1) and 2), above, to which write protection applies are given below.

| Target data/write operation | | Write protection |
|---|---|---|
| Name | CPU Unit name | Protected |
| | Built-in EtherNet/IP names | --- |
| Variables | I/O monitoring | --- |
| | Controlling BOOL variables (SET/RESET) | --- |
| | Forced refreshing | --- |
| Operation commands | Changing the operating mode | --- |
| | Online editing | Protected |
| | Clearing all memory | Protected |
| | Resetting errors for troubleshooting | --- |
| | Clearing event logs (for troubleshooting) | Protected |
| | Clock operations | --- |
| | MC Test Run | --- |
| | Resetting the Controller | --- |
| | User program execution IDs for Controllers | Protected |
| | Memory Card operations | --- |
| | Resetting | --- |
| Download | User program, global variable table, date type tables, POUs, and task settings | Protected |
| | Unit Configuration | Protected |
| | Setting data in the CJ-series Units CPU Bus Unit Setups (e.g., CONTROLLER LINK data link tables) and allocated DM Area words | --- |
| | EtherCAT Configuration and Setup | Protected |
| | Settings in the EtherCAT slaves | --- |
| | Controller Setup (including routing tables) | Protected |
| | Axis Setup | Protected |
| | Cam table settings | Protected |
| | Memory Card operations | --- |
| | Data Trace Settings | Protected |
| | Event Settings | Protected |
| Restoring | Restoring from computer (from computer to CPU Unit) | Protected |

## 9-4-4 CPU Unit Operation Restrictions for the User Program Execution ID

### Introduction

You can set a specific ID (called a user program execution ID) in the CPU Unit in advance. If you do, you can execute only a user program with the same ID.



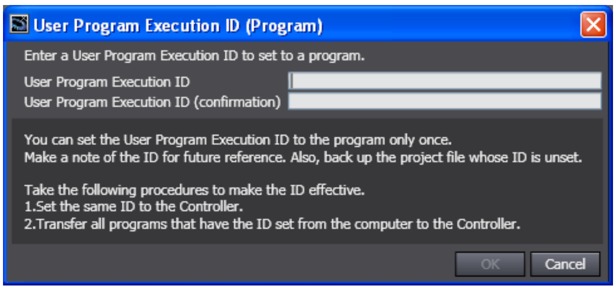

You can therefore prevent different CPU Units (hardware) from executing a user program.

In contrast to the protection function, you can still display and edit the user program even if a user program execution ID is set.

### Operating Procedure

**1** Always backup the project files before you assign a user program execution ID.

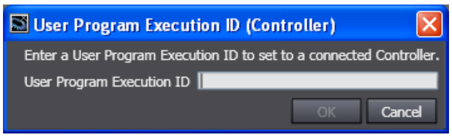
**2** Assign the user program execution ID to the user program offline from the Sysmac Studio.




**Precautions for Correct Use**

After you assign a user program execution ID to a user program, you cannot change or delete the ID. To use a different ID, read the project file without an ID that was backed up in step 1, above, and assign another user program execution ID. To delete the ID, use the project file without an ID that was backed up in step 1, above.

**3** Connect the Sysmac Studio online and register the user program execution ID that was set in step 2 in the CPU Unit.




The registration of the user program execution ID in the CPU Unit is recorded in the event log. At this time, the user program execution ID in the CPU Unit is overwritten even if it is already registered.

**4** Transfer the user program with the same user program execution ID to the CPU Unit.

If the user program execution ID in the user program does not match the user program execution ID in the CPU Unit or if one of them does not have an ID, an ID Verification Error (major fault level Controller error) occurs when you attempt to change to RUN mode and the CPU Unit will not operate.

**Precautions for Correct Use**

After you assign a user program execution ID to the CPU Unit, you cannot read or delete the ID. To delete the ID from the CPU Unit, perform the Clear All Memory operation on the CPU Unit.

## ● Operation When an ID Verification Error Occurs

### When the User Program Execution ID in the CPU Unit Is Incorrect or Not Registered:

Connect online to the CPU Unit from the Sysmac Studio and perform the following steps.

**1** Overwrite or register the correct user program execution ID in the CPU Unit.

**2** Cycle the power supply to the Controller, or reset the CPU Unit from the Sysmac Studio.

### When the User Program Execution ID Is Not Assigned to the User Program or Is Incorrect

**1** Read the backed up project file from the Sysmac Studio, and assign the correct user program execution ID.

**2** Connect the Sysmac Studio to the CPU Unit online and transfer the user program.

**3** Cycle the power supply to the Controller, or reset the Controller from the Sysmac Studio.

## ● Other Situations

### To Delete the User Program Execution ID Assigned to the User Program:

Read the backed up project file in the Sysmac Studio.

### To Delete the User Program Execution ID from the CPU Unit:

Connect the Sysmac Studio to the CPU Unit online and perform the Clear All Memory operation.

### To Check the User Program Execution ID Assigned to the User Program:

For security, the user program execution ID that is assigned to the user program cannot be checked from the Sysmac Studio. Read the backed up project file in the Sysmac Studio and set the user program execution ID again.

### To Check the User Program Execution ID in the CPU Unit:

For security, the user program execution ID that is set in the CPU Unit cannot be checked from the Sysmac Studio. Perform the Clear All Memory operation and register the correct user program execution ID.

## Specifications

### ● User Program Execution ID Verification Specifications

#### Timing of Verification

At startup, the CPU Unit compares the user program execution ID that is registered in the CPU Unit with the user program execution ID that is assigned to the user program.

#### Verification Conditions

The conditions for verifications are given in the following table.

"A" and "B" indicate the IDs.

| User program execution ID that is registered in the CPU Unit | User program execution ID that is assigned to the user program | Error | Operation |
|---|---|---|---|
| A | A | None | Possible |
| None | None | | |
| None | A | ID Verification Error | Not supported. |
| A | None | | |
| A | B | | |

#### Operation When the IDs Do Not Match

When the IDs do not match, an ID Verification Error (major fault level Controller error) occurs, and the CPU Unit does not operate. However, to reset the error you must cycle the power supply to the Controller or reset the Controller from the Sysmac Studio.

### ● User Program Execution ID Character Specifications

| Usable characters | Case sensitivity | Maximum size (without NULL) |
|---|---|---|
| 0 to 9, A to Z, and a to z | Case sensitive | 8 to 32 characters |

# 9-5 Debugging

This section describes debugging.

The NJ-series Controller provides the following debugging operations.

- Forced refreshing
- Changing present values
- Online editing
- Data tracing

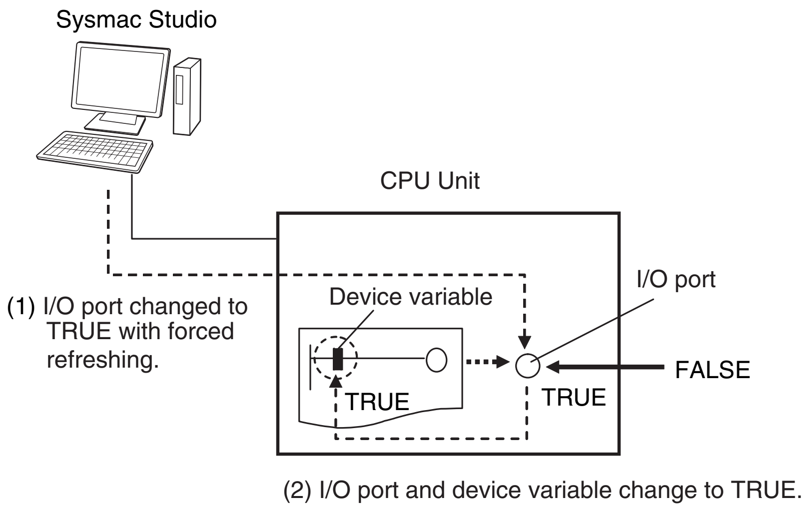
## 9-5-1 Forced Refreshing

### Description

Forced refreshing allows the user to refresh external inputs and outputs with user-specified values from the Sysmac Studio to debug the system. Forced refreshing is executed not for the specified device variables, but for the I/O ports that are assigned to the device variables. The state that is specified with forced refreshing is retained until forced refreshing is cleared from the Sysmac Studio. (Refer to *Holding/Clearing Forced Refreshing* on page 9-31 for information how forced refreshing is retained or cleared according to changes in CPU Unit status. All forced refreshing is cleared when a fatal error occurs, when a Clear All Memory operation is performed, when the operating mode is changed, when power is interrupted, or when the project is downloaded.

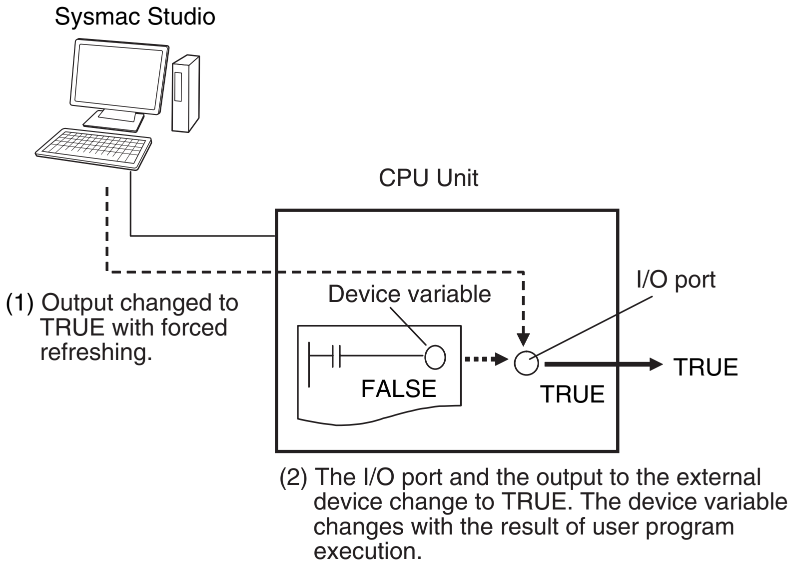
#### Inputs

The I/O port and device variable change to the status that is specified with forced refreshing regardless of the status of the external input.



### Outputs

The I/O port and the output to the external device change to the status that is specified with forced refreshing. In the user program, the status of the device variable that is assigned to the I/O port will not necessarily be the status that was specified with forced refreshing. It will change with the results of user program execution.




## Applicable Areas

You can execute forced refreshing for the following I/O ports and memory used for CJ-series Units.

- I/O ports for EtherCAT slaves
- I/O ports for CJ-series Basic I/O Units
- I/O ports for CJ-series Special Units
- I/O bits for DeviceNet slaves that is specified for an AT specification from a variable

If you execute forced refreshing from the Ladder Editor or the Watch Tab Page, the status of the I/O port or memory element for a CJ-series Unit will change via the variable.

## Number of Simultaneous I/O for Forced Refreshing

The number of variables that you can refresh with forced refreshing is listed below.

- CJ-series Units: 64 points total
- EtherCAT slaves: 64 points total

The number of external I/O points are given for the above limits. For example, if more than one variable is assigned the same external I/O point as the AT specifications, it is counted as only one point.

## Application

### ● Inputs

- To apply a simulated input signal to debug the user program
- To create a status that would occur only when a failure occurs (e.g., two exclusive bits turning ON or OFF at the same time)

### ● Outputs

- To turn outputs ON and OFF to check wiring

- To intentionally turn OFF an output you do not want to operate regardless of results of user program execution

## Operating Procedure

Operations can be performed from the following panes.

- Program Panes (Ladder diagram language)
- I/O Map
- Watch Tab Page

### ● Procedure for Forced Refreshing from Ladder Editor

**1** Select ***Monitor*** from the Controller Menu. The monitor turns ON.

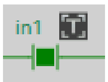
**2** Double-click the ladder program, ladder function, or ladder function block under **Programming** in the Multiview Explorer.

The rungs are displayed on the Ladder Editor in monitor status.

**3** Right-click the input or output and select ***Forced Refreshing*** – ***TRUE***. The input or output is forced to TRUE. Right-click the input or output and select ***Forced Refreshing*** – ***FALSE***. The input or output is forced to FALSE.

**4** The input or output in the Ladder Editor changes to TRUE or FALSE and the execution condition changes accordingly.

A mark that indicates that the input or output has forced status is displayed as shown below.




Ladder diagram

The TRUE or FALSE mark for forced status indicates the status that was specified for forced refreshing. It does not indicate the current value of the input or output.

| Forced status mark | Operation |
|---|---|
|  | TRUE specified with forced refreshing |
|  | FALSE specified with forced refreshing |

**Additional Information**

If there are other variables that are assigned the same memory address as one that is specified as the AT specification of a variable for which forced refreshing is specified, the forced status mark is displayed for all of the variables with that AT specification.

## Affect of Operating Modes and Power Interruptions

### ● Operating Modes for Forced Refreshing

You can execute forced refreshing in either PROGRAM mode or RUN mode. Forced refreshing is not possible while there is a major fault level Controller error.

### Status of Forced Refreshing during Operating Mode Changes or Power Interruptions

By default, the forced refreshing is cleared when the operating mode changes between RUN mode and PROGRAM mode and when the power is interrupted.

## Holding/Clearing Forced Refreshing

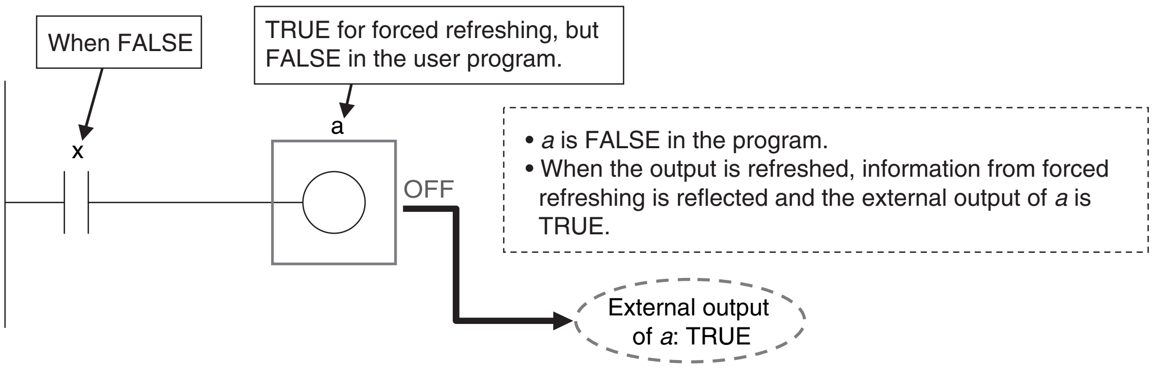
Forced refreshing is retained and cleared according to changes in the status of the CPU Unit as shown below.

| Change in status | | Forced refreshing status |
|---|---|---|
| **When power is turned ON** | | Cleared |
| **When operating mode changes** | **RUN to PROGRAM mode**<br>**PROGRAM to RUN mode** | Cleared |
| **After downloading** | | Cleared |
| **When a major fault level Controller error occurs** | | Cleared |
| **During online editing** | | Retained |

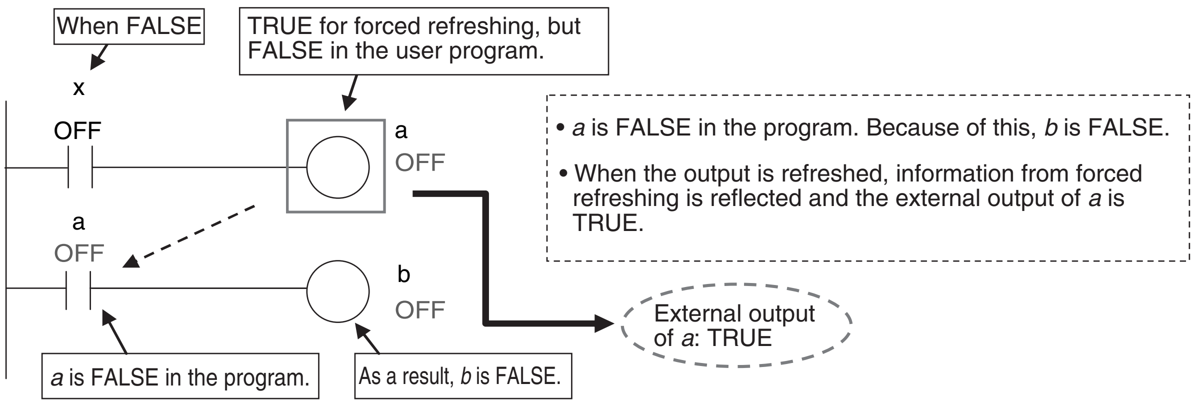
## Programming Precautions for Forced Refreshing

The status of variables for which forced refreshing is specified are overwritten by instruction in the user program. Therefore, the status that is specified for forced refreshing is not maintained in the user program. (This point differs from forced-setting/resetting with CJ-series PLCs.)
However, refreshing to external devices uses the values that were specified for forced refreshing, and not the status of the variables in the user program. Therefore, care is required when using forced values in the user program.

Example: When a Is Refreshed to TRUE with Forced Refreshing




When There Is Another Input that is Controlled by the Forced Input



**Precautions for Safe Use**

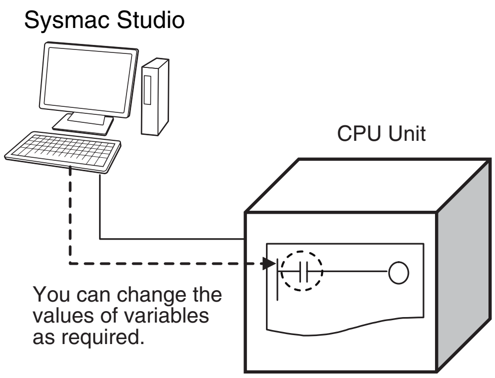
- Confirm that no adverse effect will occur in the system before you use forced refreshing.
- Forced refreshing ignores the results of user program execution and refreshes I/O with the specified values. If forced refreshing is used for inputs for which I/O refreshing is not supported, the inputs will first take the specified values, but they will then be overwritten by the user program.

Depending on the difference in the forced status, the control system may operate unexpectedly.

## 9-5-2 Changing Present Values

### Description

You can change the present values of variables that are used in the user program and settings and you can change program inputs and outputs to TRUE or FALSE. This allows you to check the operation of the user program and settings.




**Precautions for Safe Use**

Always confirm the safety of the system before you change the present value of a variable.

### Application

#### ● Changing Program Inputs and Outputs to TRUE or FALSE

You can change the value of any BOOL variable to TRUE or FALSE. The specified value is then overwritten by the execution results of the user program. If the operating mode is changed or the power supply is cycled, the initial value is restored. You can control BOOL variables in the Ladder Editor, Watch Tab Page, or I/O Map.

#### ● Changing the Values of Other Variables

You can change the present values of user-defined variables, system-defined variables, and device variables as required. You can do this on a Watch Tab Page.

**Precautions for Safe Use**

Always confirm the safety of the system before you change the present value of a variable.

## Operating Procedure

Operations can be performed from the following panes.

- Program panes (ladder diagrams)
- I/O Map
- Watch Tab Page

### Procedure in the Ladder Diagram Editor

1. Select ***Monitor*** from the Controller Menu. The monitor turns ON.
2. Double-click the ladder program, ladder function, or ladder function block under **Programming** in the Multiview Explorer.

   The rungs are displayed on the Ladder Editor in monitor status.
3. Select the variable, input, or output to change and do one of the following:
   - Controlling BOOL Variables (SET/RESET)
     Right-click and select ***SET/RESET*** – ***SET or SET/RESET*** – ***RESET***.

### Procedure in the Watch Pane

1. Select ***Watch Tab Page*** from the View Menu to display a Watch Tab Page. The rungs are displayed on the Ladder Editor in monitor status.
2. Select the variable, input, or output in the Watch Tab Page and do one of the following:
   - Controlling BOOL Variables (SET/RESET)
     Select ***TRUE*** or ***FALSE*** in the Modify Column.
   - Changing Other Variables
     Click the cell in the *Modify* Column on the Watch Tab Page, enter a value that is compatible with the variable type given in the *Data Format* Column, and then press **Enter** Key. The format for entering a value in the *Modify* Column depends on the data type that is given in the *Data Format* Column.

**Additional Information**

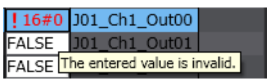
If the status of a BOOL variable that is used in a ladder diagram is changed, the execution status in the Ladder Editor changes accordingly.

### Procedure in the I/O Map

1. Double-click **I/O Map** under **Configurations and Setup** on the Multiview Explorer. The I/O Map is displayed.
2. Select the I/O port to change the present value in the I/O Map and do one of the following:
   - Right-click and select ***SET/RESET*** – ***SET*** or ***SET/RESET*** – ***RESET***.
   - Enter a value in the *Value* Column in the I/O Map.

**Additional Information**

If the value is entered in the wrong format, an error occurs. The illegal values are highlighted in red and an error icon is displayed. Place the mouse over the error icon to view the error details.



## Precautions on Changing the Status of Outputs Assigned to External Devices by Changing Present Values

Observe the following precautions when you change the status of an output that is assigned to an I/O port of a CJ-series Basic Output Unit or EtherCAT output slave by changing a present value.

### ● Changing Present Values in the I/O Map in RUN Mode

Any value of an I/O port that is changed in the I/O Map is then overwritten by the execution results of the user program. The value that was specified by changing the present value is not output to the external device. To change the value of an I/O port and output that value to an external device, use forced refreshing.

### ● Changing Present Values in a Watch Tab Page in PROGRAM Mode

The value that was specified in a Watch Tab Page by changing the present value of a device variable* that is defined as an external or local variable is not output to the external device. To output a specified value to an external device, do one of the following:

- Use forced refreshing.
- Change the present value in a Watch Tab Page of a device variable* that is defined as a global variable.

* The devices variables must be assigned to an I/O port of a CJ-series Basic Output Unit or EtherCAT output slave. This also applies to a global variable with an AT specification to an output bit that is assigned to a CJ-series Basic Output Unit.

### ● Precaution When Directly Writing to I/O Memory Addresses Assigned to Output Bits for CJ-series Basic Output Units

Any value that is written to an I/O memory address that corresponds to an output bit that is assigned to a CJ-series Basic Output Unit through a tag data link will be overwritten by the execution results of the user program. The value that is written directly to the I/O memory address from the tag data link will therefore not be output to the external device.

# 9-5-3 Online Editing

## Introduction

The online editing function is used to add to or change part of a program in the CPU Unit directly from the Sysmac Studio.

You can select any of the following to perform online editing.

- POUs (programs, functions, and function blocks)
  For a ladder diagram program, select a section.
- Global variables

## Application

To change a user program without stopping the operation of the CPU Unit.

## Sysmac Studio Operations

### ● Performing Online Editing

1. Select the item to edit online.

**2** Select ***Online Edit*** from the Project Menu.

**3** Make the required changes.

**4** Select ***Online Edit*** – ***Transfer*** from the Project Menu.

**5** Check the results.

**6** The user program will begin operation after online editing.

## ⚠ Caution

Execute online editing only after confirming that no adverse effects will occur if the I/O timing is disrupted. If you perform online editing, the task execution time may exceed the task period, I/O may not be refreshed with external devices, input signals may not be read, and output timing may be changed.

**Precautions for Correct Use**

If the power supply to the Controller is interrupted when online edits are being saved,* a major fault level Controller error (User Program/Controller Configurations and Setup Transfer Error, Non-volatile Memory Restored or Formatted) occurs. If this error occurs, download the user program again.

* Online edits are saved from when you click the **Yes** Button in the confirmation dialog box until you leave the Online Editing Pane."

## Restrictions to Online Editing

### ● Internal Status of Differentiated Instructions

The differentiation status of differentiated instructions in a program that is edited online is initialized.

**Precautions for Correct Use**

When online editing changes are applied, the execution times of the affected tasks are extended. Set the task period appropriately so that you do not cause a Task Period Exceeded error due to online editing.

## 9-5-4 Data Tracing

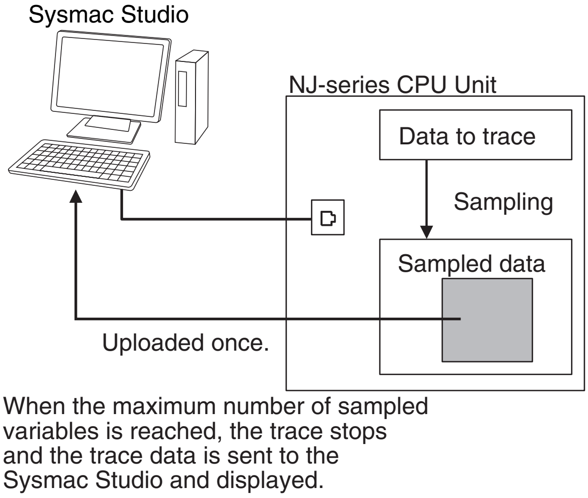
You can use data tracing to sample variables without any additional programming. You can read and check the data from the Sysmac Studio, and save the data to a file. This is used to start up, operate, and maintain devices.

The two tracing methods are described below.

### ● Triggered Tracing

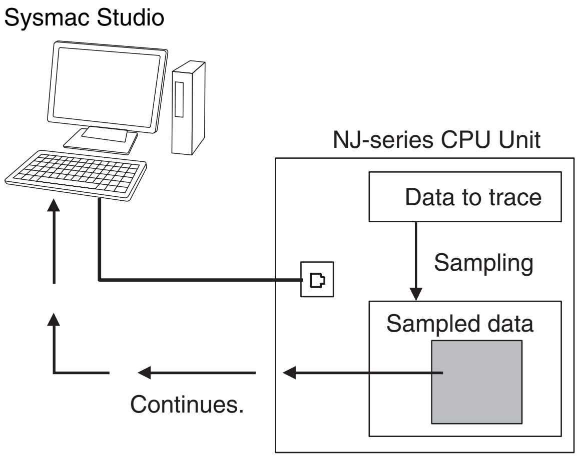
Trigger conditions are set to record data before and after an event. Sampling stops automatically when the maximum number of sampled variables is reached.

- You can check the flow of the program based on the status of changes in the present values of variables.
- You can use the data to investigate the cause of unexpected changes in the present values of variables.




- **Continuous Tracing**

Sampling without a trigger is continuously performed. Sample data is transferred to the Sysmac Studio as it is collected and saved to a file. The Sysmac Studio also continues to read the trace data. When the display buffer is full, the data is automatically saved to a CSV file. You can use this to store trace results data for a long tracing period in multiple CSV files.



## Data Tracing Specifications

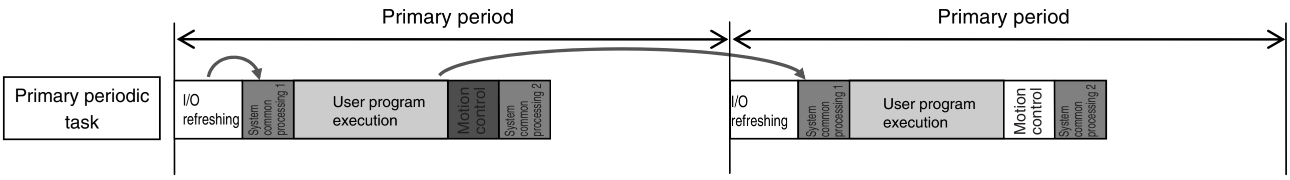
| Item | | Description |
|---|---|---|
| **Trace Type settings** | **Triggered tracing** | Set a trigger condition to start sampling. Data from before and after the condition is met is saved. |
| | **Continuous tracing** | Sample data is transferred to a computer as it is collected and saved to a file. |
| **Setting of timing of sampling** | **Period of specified task** | Specify a task. The period of that task is set as the sampling period. |
| | **Specified fixed interval** | The time you enter is set as the sampling period. However, the time you enter is rounded off to an integer multiple of the primary periodic task. |
| | **When the trace sampling instruction is executed** | With this method, sampling is performed whenever the *TraceSamp* instruction is executed in the user program. |
| **Setting sampled data** | **Maximum number of targets** | 192 variables max. |
| | **Data types** | Basic data types except for text strings<br>Arrays (specify the element), structures (specify the member), and unions (specify the member) |
| **Sampled data** | | 10,000 samples per variable |
| **Setting trigger positions** | | The trigger position is set in respect to the overall trace time or quantity. |
| **Setting triggers** | **Condition data types** | Basic data types except for times, durations, dates, and text strings<br>Arrays (specify the element), structures (specify the member), and unions (specify the member) |
| | **Condition expression** | BOOL: TRUE or FALSE<br>Non-BOOL: Equals (=), Greater than (>), Greater than or equal (≥), Less Than (<), Less than or equal (≤), Not equal (≠)<br>**Note** Combinations of multiple condition expressions are not permitted. |
| | **Trace Trigger ON instruction** | Sampling is performed when the TraceTrig instruction is executed. |
| | **Evaluation timing** | When sampling is executed |
| **Starting a trace** | **Starting tracing at start of operation** | You can set tracing to start automatically when operation is started. |
| **Setting continuous tracing** | **Maximum data storage period** | You can set the maximum amount of time to save continuous trace data. |
| | **Maximum data storage size** | You can set the maximum total size of all files saved during continuous tracing. |
| | **Data items per file** | You can set the number of data items to save in each file during a continuous trace. |
| | **File save location** | You can specify the location to create files to save data during a continuous trace. |
| | **File name prefix** | You can specify a prefix to automatically add to the beginning of the file names. |
| | **Operation when limit is reached** | You can specify the operation to perform when the storage time period or size limit is reached. (For example, stopping tracing or deleting the oldest file and continuing.) |

| Item | | Description |
|---|---|---|
| **Displaying trace results** | **Graph display** | You can display a graph where the X axis represents time and the Y axis represents the value of the variable. You can display both BOOL variables and other variables on the same graph. |
| | **Table display** | You can display the maximum value, minimum value, average value, and value at the specified time for each variable in a table. |
| | **3D Motion Trace Display Mode** | You can position a virtual composition model in 3D space and display the composition motion based on the command positions and actual positions of the motion axes. |
| **Exporting trace data** | **Exporting to CSV files** | You can save the trace results and all settings other than the trace number to a CSV file. |
| **Importing trace data** | | You can read the saved CSV format trace results and display it on top of the current graph. |
| **Saving** | | You can save the trace results in the project along with the trace settings. |
| **Printing** | | You can print graphs The Sysmac Studio's printing functionality is used. |

## Data Trace Operation

Processing for data traces (sampling and trigger detection) are performed in System Common Processing 1, between I/O refreshing and user program execution.

Example: If sampling is specified in the primary periodic task, data tracing is executed in System Common Processing 1, as shown in the following diagram.



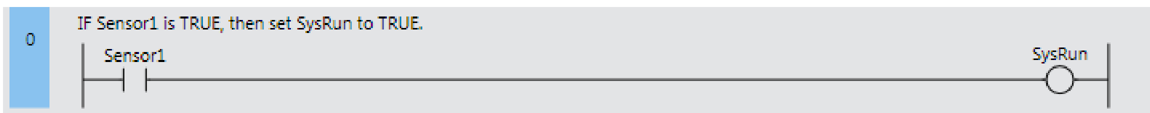

Display examples for data trace operations and execution results is given below for sampling in a specified task period.

### Additional Information

I/O refreshing, user program execution, and motion control processing are all executed in the same task period. For data tracing, user program execution and motion control processing for the current task period and I/O refreshing for the next task period are displayed at the same time. The timing charts in the *NJ-series Motion Control Instructions Reference Manual* (Cat. No. W508) are based on the task periods, so the display are not the same as those for data tracing.

Example 1:

In this example, the *SysRun* variable is changed to TRUE in the user program when the *Sensor1* variable (assigned to the sensor input signal) changes to TRUE.

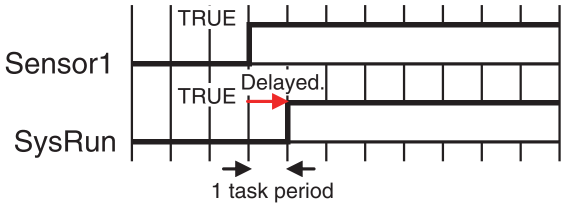



The data trace operations and display of the execution results are given below.

1. In data trace processing in System Common Processing 1, TRUE is obtained for *Sensor1*.
2. *SysRun* is changed to TRUE in the user program.
3. In data trace processing in System Common Processing 1 in the next primary period, TRUE is obtained for *SysRun*.

Therefore, in the data trace display, *SysRun* is shown as TRUE one task period after *Sensor1*.

Data Trace Display

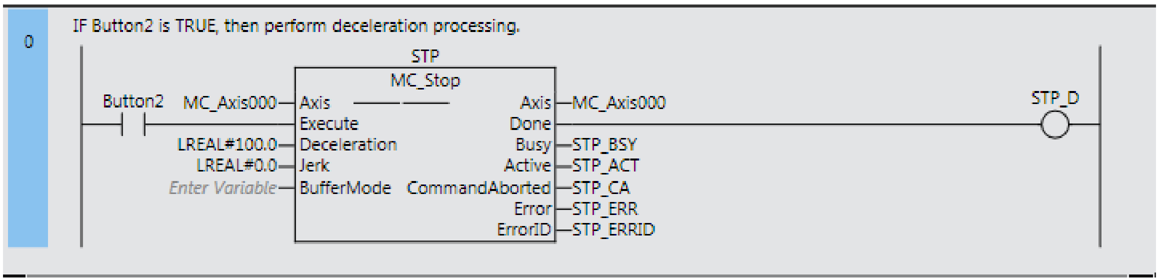



**Additional Information**

If the values of variables change during user program execution, the changes in the values and changes for output processing for I/O refreshing are changed in the same task period.

Example 2:

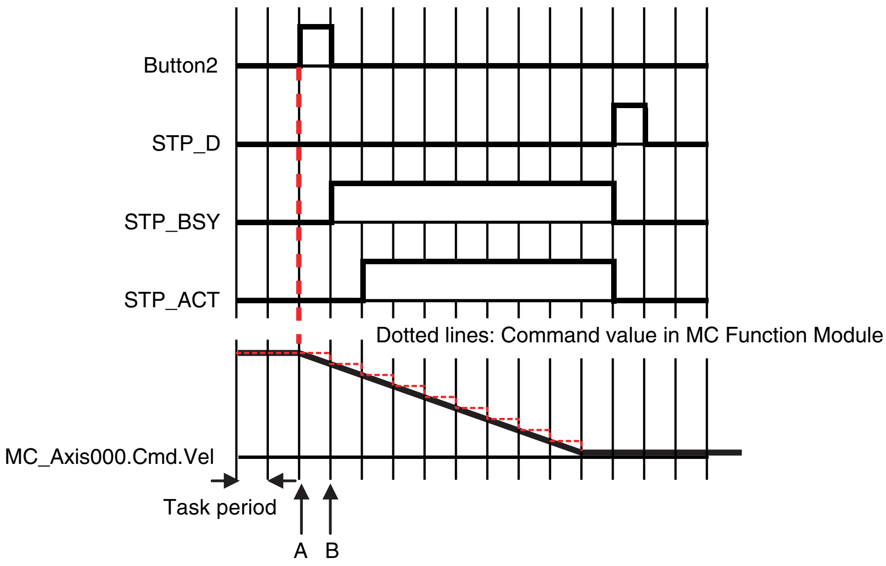
When the *Button2* variable (assigned to an input signal from a pushbutton) changes to TRUE during velocity control, the user program in this example decelerates axis 0 (*MC_Axis000*) to a stop.




The data trace operations and display of the execution results are given below.

1. In data trace processing in System Common Processing 1, TRUE is obtained for *Button2*.
2. *STP_BSY* is changed to TRUE in the user program and the Motion Control Function Module performs deceleration processing.
3. In data trace processing in System Common Processing 1 in the next primary period, TRUE is obtained for *STP_BSY* and the status of the motion variable is obtained.
4. *STP_ACT* is changed to TRUE in the user program.
5. In data trace processing in System Common Processing 1 in the next primary period, TRUE is obtained for *STP_ACT*.

The command value in the MC Function Module starts changing (B in the following diagram) when *STP_BSY* changes to TRUE in the user program and the Motion Control Function Module starts to perform deceleration processing. The command value changes stepwise in synchronization with the primary periodic task. The data trace, however, interpolates the values to connect the values for the previous and current periods. Therefore, the display shows that the command value for the Command Velocity motion control variable (*MC_Axis000.Cmd.Vel*) changes one period early, i.e., when *Button2* changes to TRUE (A in the following figure). The display also shows that *STP_BSY* changes to TRUE one period after deceleration starts and then *STP_ACT* changes to TRUE after another period.




**Additional Information**

For function blocks that contain motion control instructions, the values of input parameters are passed to the input variables when execution of the function block starts, and the values of the output variables are passed to the output parameters when execution of the function block ends. (Refer to *Variable Designations for Function Blocks* on page 6-11.) On the data trace displays, input parameters and input variable, and output parameters and output variables, change in the same task period.

## Related System-defined Variables

| Variable name | Member | Meaning | Description | Data type |
|---|---|---|---|---|
| _PLC_TraceSta[0..3] | | | | |
| | .IsStart | Trace Busy Flag | TRUE when a trace starts. | BOOL |
| | .IsComplete | Trace Completed Flag | TRUE when a trace is completed.<br>Changes to FALSE when the next trace starts. | BOOL |
| | .IsTrigger | Trace Trigger Monitor Flag | TRUE when the trigger condition is met. Changes to FALSE when the next trace starts. | BOOL |
| | .ParamErr | Trace Parameter Error Flag | Changes to TRUE when a trace starts if there is an error in the trace settings. FALSE when the settings are normal. | BOOL |

You cannot use these system-defined variables in the user program. Use the GetTraceSta instruction to read the status of data trace from the user program.

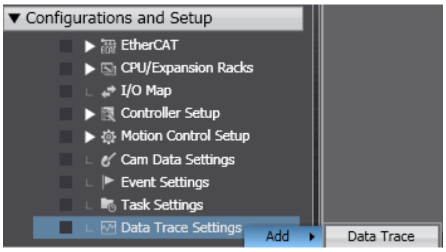
## Overview of Data Trace Procedure

Use the following procedure to execute a data trace.

**1** Start the Sysmac Studio and create a project.

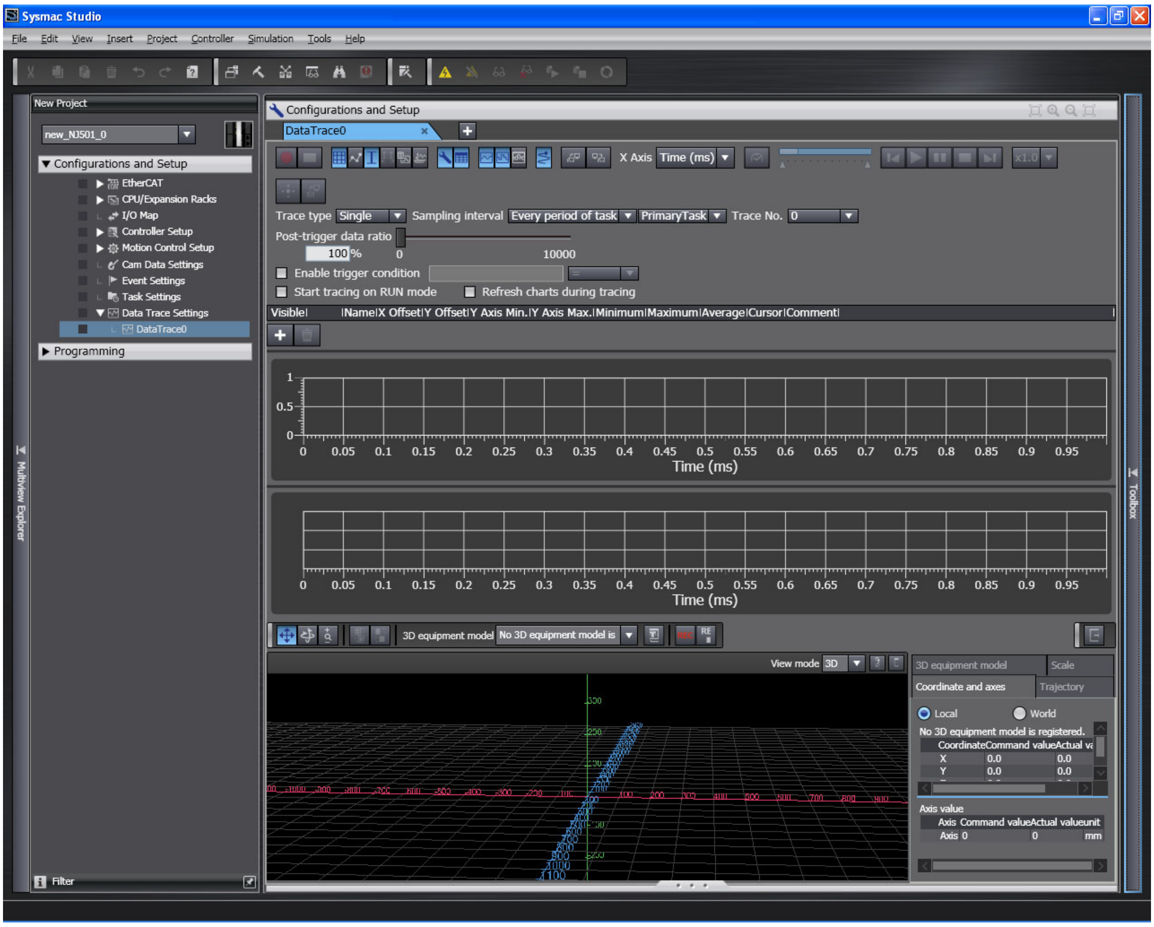
**2** Right-click **Data Trace Settings** under **Configurations and Setup** in the Multiview Explorer and select ***Add*** – ***Data Trace*** from the menu.

**Data Trace** is added to the Multiview Explorer.




**3** Double-click **Data Trace**.

The Data Trace Tab Page is displayed in the Edit Pane.



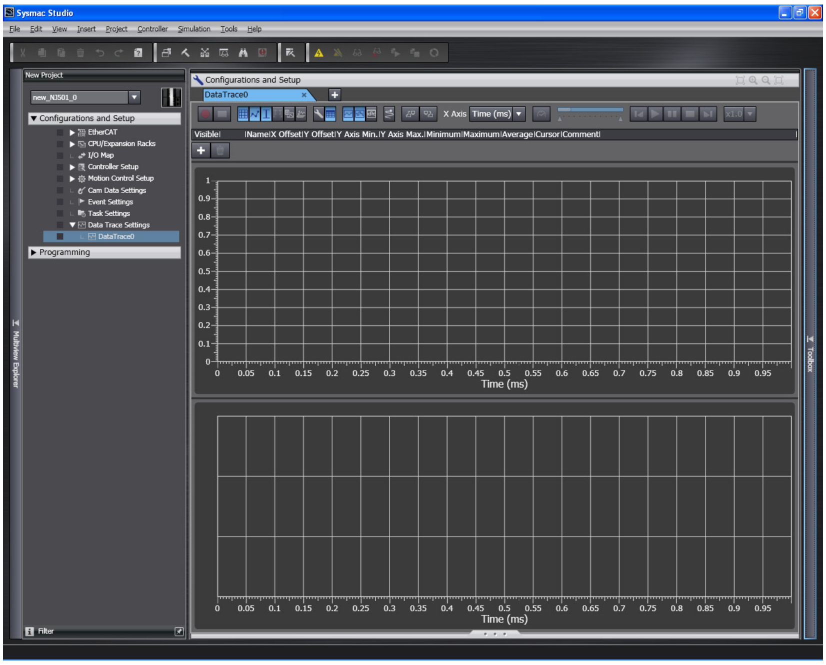

- Set the trace type, sampling interval, variables to sample, trigger settings (for trigger tracing), and other data trace parameters.

**4** Go online and click the **Execute Trace** Button. The graph is drawn as soon as sampling starts if displaying the graph while tracing is enabled.

## ● Display Examples

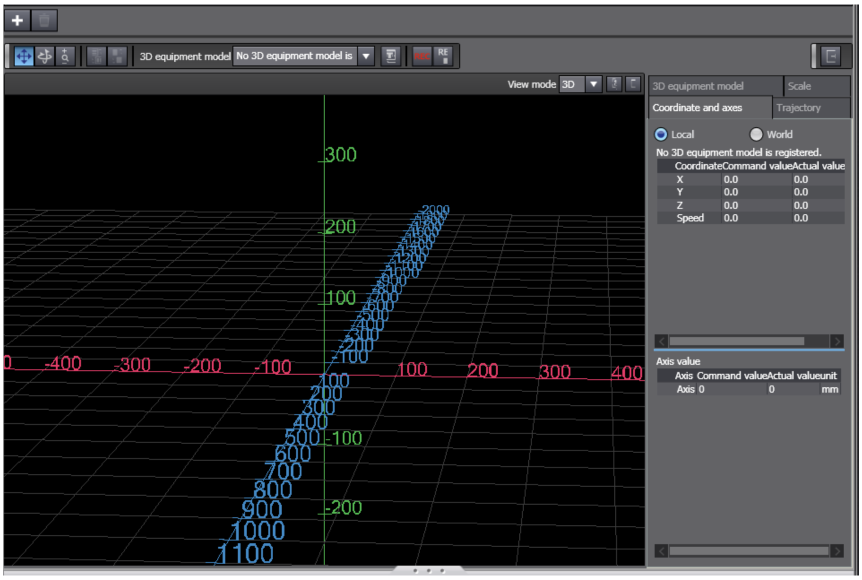
### Example 1: When Only the Leftmost Toggle Button Is ON

The data trace graph is displayed. The vertical axis represents the value of the variable. The horizontal axis represents time.




### Example 2: When Only the Rightmost Toggle Button Is ON

The 3D motion trace display appears.

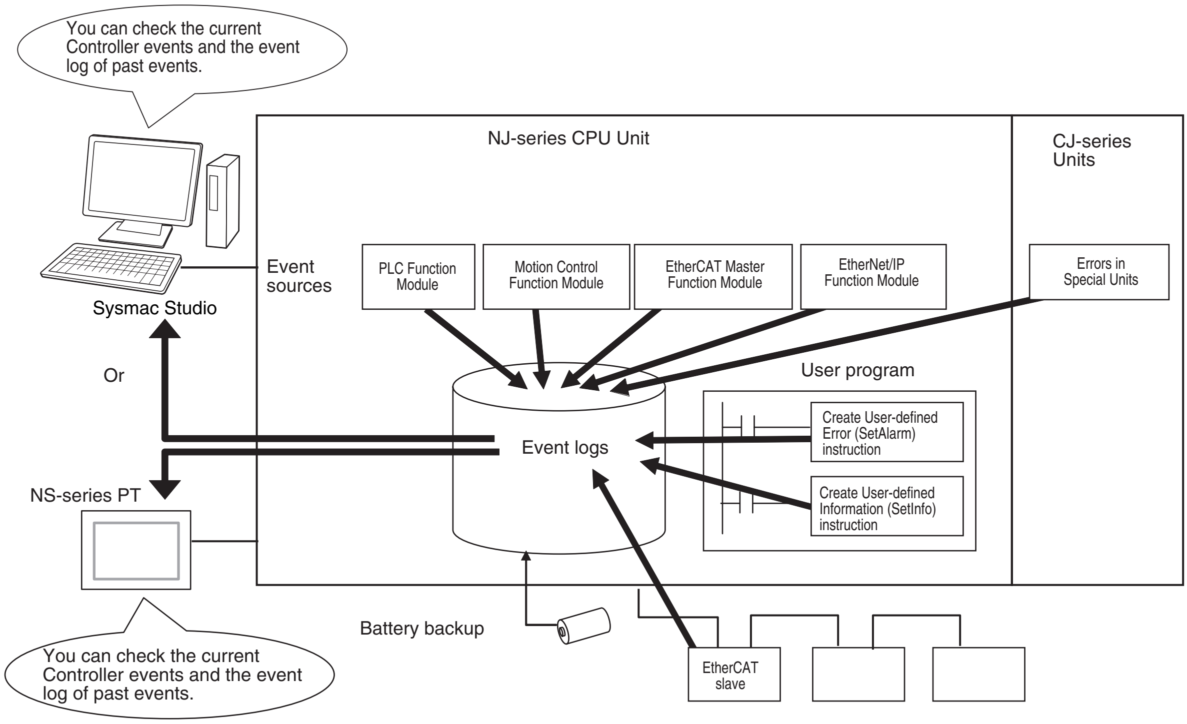


# 9-6 Event Logs

This section describes the event logs.

## 9-6-1 Introduction

The event logs contain records of events,* such as errors, status changes, and user-defined events, that occurred in the NJ-series Controller.




* Here, events are unscheduled events that occur on the Controller, such as errors. “Event” refers to an error or non-error information for which the user must be notified for the Controller or for a user definition. There are two types and four classifications of events.

- Controller events
  Controller errors
  Controller information
- User-defined events
  User-defined errors
  User-defined Information

### Features

Event logs have the following features.

- In addition to error records, various records are recorded for events such as the time the power supply is turned ON or OFF, and the time when operation is started.
- You can check these records based on the time. You can therefore use them to isolate the causes of errors when problems occur.

### Types of Events

Events are classified as shown below.

- **System-defined Events (Controller Events)**

The Controller automatically detects these events. Controller events include events for the function modules in the CPU Unit, CJ-series Units, and EtherCAT slaves. The different types of system-defined events are as follows:

- Controller errors
- Controller information

- **User-defined Events**

These are events that occur in applications that the user developed. You can execute instructions to create the following types of events.

- User-defined errors
- User-defined information

You can read the event logs from the Sysmac Studio or from an NJ-series-compatible NS-series PT.

## 9-6-2 Detailed Information on Event Logs

### Event Sources

This information identifies where an event occurred in the Controller. The event sources are given below for Controller events and user-defined events.

- **Sources of Controller Events**

Controller events occur in the function modules in the CPU Unit.

For some function modules, there is more detailed information about the event source. This information is called the detailed event source.

The following are Controller events.

| Unit/Slave | Event source | Source details |
|---|---|---|
| CPU Unit | PLC Function Module | Bus master |
| | Motion Control Function Module | Common, axis, or axes group |
| | EtherCAT Master Function Module | Communications port or master |
| | EtherNet/IP Function Module | Communications port, CIP, FTP, NTP, or SNMP |
| CJ-series Units | | Errors in the memory words allocated to a Special Unit* |
| EtherCAT slaves | | Individual EtherCAT slaves |

* The source details information does not show information from the error histories from within CJ-series CPU Special Units or EtherCAT slaves. Read the error histories from the appropriate Support Software.

- **Sources of User-defined Events**

User-defined events occur in the PLC Function Module.

## Category

This information displays the category of event log. It is used to access error logs from the Sysmac Studio or an HMI.

| Event type | Event log category | Description |
|---|---|---|
| Controller events | System log | The Controller automatically detects and records these events. CJ-series Unit errors are also included. |
| | Access log | This is a record of events that have affect Controller operation due to user actions. |
| User-defined events | User event log | This is a log of events that are defined by the user. |

## Number of Records

Each event log can contain the following number of records. If the number of events exceeds the number of records permitted, the CPU Unit overwrites the oldest events.

| Event type | Event log category | Maximum number of records |
|---|---|---|
| Controller events | System log | 1,024 events |
| | Access log | 1,024 events |
| User-defined events | User event log | 1,024 events |

## Retaining Events during Power Interruptions

The NJ-series CPU Unit uses a Battery to retain the event logs when the power is interrupted.

**Precautions for Correct Use**

The event logs are retained by Battery. They are not retained when there is no Battery.

Periodically export event logs as required.

## Event Codes

Event codes are assigned to Controller events by the system in advance according to the type of event. Event codes are assigned to user-defined events by the user. Controller event codes are 8-digit hexadecimal values. You can use the Get Error Status instruction to read the error codes of current errors. You can assign a decimal number from 1 to 60,000 as the event code for a user-defined event.

## Event Levels

Each event has an event level that indicates its level. The event level depends on the type of event. Levels are defined separately for Controller events and user-defined events.

## Controller Events

Controller events are classified into five levels according to the degree of the effect that the events have on control, as shown in the following table.

| No. | Level | | Classification |
|---|---|---|---|
| 1 | High | Controller errors | Major fault level |
| 2 | ↑ | | Partial fault level |
| 3 | | | Minor fault level |
| 4 | ↓ | | Observation level |
| 5 | Low | Controller information | Information level |

Errors with a higher level have a greater affect on the functions that the NJ-series System provides, and it is more important to recover from them. When an event in one of these levels occurs, the Sysmac Studio or NJ-series-compatible NS-series PT will display the error.

## User-defined Events

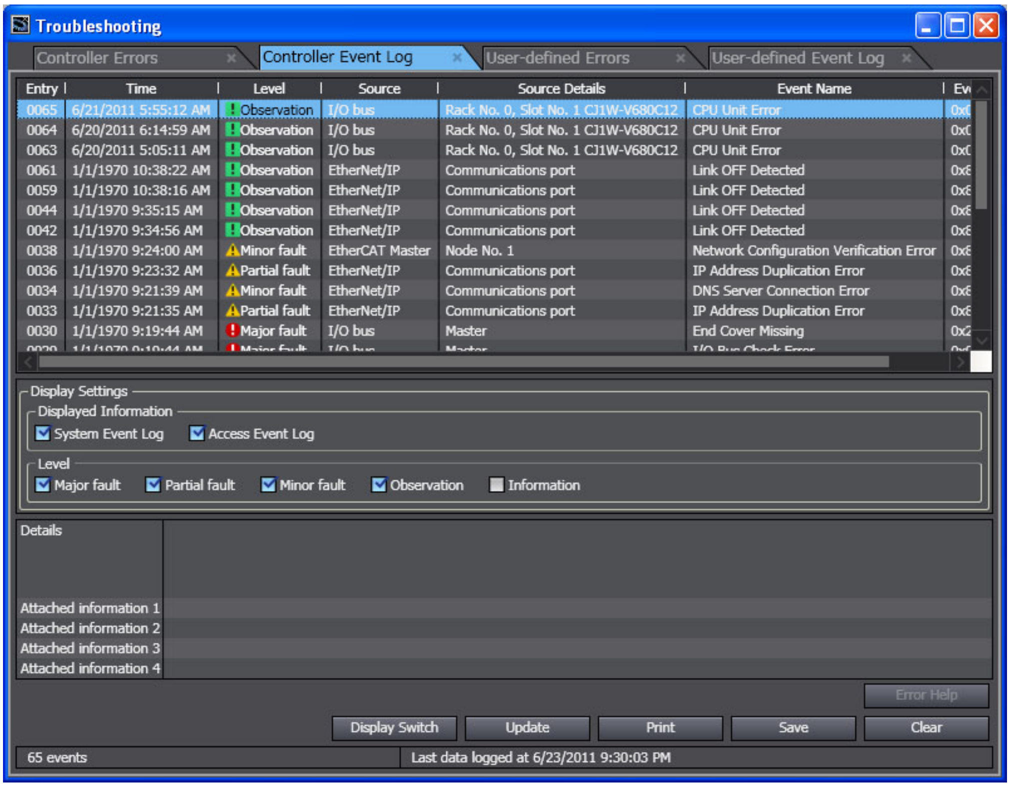
User-defined events are classified into the following levels. These levels are defined by the NJ-series System. The event levels are defined for user-defined events.

| No. | Level | Type | Meaning |
|---|---|---|---|
| 1 | High | User fault Level 1 | These event levels indicate a user-defined error in an application. The user executes the SetAlarm (Create User-defined Error) instruction to create the event. |
| 2 | ↑ | User fault Level 2 | |
| 3 | | User fault Level 3 | |
| 4 | | User fault Level 4 | |
| 5 | | User fault Level 5 | |
| 6 | | User fault Level 6 | |
| 7 | | User fault Level 7 | |
| 8 | ↓ | User fault Level 8 | |
| 9 | Low | User Information | These event levels indicate user-defined information in an application. The user executes the SetInfo (Create User-defined Information) instruction to create the event. |

## Displaying Event Logs

The Sysmac Studio or an NJ-series-compatible NS-series PT displays two event logs: the Controller event log and the user-defined event log. You can also display the error logs that are recorded in the CJ-series Units and EtherCAT slaves.

### ● Event Log List Display




### ● Event Log Details Display

If you want to display detailed information about an event in the list, select the desired event.

| Time of occurrence | Level | Source | Event |
|---|---|---|---|
| 07/3/2 9:00:12 | Information | PLC | Power ON |
| 07/3/1 21:40:12 | Information | PLC | Power OFF |
| 06/2/2 12:15:13 | Warning | MC | Non-fatal error, axis stop error |
| 05/7/1 22:21:45 | Error | PLC | Fatal error, program error |
| 06/2/3 12:00:00 | Information | PLC | Operating mode, RUN |
| 05/7/1 19:11:42 | Information | PLC | Program changed |
| 05/7/1 19:12:15 | Information | MC | Configuration changed. |
| 05/7/1 19:11:42 | Information | PLC | Operating mode, PROGRAM |
| : | | | |
| 05/6/1 10:33:05 | Information | PLC | Operating mode, RUN |
| 05/6/1 10:32:03 | Information | PLC | Power ON |

| | |
|---|---|
| Time of occurrence | 2005/7/1 22:21:45 |
| Level | Fatal error |
| Event Sources | PLC Function Module |
| Event Name | Program error (2062) |
| Description | A program error occurred.<br>An error occurred in the following location.<br>Refer to attached information 1 for the task number.<br>Refer to attached information 2 for the program line.<br>■Cause<br>□□□ could be the cause of this error.<br>■ Correction<br>Check the program and correct any errors. |
| Attached information 1 | 126 |
| Attached information 2 | 8032 |

## Clearing Event Logs

### ● Clearing Event Logs from the Sysmac Studio or an HMI

You can clear the event logs from the Sysmac Studio or from an NJ-series-compatible NS-series PT. You can clear the Controller event log and user-defined event log separately.

**Precautions for Correct Use**

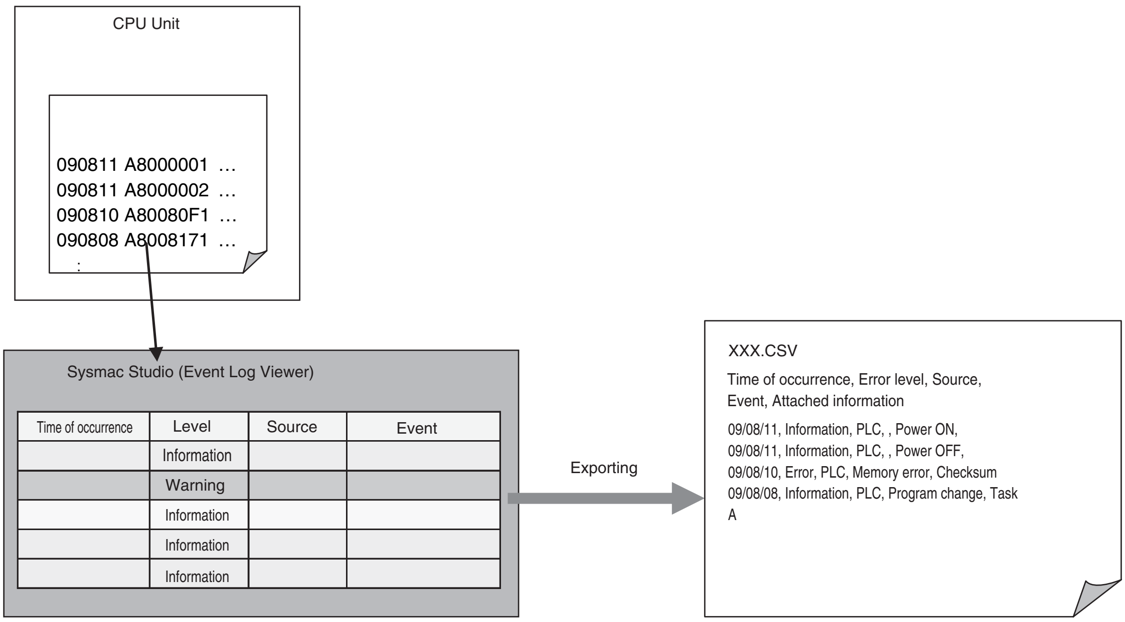
If you need to delete event log in the CPU Unit from the Sysmac Studio or HMI, make sure you do not need any of the event information before you delete the event log. You may have overlooked some important information and observation level Controller events or user-defined events. Always check for these before you delete an event log.

### ● Clearing Event Logs with the Clear All Memory Operation

When you perform the Clear All Memory operation for an NJ-series CPU Unit from the Sysmac Studio, you can select whether to clear the event logs.

## Exporting Event Logs

You can use the Sysmac Studio or an NJ-series-compatible NS-series PT to export the displayed event log to a CSV file.



## 9-6-3 Controller Events (Controller Errors and Information)

### Introduction

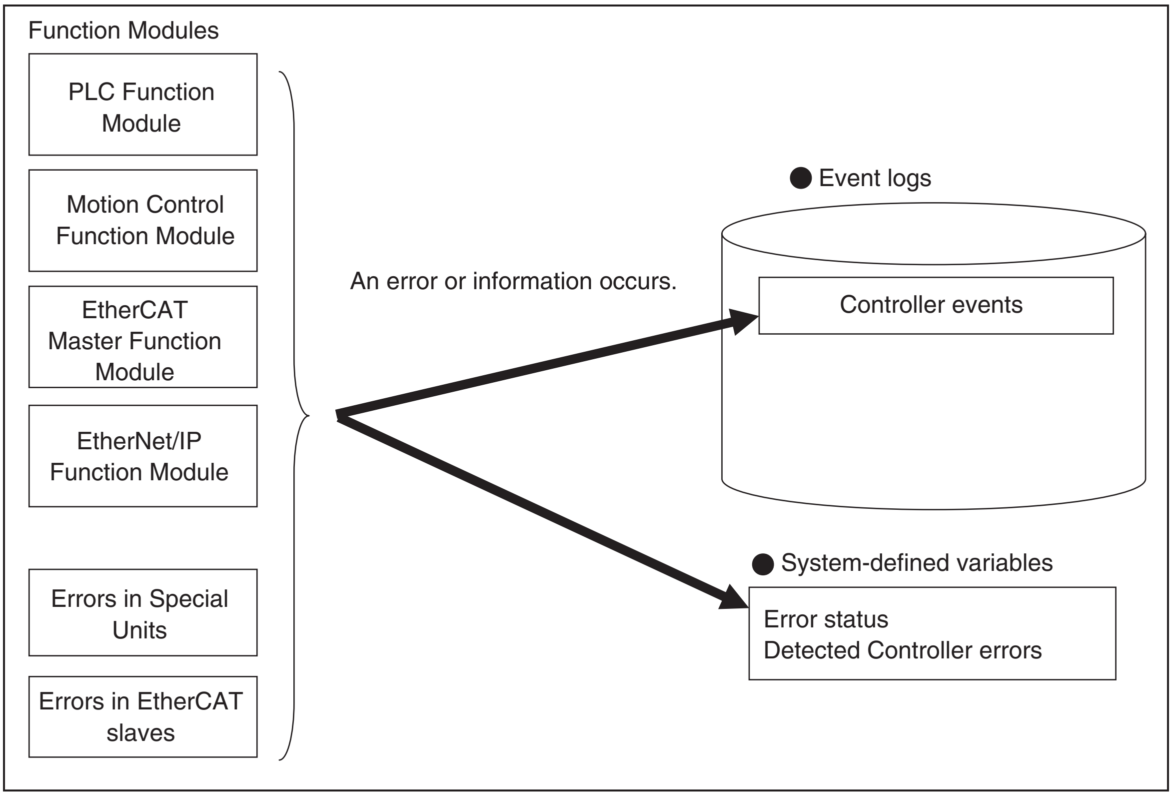
Controller errors and information are defined by the NJ-series System. These events occur when the NJ-series System detects an error or information factor.

#### ● Controller Errors

These are system-defined errors. “Controller error” is a collective term for major fault level, partial fault level, minor fault level, and observation level Controller events. Errors in the function modules of the CPU Unit, CJ-series Units, and EtherCAT slaves are detected. When one of these events occurs, a Controller error is recorded in the event log. To check the status of a Controller error on the user program, you execute the Get Error Status instruction to access the status of the Error Status variable, which is a system-defined variable. Controller errors are not reset when the operating mode changes. Refer to the *NJ-series Troubleshooting Manual* (Cat. No. W503) for details on Controller Errors.

#### ● Controller Information

Controller information is system-defined notification information. This information does not indicate errors. It represents information level Controller events. Examples include events other than errors, such as turning the power ON and OFF, starting and stopping operation, connecting the Sysmac Studio online, and downloading user programs.



## 9-6-4 User-defined Events (User-defined Errors and Information)

### Introduction

These errors and information are defined by the user. You can use instructions to create them.

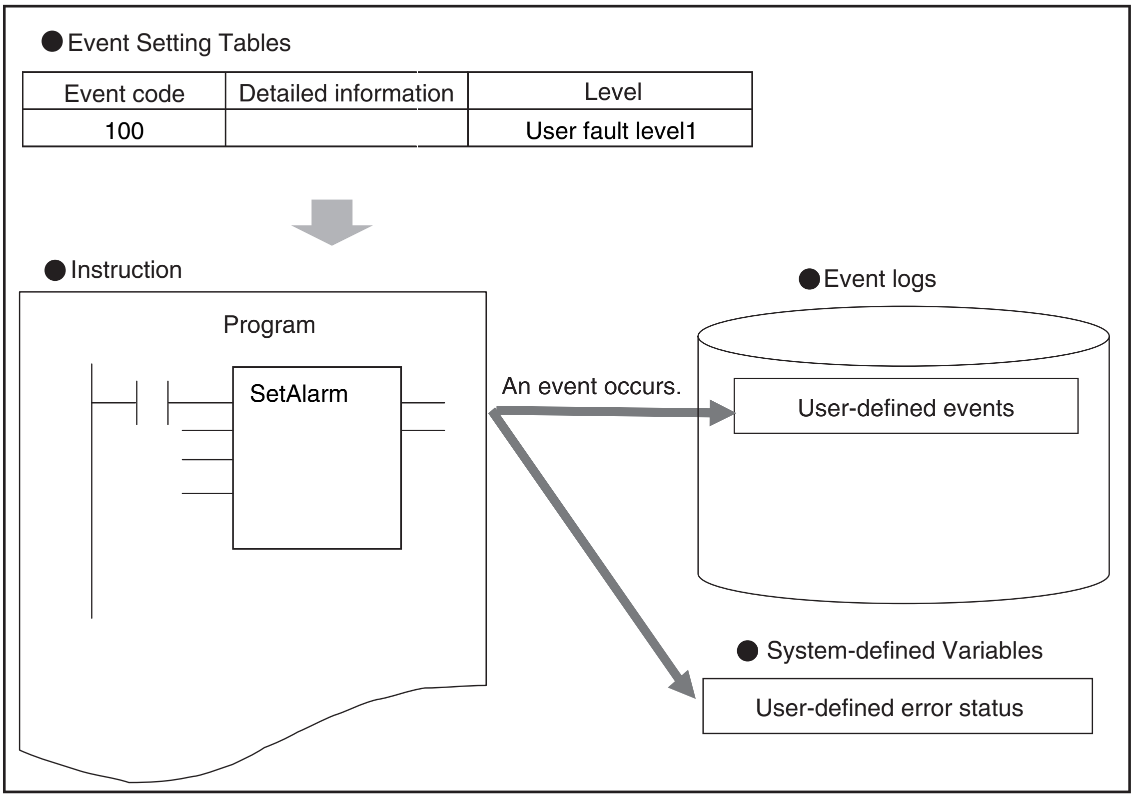
#### ● User-defined Errors

These errors are defined by the user. Use the Create User-defined Error (SetAlarm) instruction to create user-defined errors. When this instruction is executed, a user-defined error is recorded in the event log.

The corresponding system-defined variable changes to TRUE. User-defined errors are not reset when the operating mode changes.

#### ● User-defined Information

User-defined information is user-defined notification information. This information does not indicate errors. Use the Create User-defined Information (SetInfo) instruction to create user-defined information. When this instruction is executed, user-defined information is recorded in the event log.



## Application Procedures

Use the following procedures.

### ● User-defined Errors

1. Register a user-defined error in the Event Setting Table.

2. Execute the Create User-defined Error (SetAlarm) instruction.
   (Specify an event code that is defined in the Event Setting Table.)

3. A user-defined error occurs.

4. The corresponding system-defined variable _AlarmFlag (User-defined Error Status) changes to TRUE. Execute any process for that condition.

5. Check the user-defined error in the event log with the Sysmac Studio, an instruction, or an HMI.

### ● User-defined information

1. Register user-defined information in the Event Setting Table.

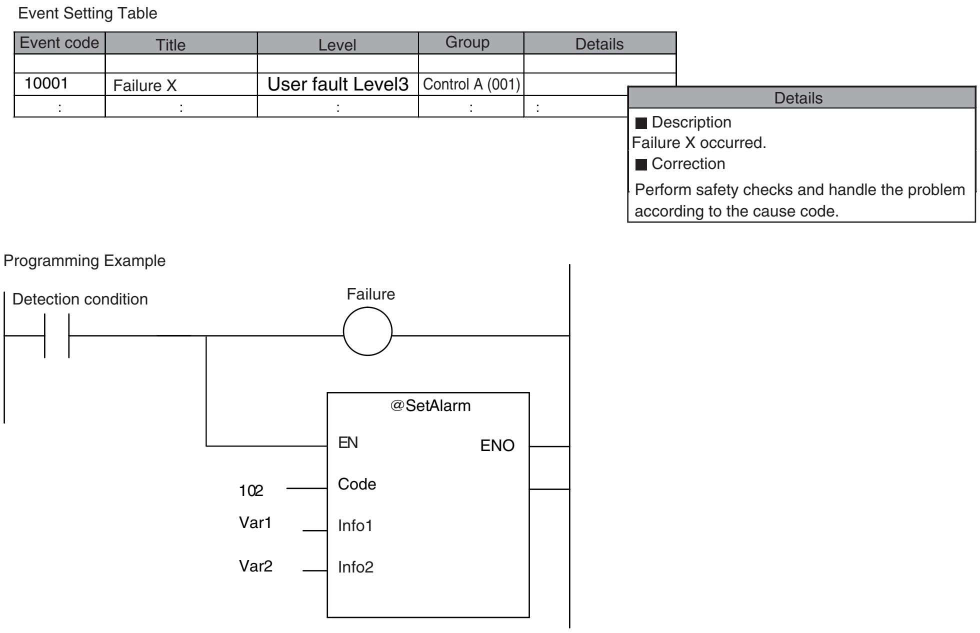
2. Execute the Create User-defined Information (SetInfo) instruction.

3. Check the record in the event log.

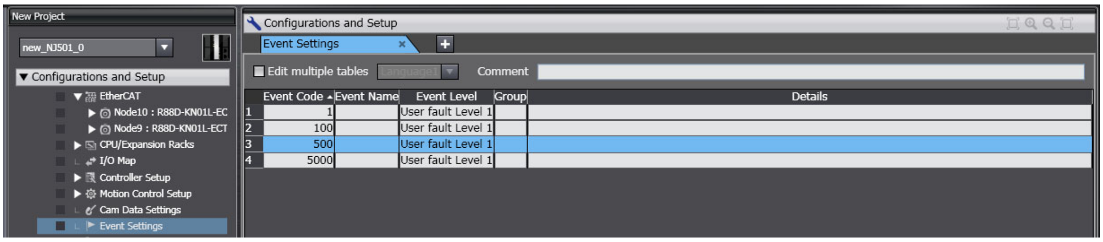
## Setting the Event Setting Table

To create a user-defined error or user-defined information, register the user-defined error or user-defined information in the Event Setting Table in the Sysmac Studio in advance. The user events that you set here can be displayed on the Sysmac Studio or NJ-series-compatible NS-series PT with the same information. You can register up to 5,120 events in the Event Setting Table.

### Event Setting Table Tab Page




The following items are set in the Event Setting Table.



## ● Contents of the Event Setting Table

| Item | Description | Values |
|---|---|---|
| Event Code | You can specify a number to identify the event according to the event level. | User-defined error: 1 to 40,000<br>User-defined information: 40,001 to 60,000 |
| Event Name | You can include a title for the event. | 128 characters max. |
| Event Level | You can specify the level of the event. The level is indicated with a number. The lower the number is, the higher the level is. | User-defined error: User fault levels: 1 to 8<br>User-defined information: User information |
| Group | You can specify a group name to represent the location or type of the event. You can use user-defined groupings for the events. | 32 characters max.<br>There are no restrictions on the characters that can be used. Case sensitive. Reserved words: None |
| Details | You can include a message that describes the event. The user can enter any text string. The message is used when the event is displayed on the Sysmac Studio or an HMI. | 1,024 characters max.<br>There are no restrictions on the characters that can be used. Case sensitive. Reserved words: None |
| Error details that are displayed on the HMI when a major fault level Controller error occurs | Refer to the additional information that is given below on displaying user messages on an NJ-series-compatible NS-series PT when a major fault level Controller error occurs for more details. | 128 characters max.<br>There are no restrictions on the characters that can be used.<br>Case sensitive. Reserved words: None |

**Additional Information**

You can set up to nine different languages for the same event code for different regions and users. On the Sysmac Studio, you can import an Event Setting Table from an Excel file via the clipboard.

**Additional Information**

**Displaying User Messages on an NJ-series-compatible NS-series PT When a Major Fault Level Controller Error Occurs:**

When a major fault level Controller error occurs, the user program execution stops. The NJ-series Controllers can display user messages on an NJ-series-compatible NS-series PT when a major fault level Controller error occurs. You can set the display messages under the list of user-defined events in the Event Setting Table on the Sysmac Studio.

### Event Levels and Event Codes

| Event classification | Level | Event level category* | Range of corresponding event code | Description |
|---|---|---|---|---|
| User-defined errors | High | User fault Level1 | 1 to 5000 | Select from eight levels. |
| | ↑ | User fault Level2 | 5001 to 10000 | |
| | | User fault Level3 | 10001 to 15000 | |
| | | User fault Level4 | 15001 to 20000 | |
| | | User fault Level5 | 20001 to 25000 | |
| | | User fault Level6 | 25001 to 30000 | |
| | | User fault Level7 | 30001 to 35000 | |
| | ↓<br>Low | User fault Level8 | 35001 to 40000 | |
| User-defined Information | Lowest | User Information | 40001 to 60000 | The event type is user-defined information. |

* User-defined error levels are separate from Controller error levels.

**Precautions for Correct Use**

If you update the Event Setting Table and transfer it to the CPU Unit, the event logs for user-defined events still contain old information. This can result in inconsistencies with the new Event Setting Table. Program operations with caution.

## Related Instructions

Use the following instructions to create and reset user-defined errors and to create user-defined information. Up to 32 events per level can occur simultaneously, for a total of 256 possible simultaneous events.

| Instruction name | Instruction | Description |
|---|---|---|
| Create User-defined Error | SetAlarm | The SetAlarm instruction creates a user-defined error. |
| Reset User-defined Error | ResetAlarm | The ResetAlarm instruction resets a user-defined error. |
| Create User-defined Information | SetInfo | The SetInfo instruction records the specified user-defined information in the event log. |

### Checking for User-defined Errors:

You can use the Get User-defined Error Status (GetAlarm) instruction to obtain the status of the current user-defined errors (user-defined error levels 1 to 8) and the highest priority event code.

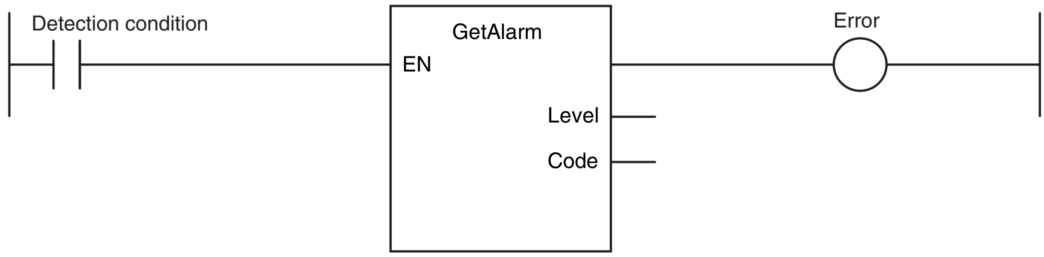
Example:

Event Setting Table

| Event code | Title | Level | Group | Details |
|---|---|---|---|---|
| | | | | |
| 10001 | Failure X | User fault Level3 | Control A (001) | |
| : | : | : | : | : |

| Details |
|---|
| ■ Description<br>Failure X occurred.<br>■ Correction<br>Perform safety checks and handle the problem according to the cause code. |

Actual Programming




**Additional Information**

You can use user-defined errors to add a message on possible corrections or other information when a Controller error occurs. Use instructions such as the GetPLCError instruction to obtain information about the error status or event code when a Controller error occurs. You can then use the information to trigger a user-defined error.

Example 1

When a Low Battery Voltage error occurs, the event code (16#000B0000) is obtained and the following message is displayed.

| |
|---|
| Battery is dead.<br>Apply power for at least five minutes before changing the Battery.<br>Install a new Battery within five minutes of turning OFF the power supply. |

Example 2

When a partial fault level Controller error occurs, the event error level is obtained (highest level status: 2) and the following message is displayed.

| |
|---|
| A device failed. Call the following number for support.<br>Repair Contact<br>Hours: 8:00 AM to 9:00 PM<br>TEL: xxx-xxxx-xxxx |

## System-defined Variables Related to User-defined Errors

| Variable name | Meaning | Description | Data type | R/W |
|---|---|---|---|---|
| _AlarmFlag | User-defined Error Status | The bit corresponding to the event level is TRUE while there is a user-defined error. Bits 00 to 07 correspond to user fault levels 1 to 8. | WORD | R |

## Records in Event Log

An event is recorded in the event log when you create user-defined information or a user-defined error, or when you use the ResetAlarm instruction to reset an error. When this happens, the time, event code, event level, and attached information 1 and 2 are recorded in the user-defined event log in the event logs.

## Reset User-defined Errors

User-defined errors are cleared when the power supply to the NJ-series Controller is turned ON. You can also clear errors with the Sysmac Studio, the Reset User-defined Error instruction (ResetAlarm) and an HMI.

# 9-7 Using the Sysmac Studio to Back Up and Restore Data

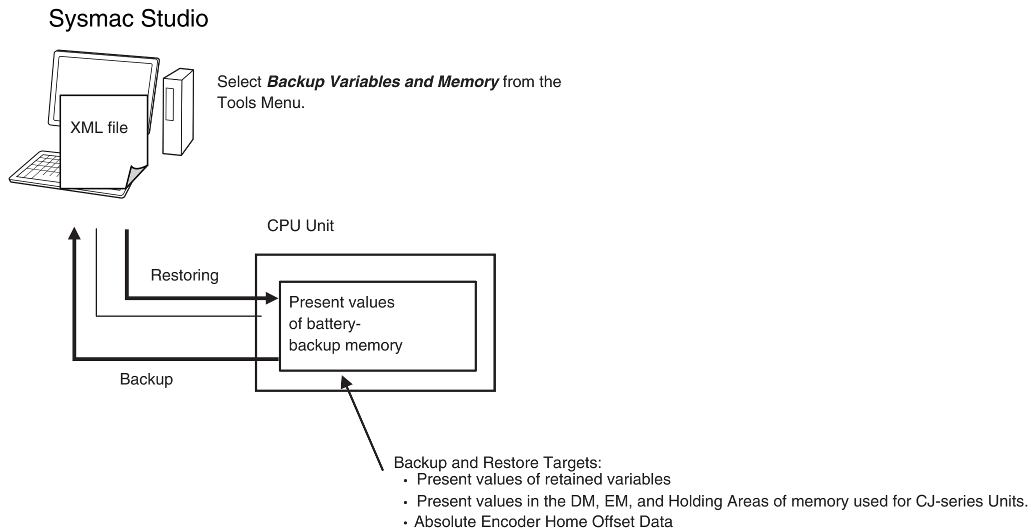
This section describes how to use the Sysmac Studio to back up data. You can back up the present values of the battery-backup memory from the Sysmac Studio.

## 9-7-1 Backing Up and Restoring the Present Values of Battery-backup Memory

### Introduction

You can back up the present values of the battery-backup memory in the CPU Unit to an XML file on your computer or restore the battery-backup memory from a previously saved backup file. This applies to the following data.

- Present values of variables with a Retain attribute
- Present values in the DM, EM, and Holding Areas of memory used for CJ-series Units
- Absolute Encoder Home Offset Data

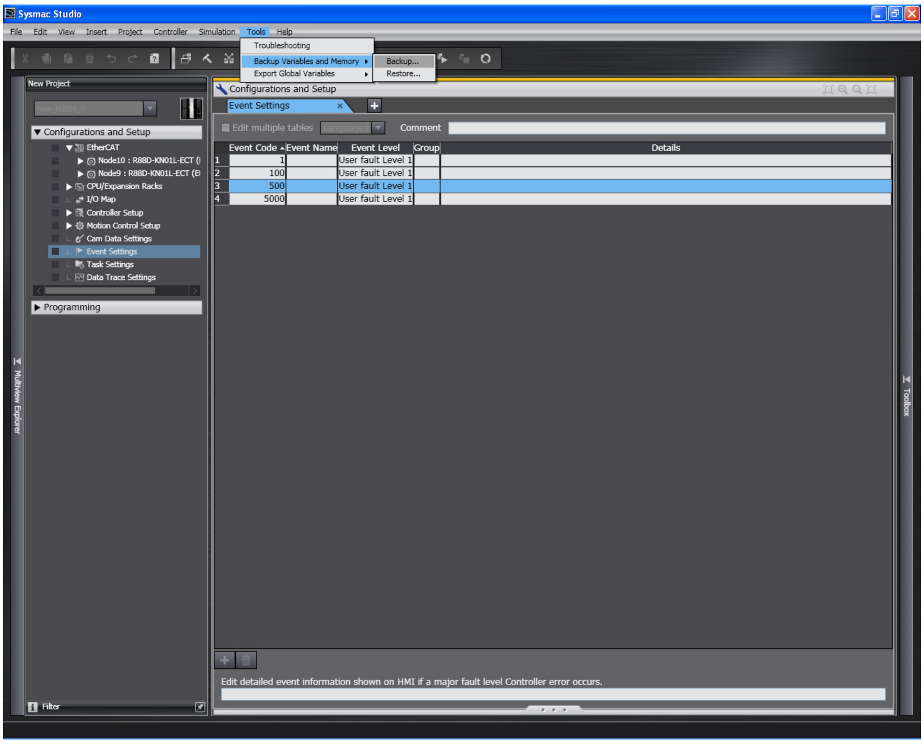



### Sysmac Studio Procedure

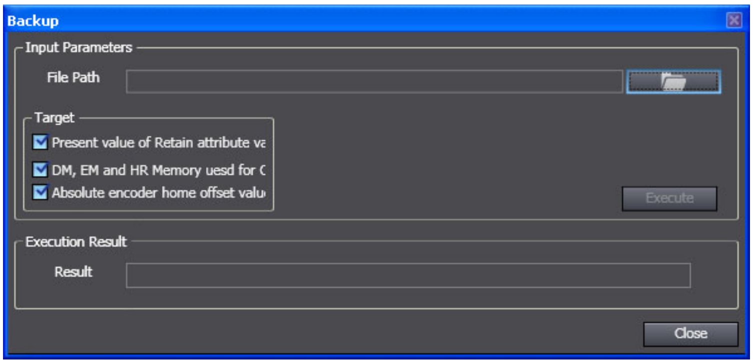
Place the Sysmac Studio online with the CPU Unit, and select either ***Backup Variables and Memory*** – ***Backup*** or ***Backup Variables and Memory*** – ***Restore*** from the Tools Menu. Refer to the *Sysmac Studio Version 1 Operation Manual* (Cat. No. W504) for details.

#### ● Backup Procedure

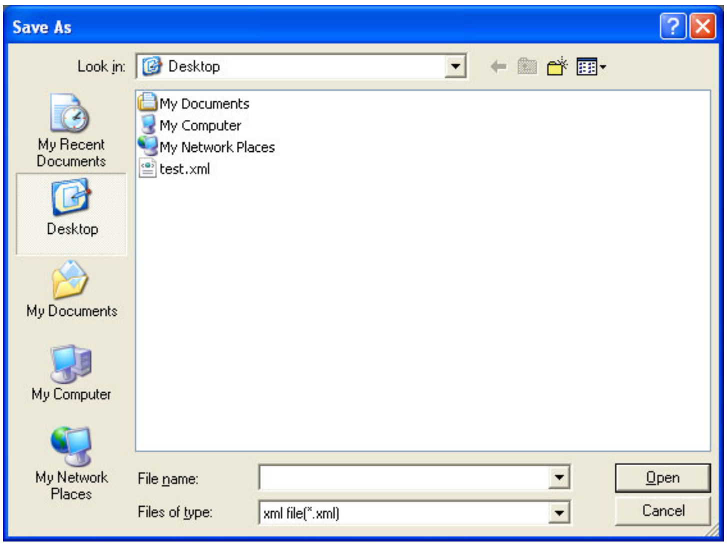
**1** Select ***Backup Variables and Memory*** – ***Backup*** from the Tools Menu of the Sysmac Studio.



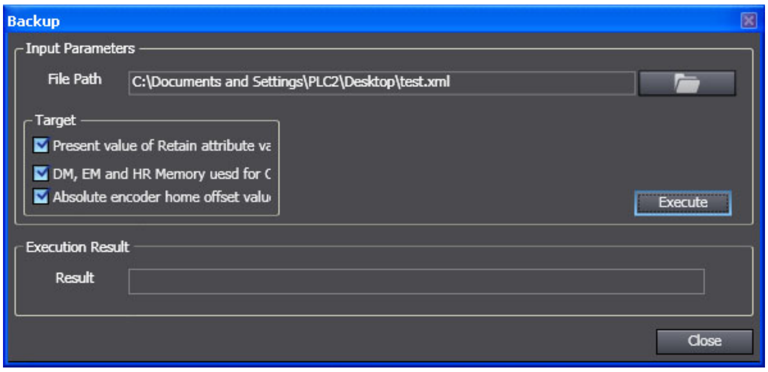

The Backup Dialog Box is displayed.




**2** Click the **View File Selection Dialog** Button. The File Selection Dialog Box is displayed. Specify the file path name and file name.



**3** Select the check boxes for the memory to back up, and then click the **Execute** Button. The data is backed up.




When the backup is completed, the results are displayed in the Execution Results Text Display Area.

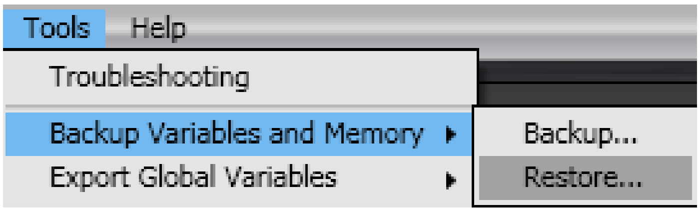
### Additional Information

To back up the data, the contents of the NJ-series Controller and the project must match. If it does not match, stop the backup and synchronize the data to make it match.

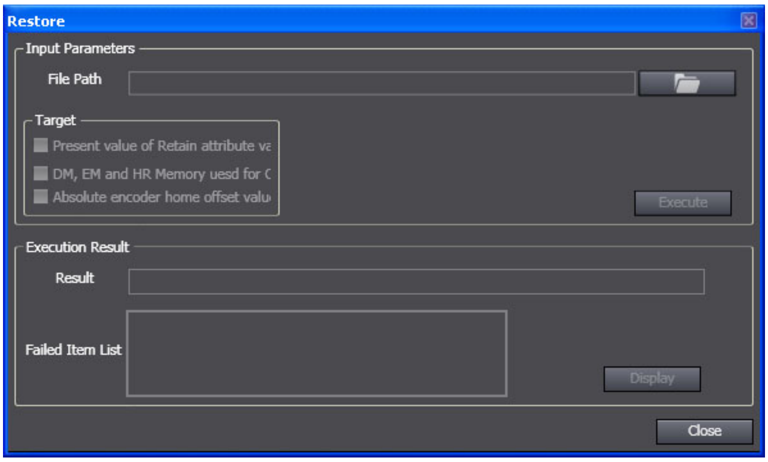
## ● Restoring Data

### Restore Procedure

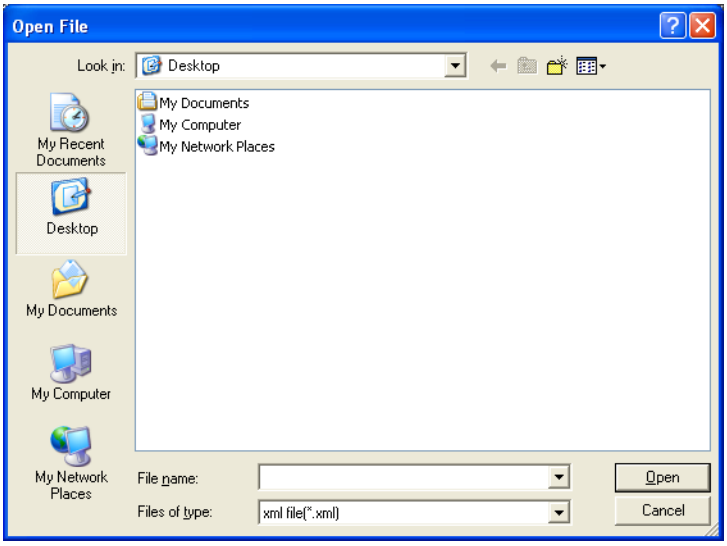
**1** Select ***Backup Variables and Memory*** – ***Restore*** from the Tools Menu of the Sysmac Studio.



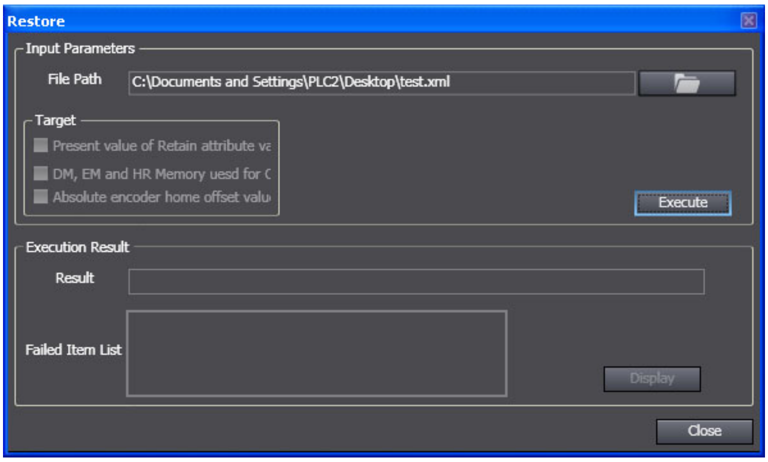

The Restore Dialog Box is displayed.



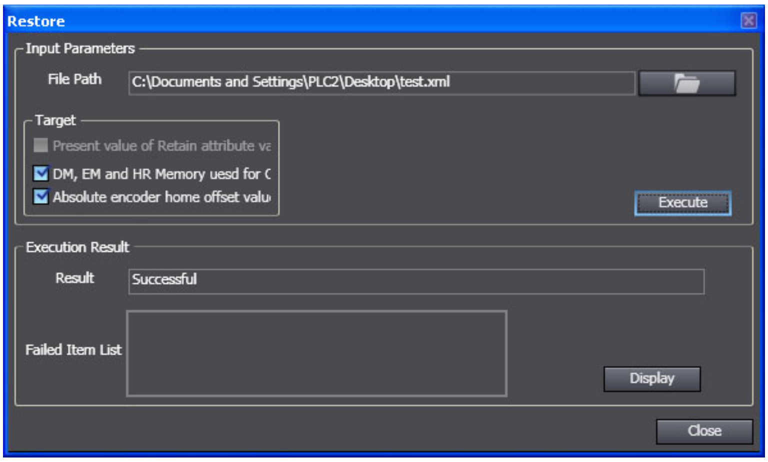
**2** Click the **View File Selection Dialog** Button. The File Selection Dialog Box is displayed. Specify the file path.




**3** Select the check boxes for the memory to restore, and then click the **Execute** Button. The data is restored.




When the restore operation is completed normally, the results are displayed in the Execution Results Text Display Area. A dialog box for restarting the NJ-series Controller is displayed to reflect the results of the restored data.




If the restore operation fails, the number of items that were not restored is shown in the *Failed Item List* Text Box. Click the **Display** Button. The names of the data that were not restored are displayed in the *Failed Item List*.

**Additional Information**

To restore the backup, the contents of the NJ-series Controller and the project must match. If it does not match, stop the restore process and synchronize the data to make it match.

If you replace the Controller, you must restore the absolute encoder home offset as well.

When you replace a Servo Drive, you must redefine home in the Controller.

# 10



# Communications Setup

This section describes how to go online with the CPU Unit and how to connect to other devices.

**10-1 Communications System Overview . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10-2**
10-1-1 Introduction . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10-3
**10-2 Connection Configuration for Sysmac Studio . . . . . . . . . . . . . . . . . . . . . 10-4**
10-2-1 Configurations That Allow Online Connections . . . . . . . . . . . . . . . . . . . . . . . 10-4
10-2-2 Configurations That Do Not Allow Online Connections . . . . . . . . . . . . . . . . . 10-6
**10-3 Connection Configurations between Controllers, and between Controllers and Slaves . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10-7**
10-3-1 Connection Configurations between Controllers . . . . . . . . . . . . . . . . . . . . . . 10-7
10-3-2 Connection Configuration between Controllers and Slaves . . . . . . . . . . . . . 10-10
**10-4 Connection Configurations with HMIs and Devices with Serial Communications . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10-11**
10-4-1 Connections to HMIs . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10-11
10-4-2 Connections to Devices with Serial Communications . . . . . . . . . . . . . . . . . 10-11

# 10-1 Communications System Overview

This section gives an overview of the communications systems that are supported by NJ-series Controllers.

The shaded steps in the overall procedure that is shown below are related to the communications systems.

**Step 1. Software Design**

- Step 1-1 Designing I/O and Processing
- Step 1-2 Designing Tasks
- Step 1-3 Designing Programs

**Step 2. Software Setups and Programming**

- Step 2-1 Slave and Unit Configurations
- Step 2-2 Controller Setup
- Step 2-3 Programming
- Step 2-4 Offline Debugging

**Step 3. Mounting and Setting Hardware**

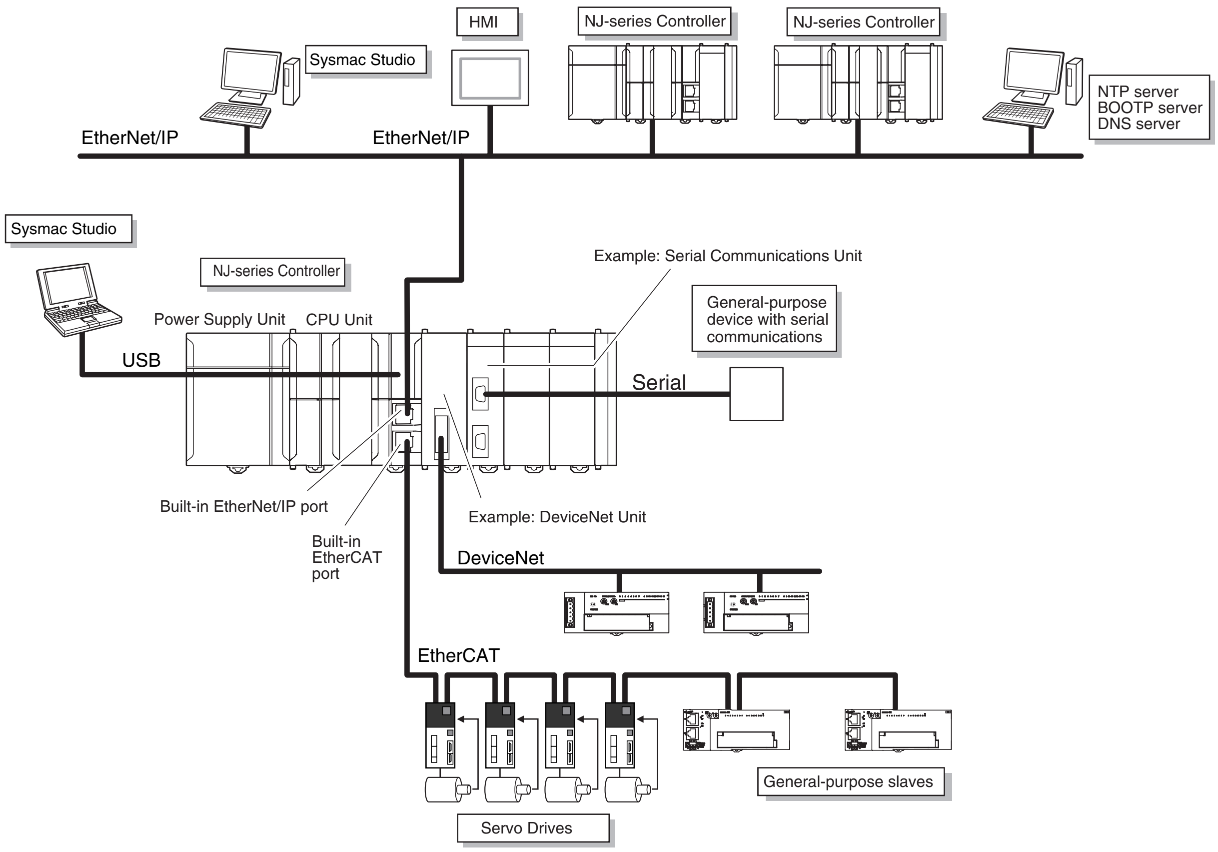
**Step 4. Wiring**

**Step 5. Confirming Operation and Starting Actual System Operation**

Refer to *1-3 Overall Operating Procedure for the NJ-series Controller* for details.

## 10-1-1 Introduction

You can use the NJ-series System to build the communications system shown below.




| Connection | | Connection method |
|---|---|---|
| Sysmac Studio connection | | Use USB or the built-in EtherNet/IP port. |
| Connections between Controllers | Connections with NJ-series Controller or CJ2 CPU Unit | Use the built-in EtherNet/IP port. |
| | Connections to CS/CJ-series PLCs | Mount a Controller Link Unit and use Controller Link. |
| Connections between Controllers and slaves | Connections to Servo Drives and general-purpose slaves | Use the built-in EtherCAT port. |
| | I/O controls | Mount a DeviceNet Master Unit and use DeviceNet. |
| Connections to HMIs | | Use the built-in EtherNet/IP port. |
| Connections for serial communications | | Mount a Serial Communications Unit. |
| Connections to servers | Connections to BOOTP servers, DNS servers, or NTP servers | Use the built-in EtherNet/IP port. |

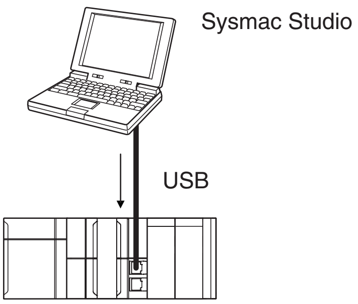
# 10-2 Connection Configuration for Sysmac Studio

This section describes the configurations for connecting the Sysmac Studio to an NJ-series Controller.

## 10-2-1 Configurations That Allow Online Connections

You can connect online from the Sysmac Studio to the peripheral USB port or built-in EtherNet/IP port of the NJ-series CPU Unit.

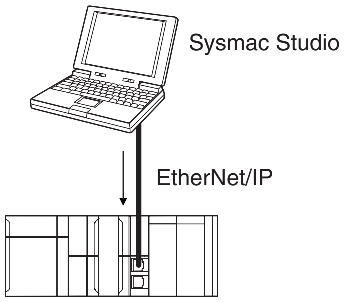
### ● Connecting with USB




A direct connection is made from the computer that runs Sysmac Studio. You do not need to specify the connection device.

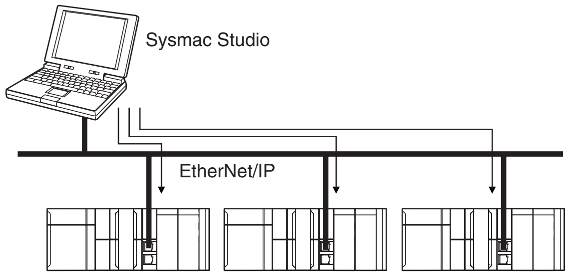
## ● Connecting with EtherNet/IP

1:1 Connection



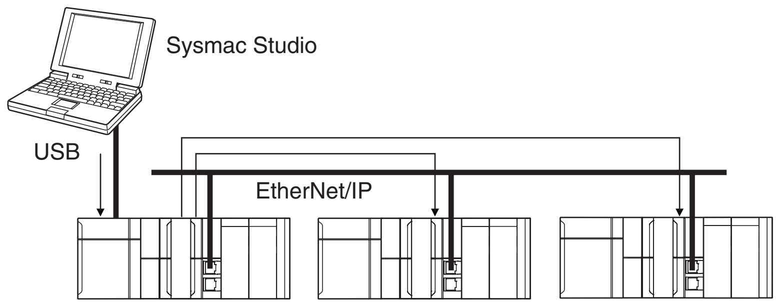

- A direct connection is made from the computer that runs Sysmac Studio. You do not need to specify the IP address or connection device.
- You can make the connection either with or without a switching hub.
- You can use either a cross cable or a straight cable.

1:N Connections




Directly specify the IP address of the remote device or select the remote device from the node list.

## ● Connecting to EtherNet/IP through USB

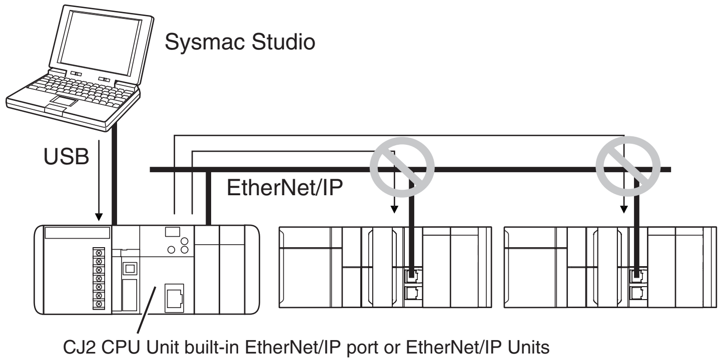



Directly specify the IP address of the remote device or select the remote device from the node list.

## 10-2-2 Configurations That Do Not Allow Online Connections

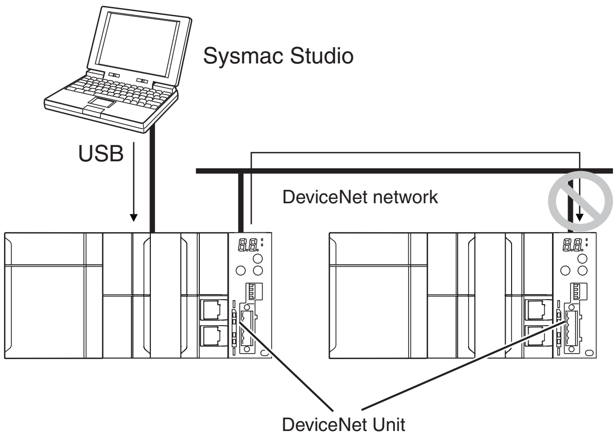
### ● Routing through CS/CJ-series EtherNet/IP Units/Ports

You cannot connect to an NJ-series Controller by routing through a CS/CJ-series Ethernet/IP Unit or port (CS1W-EIP2, CJ1W-EIP21, CJ2 CPU Unit built-in EtherNet/IP port, or CJ2M CPU Unit built-in EtherNet/IP port).




### ● Routing through Networks Other Than EtherNet/IP, Such as DeviceNet

You cannot route through any networks other than EtherNet/IP networks. (For example, routing is not possible for Controller Link networks and DeviceNet networks.)



# 10-3 Connection Configurations between Controllers, and between Controllers and Slaves

This section shows the connection configurations that are used between Controllers and between Controllers and slaves.

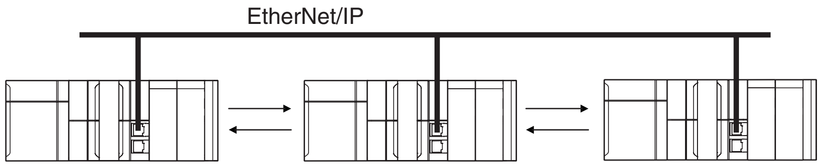
## 10-3-1 Connection Configurations between Controllers

### EtherNet/IP

Refer to the *NJ-series CPU Unit Built-in EtherNet/IP Port User's Manual* (Cat. No. W506) for details.

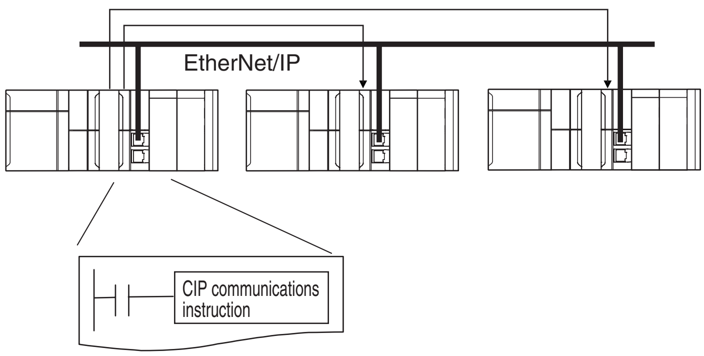
#### ● Tag Data Links

You can create tag data links between NJ-series CPU Units on an EtherNet/IP network.



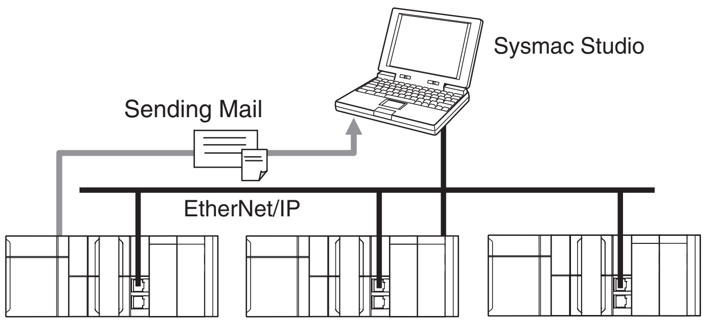

#### ● Message communications

You can send CIP messages from the user program.



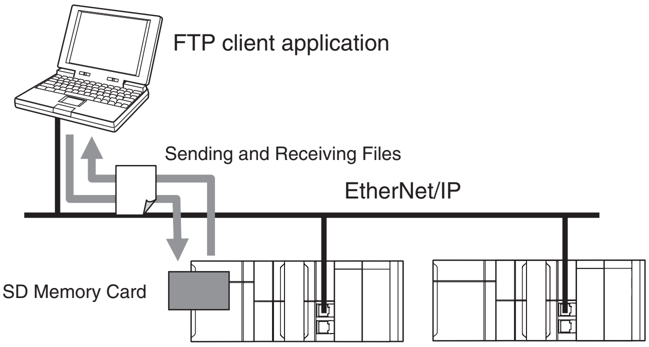

#### ● Sending Mail

You can send e-mails to specified email addresses when the specified conditions are met.



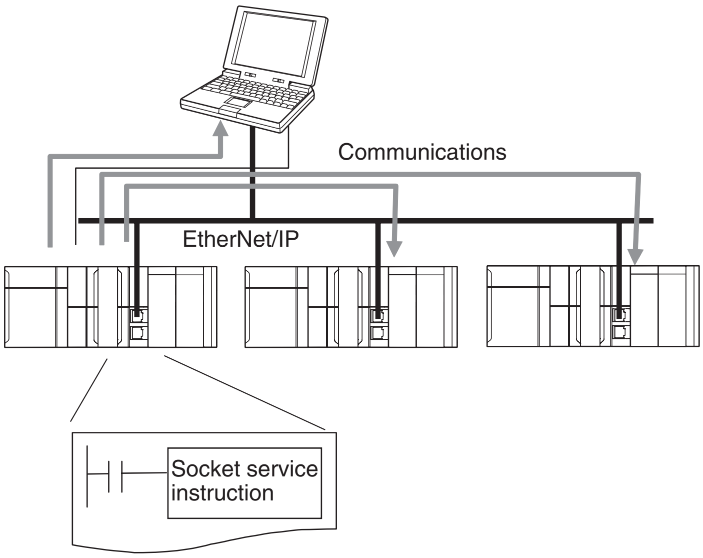
## ● Sending and Receiving Files

You can send and receive files on the SD Memory Card that is inserted in the NJ-series CPU Unit from an FTP client application.



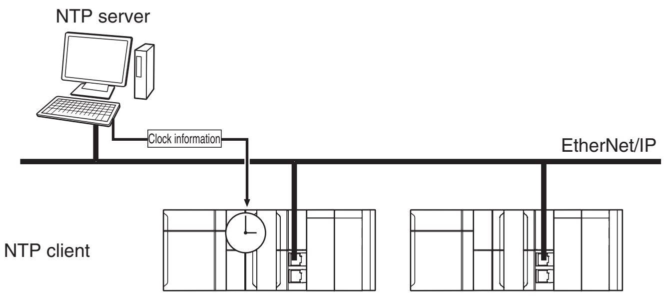

## ● Socket Services

You can directly use TCP or UDP from the user program to send and receive any data with remote nodes between a host computer and the Controller, or between Controllers.




## ● Updating Clock Information

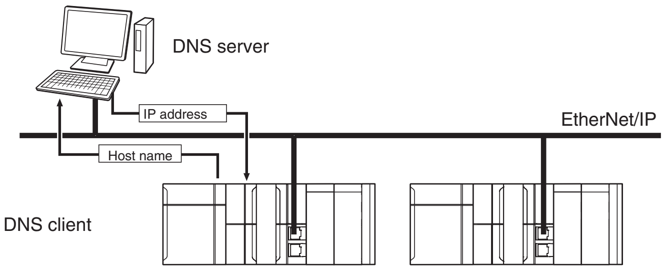
You can obtain clock information from an NTP server to update the built-in clock.



## ● Specifying Host Names

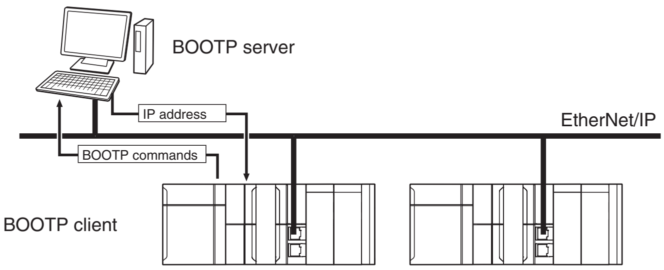
You can use the DNS client or set up your Hosts so that you can specify the IP address of the NTP server or SNMP manager or the target destination of a socket instruction or CIP communications instruction with a host name instead of an IP address.

Example: Setting Host Names on the DNS Server



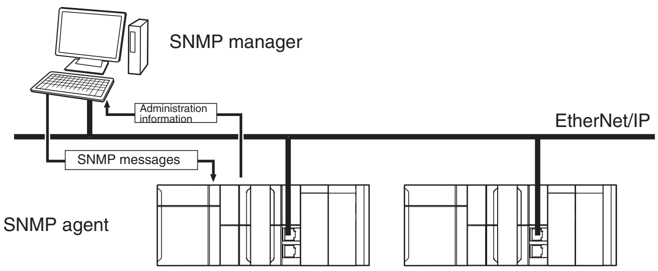

## ● Obtaining an IP Address When the Power is Turned ON

You can obtain an IP address for the built-in EtherNet/IP port from the BOOTP server when the power supply is turned ON.




## ● Specifying an SNMP Agent

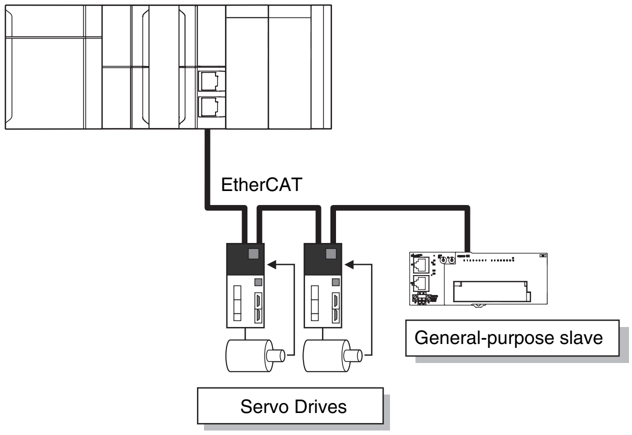
Built-in EtherNet/IP port internal status information is provided to network management software that uses an SNMP manager.



## 10-3-2 Connection Configuration between Controllers and Slaves

### EtherCAT

High-speed, high-precision communications are possible with Servo Drives and general-purpose slaves. Refer to the *NJ-series CPU Unit Built-in EtherCAT Port User's Manual* (Cat. No. W505) for details.



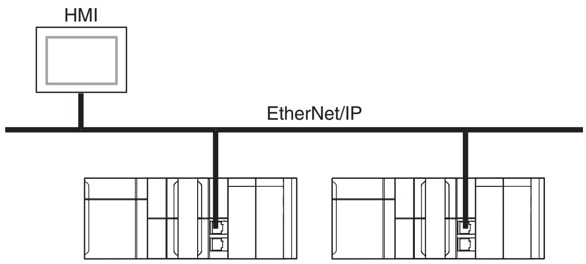
# 10-4 Connection Configurations with HMIs and Devices with Serial Communications

This section shows the connection configurations used to connect HMIs and devices with serial communications to the NJ-series Controller.

## 10-4-1 Connections to HMIs

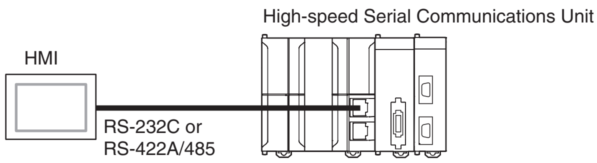
### ● EtherNet/IP

You can use the built-in EtherNet/IP port to connect to an HMI. Refer to the *NJ-series CPU Unit Built-in EtherNet/IP Port User's Manual* (Cat. No. W506) for details.



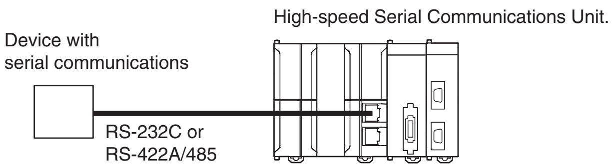

### ● Serial Communications

You can use a Serial Communications Unit to connect to an HMI. Refer to the *CJ-series Serial Communications Units Operation Manual for NJ-series CPU Unit* (Cat. No. W494) for details.




## 10-4-2 Connections to Devices with Serial Communications

You can use a Serial Communications Unit to connect to an HMI. Refer to the *CJ-series Serial Communications Units Operation Manual for NJ-series CPU Unit* (Cat. No. W494) for details.



# 11



# Example of Actual Application Procedures

This section describes the procedures that are used to actually operate an NJ-series Controller.

**11-1 Example Application . . . . . . . . . . 11-2**
11-1-1 System Configuration . . . . . . . . . . 11-2
11-1-2 Operation . . . . . . . . . . 11-3
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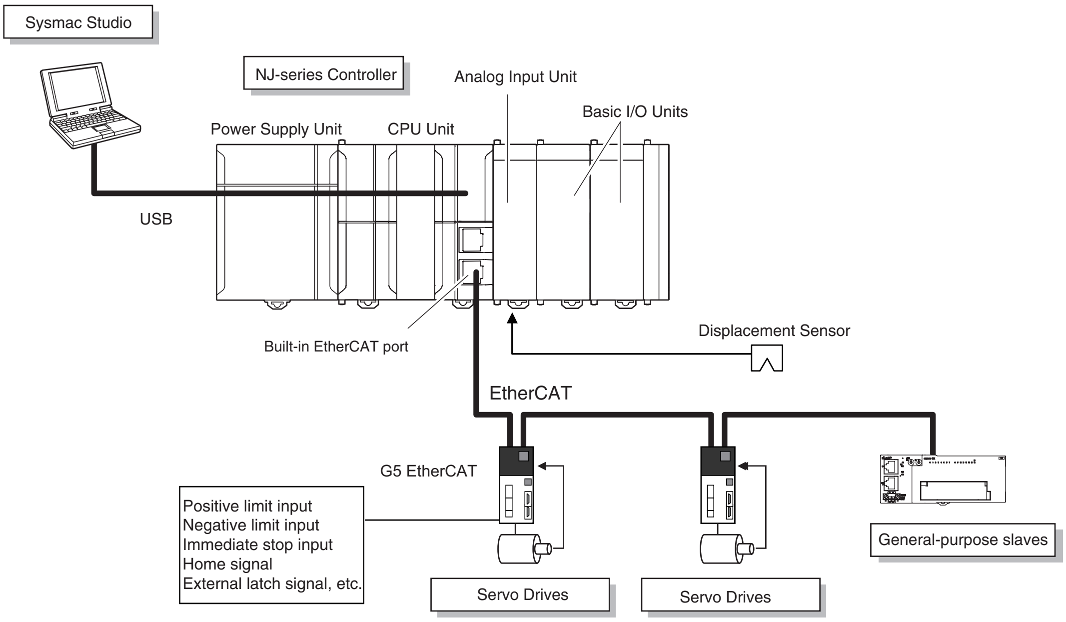
# 11-1 Example Application

This section describes an example application for an NJ-series Controller.

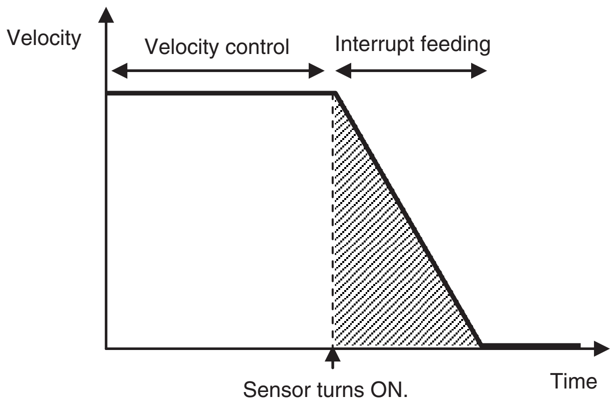
## 11-1-1 System Configuration

| Unit name | | Qty | Connected device |
|---|---|---|---|
| Power Supply Unit | --- | --- | --- |
| CPU Unit | --- | 1 | --- |
| CJ-series Basic I/O Units | --- | 2 | --- |
| CJ-series Analog Input Unit | --- | 1 | Displacement Sensor |
| EtherCAT slaves | Servo Drives (G5 Ether-CAT) | 2 | --- |
| | I/O Terminal | 1 | --- |



## 11-1-2 Operation

Interrupt feeding starts when the sensor signal changes to ON during velocity control.




The vertical position changes based on the analog input from the Displacement Sensor.

# 11-2 Overview of the Example Procedure

This section describes examples of the actual operating procedures for an NJ-series Controller.

## 11-2-1 Wiring and Settings

Wire the Controller and make the hardware settings.

## 11-2-2 Software Design

Design the I/O, tasks, POUs, and variables.

### I/O Design

- Design the relationship between the external I/O and the unit configuration.
- Determine the intervals at which to refresh external I/O.

### Task and POU Design

Consider the following:
- What task configuration is required
- Which programs to assign to which tasks
- Which Units to assign to which tasks
- What processing to place in programs and what processing to place in function blocks and functions

### Variable Design

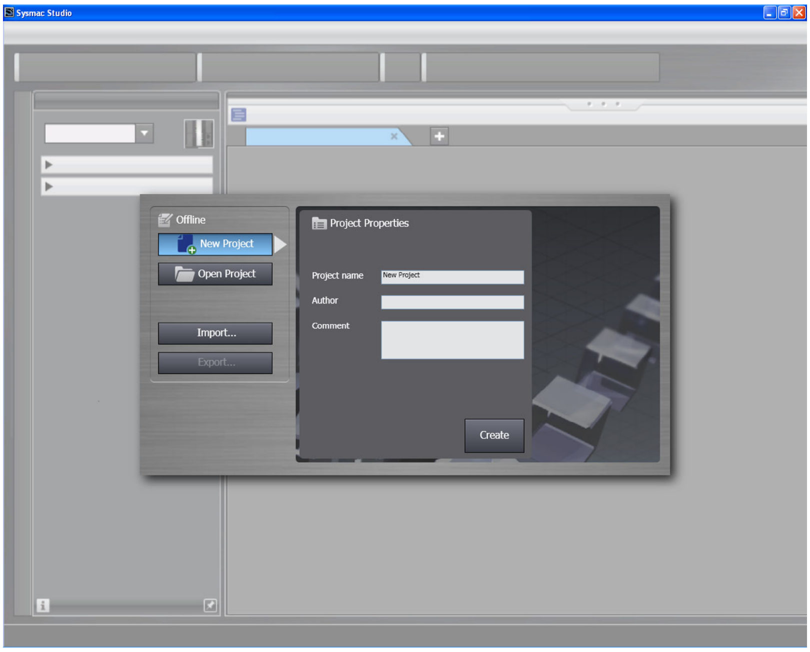
Consider the following:
- The separation of variables into those that you use in more than one POU (global variables) and variables that you use in only specific POUs (local variables)
- Defining the variable names for the device variables that you use to access slaves and Units
- Defining the attributes of variables, such as the Name and Retain attributes
- Designing the data types of variables

## 11-2-3 Software Settings from the Sysmac Studio

On the Sysmac Studio, you set the Unit and slave configurations, register global variables and device variables, create axes (axis variables), and set the Controller Setup and Special Unit Setup.

### Start the Sysmac Studio.

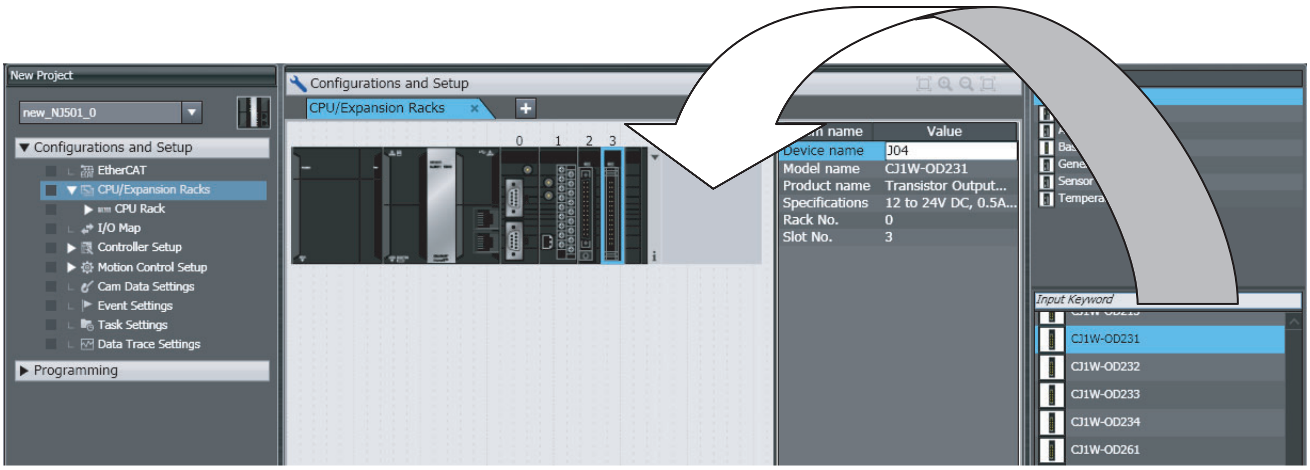
Create a project in Sysmac Studio.




### Create the Unit Configuration.

**1** Double-click **CPU/Expansion Racks** under **Configurations and Setup**.

**2** Create the Unit configuration by dragging Units.

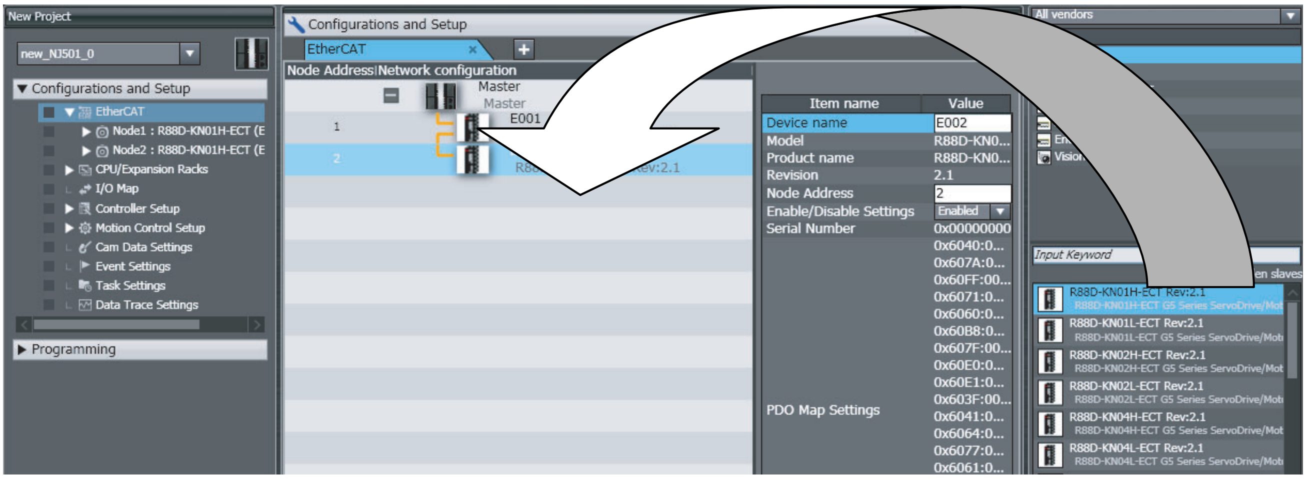



**3** Select each Unit and make the required settings.

## Create the EtherCAT Slave Configuration.

**1** Double-click **EtherCAT** under **Configurations and Setup**.

**2** Create the slave configuration by dragging slaves.




**3** Select the master and set the master parameters.

**4** Select each slave and set the slave parameters.

### Additional Information

At this point, you can use forced resetting from the I/O Map to check the wiring.

## Register the Global Variables and Device Variables.

### ● Registering Global Variables

**1** Double-click **Global Variables** under **Programming** – **Data**.

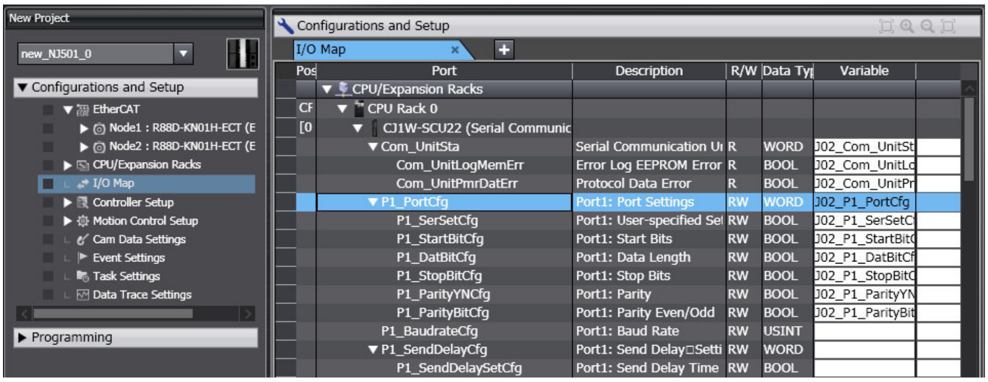
**2** Register the global variables in the global variable table.

### ● Registering Device Variables

**1** Double-click **I/O Map** under **Configurations and Setup**.

**2** In the I/O Map, assign the variables to the I/O ports. (The I/O ports are created automatically from the Unit and slave configurations.)

You can automatically create device variable names with the Sysmac Studio. To do so, right-click an I/O port and select ***Create Device Variables*** from the menu.

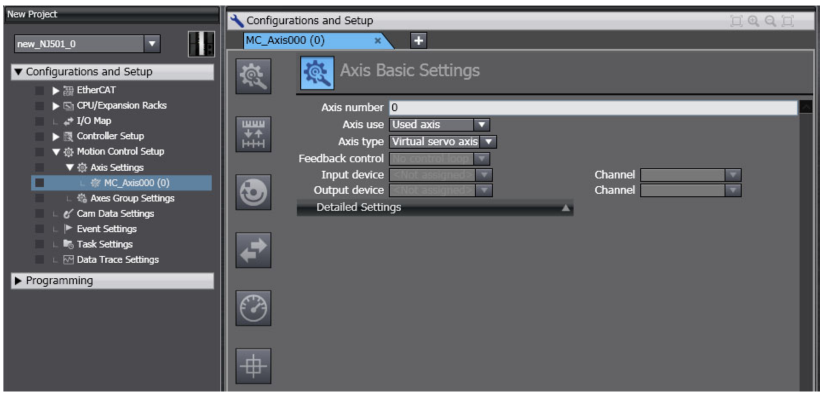


By default, device variables are registered in the global variable table. If necessary, you can change the variable type from a global variable to a local variable (internal variable) for a POU.

## Create Axes (Axis Variables)

**1** Right-click **Axis Settings** under **Configurations and Setups** – **Motion Control Setup** and select Add – Axis Settings from the menu.

**2** Assign Servo Drives to the axes (axis variables) that you created in the EtherCAT configuration.



- Set the *Axis Use* parameter to *Used Axis*.
- Set the *Axis Type* parameter to *Servo Axis*.
- Set the *Input Device* parameter to the Servo Driver that you registered in the slave configuration.

Set the other parameters, such as the Unit Conversion Settings and Operation Settings.

## Set the Controller Setup and the Special Unit Setup.

### ● Initial Settings for the PLC Function Module:

The Controller Setup includes the Startup Mode and other parameters.

### ● Initial Settings for Special Units:

Unit Configuration and Setup: Set the initial settings of the Analog Input Unit.

# 11-2-4 Programming with the Sysmac Studio

On the Sysmac Studio, create the programs, set the tasks, and build the project.

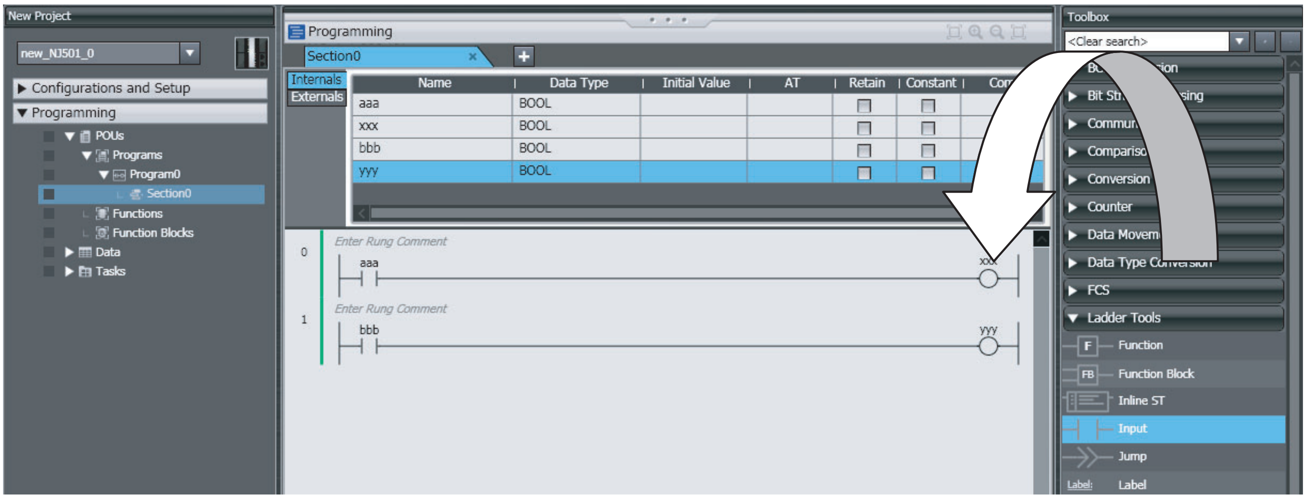
## Write the Programs.

**1** Right-click **Programs** under ***Programming*** – ***POU*** and select ***Add*** – ***Ladder or Add*** – ***ST*** from the menu.

**2** Double-click **Section□** under the program that you registered.

**3** Register the local variables for each program.

**4** Enter the programs.




Create a program with the following instructions.

- Homing: MC_Home instruction
- Velocity control: MC_MoveVelocity instruction
- Interrupt feeding: MC_MoveFeed instruction
- Positioning: MC_Move instruction

**5** As required, right-click **Functions** or **Function Blocks** under **Programming** – **POU** and select ***Add*** – ***Ladder or Add*** – ***ST*** from the menu.

Double-click the function or function block that you registered. Register local variables for each function and function block. Create the algorithms.

**Note** For a ladder diagram, press the **R** Key and create the following rungs.

## Set Up the Tasks.

Double-click **Task Setup** under **Configurations and Setup**.

- In the Task Setup, set the task period and execution condition for the primary periodic task from the pulldown list.
- In the *I/O Control Task Setting*, select the task name to which to assign each Unit and slave.
- Use the Program Assignments to assign the programs to the primary periodic task or the priority-16 periodic task.

## Build the Project.

Select ***Build*** from the Project Menu.

# 11-2-5 Simulation with the Sysmac Studio

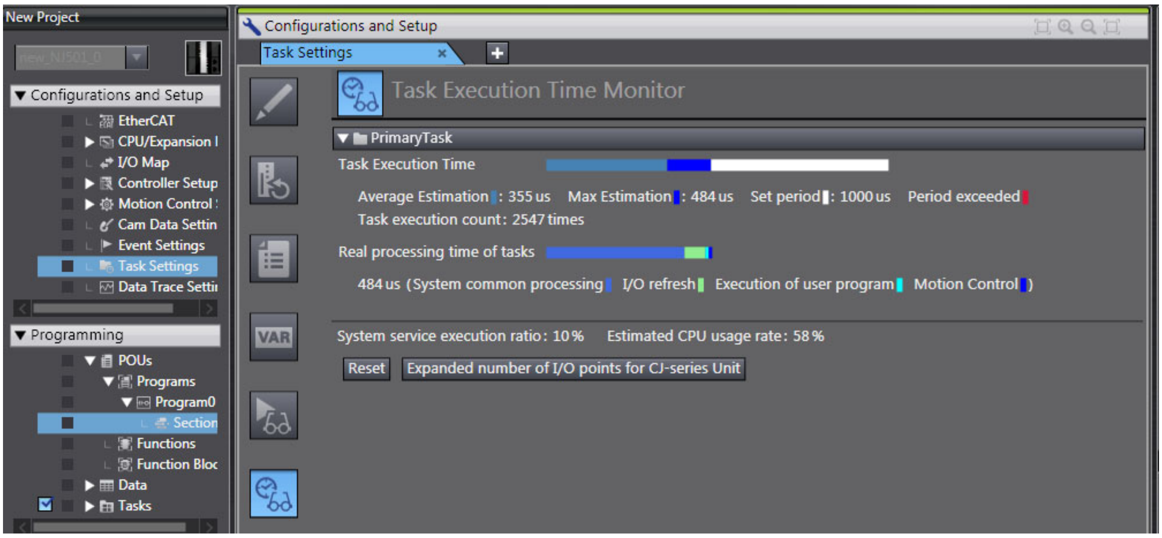
Simulation is used to perform desktop debugging. Check the task execution times and the real processing times of tasks. Review the task design as required.

## Starting the Simulator and Connecting to It

Select ***Execute*** from the Simulation Menu. The Simulator (i.e., the virtual Controller) starts. An online connection is created automatically.

## Checking the Task Execution Time on the Simulator

Double-click **Task Settings** under **Configurations and Setup**. Check to see if the task execution times in the Task Execution Time Monitor exceed the task periods.




If necessary, review the task configuration, program assignments, and task periods.

## Saving the Project

Select ***Save As*** from the File Menu.

## 11-2-6 Checking Operation and Actual Operation

Go online with the Controller, download the project, check the wiring and perform test operation before you start actual operation.

### Going Online

1. Turn ON the power supply to NJ-series Controller.
2. Connect the computer and the CPU Unit with a USB cable.
3. Select ***Communications Setup*** from the Controller Menu. Select the connection method for the connection configuration in the *Connection Type* Field.
4. Select ***Online*** from the Controller Menu.

### Downloading the Project with the Synchronize Menu

Select ***Synchronize*** from the Controller Menu and download the project to the Controller.

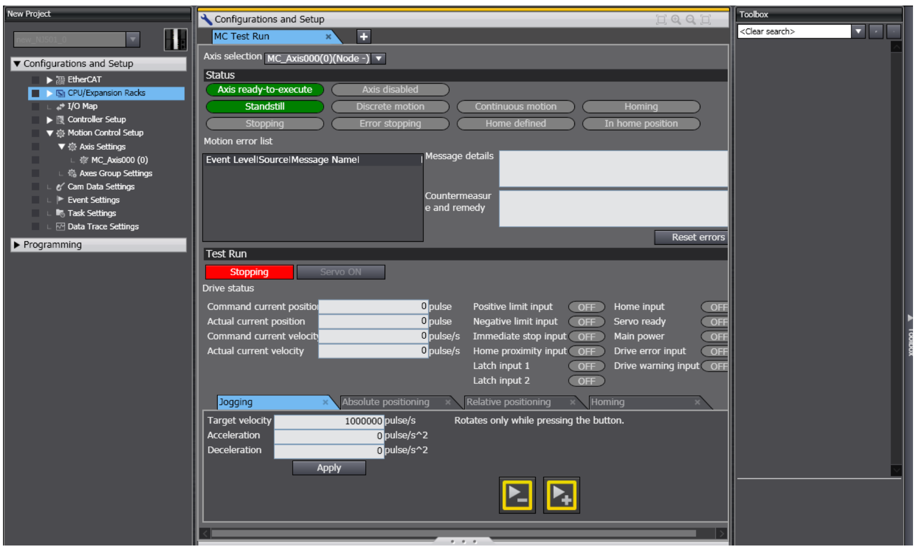
**Note** Use the Synchronize Menu of the Sysmac Studio to upload and download the project.

### Checking Wiring

Check the wiring by performing forced-refreshing with user-specified values from the I/O Map or Ladder Editor.

### MC Test Run

1. Open the MC Test Run Dialog Box.
2. Change the CPU Unit to PROGRAM mode.
3. Monitor input signals on the display to check the wiring.
4. Jog the axis from the display.



## Manual Operation

Change the CPU Unit to RUN mode.

- Turning the Servo ON and OFF: Execute the MC_Power motion control instruction.
- Jogging: Execute the MC_MoveJog motion control instruction.

## Homing

Homing: Execute the MC_Home instruction.

## Actual Operation

Select ***Operation Mode*** – ***RUN Mode*** from the Controller Menu. If an error occurs, investigate the cause and edit the user program.

# 12

# Troubleshooting



This section describes the event codes, error confirmation methods, and corrections for errors that can occur.

**12-1 Operation after an Error . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12-2**
12-1-1 Overview of NJ-series Status . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12-2
12-1-2 Fatal Errors in the CPU Unit . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12-3
12-1-3 Non-fatal error in CPU Unit . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12-4
**12-2 Troubleshooting . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 12-11**
12-2-1 Checking to See If the CPU Unit Is Operating . . . . . . . . . . . . . . . . . . . . . . . 12-11
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12-2-5 Troubleshooting Errors That Are Not in the CPU Unit . . . . . . . . . . . . . . . . . 12-36

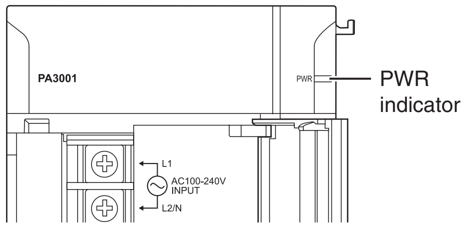
# 12-1 Operation after an Error

This section describes the error status of the NJ-series Controller and the operation that occurs after an error is detected. Refer to *12-2 Troubleshooting* for details on corrections for specific errors. Refer to the *NJ-series Troubleshooting Manual* (Cat. No. W503) for all of the errors that may occur in an NJ-series Controller.

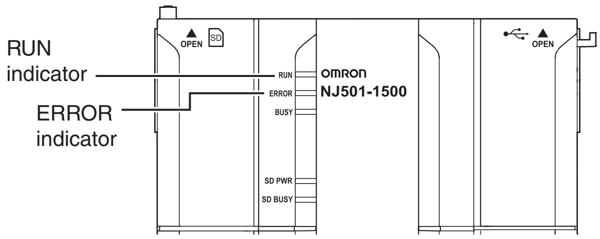
## 12-1-1 Overview of NJ-series Status

You can check the operating status of the CPU Unit with the PWR, RUN, and ERROR indicators on the front panels of the Power Supply Unit and CPU Unit.

Power Supply Unit




CPU Unit




The following table shows the status of front-panel indicators, the status of user program execution, and the ability to connect communications to the Sysmac Studio or NS-series PTs during startup, during normal operation, and when errors occur.

| CPU Unit operating status | | Front-panel indicators | | | User program execution status | Communications with Sysmac Studio or NS-series PT |
|---|---|---|---|---|---|---|
| | | PWR (green) | RUN (green) | ERROR (red) | | |
| **Startup** | | Lit | Flashing (1-s intervals) | Not lit | Stopped. | Not possible. |
| **Normal operation** | **RUN mode** | Lit | Lit | Not lit | Continues. | Possible. |
| | **PROGRAM mode** | Lit | Not lit | Not lit | Stopped. | |
| **Fatal error in CPU Unit** | **Power Supply Error*1** | Not lit | Not lit | Not lit | Stopped. | Not possible. |
| | **CPU Unit Reset*1** | Lit | Not lit | Not lit | Stopped. | |
| | **Incorrect Power Supply Unit Connected*1** | Lit | Flashing (3-s intervals) | Lit | Stopped. | |
| | **CPU Unit Watchdog Timer Error*1** | Lit | Not lit | Lit | Stopped. | |
| **Non-fatal error in CPU Unit** | **Major fault*2** | Lit | Not lit | Lit | Stopped. | Possible. (Communications can be connected from an NS-series PT if EtherNet/IP is operating normally.) |
| | **Partial fault*2** | Lit | Lit | Flashing (1-s intervals) | Continues.*3 | |
| | **Minor fault*2** | Lit | Lit | Flashing (1-s intervals) | Continues. | |
| | **Observation*2** | Lit | Lit | Not lit | Continues. | |

*1 Refer to *12-1-2 Fatal Errors in the CPU Unit* for information on individual errors.

*2 Refer to *12-1-3 Non-fatal error in CPU Unit* for information on individual errors.

*3 The function module where the error occurred stops.

## 12-1-2 Fatal Errors in the CPU Unit

### Types of Fatal Errors

Some errors are fatal and prevent the CPU Unit from operating. This section describes the errors that cause the operation of the CPU Unit to stop. The Sysmac Studio and NS-series PTs cannot connect communications if a fatal error occurs.

#### ● Power Supply Error

Power is not supplied, the voltage is outside of the allowed range, or the Power Supply Unit is faulty.

#### ● CPU Unit Reset

The CPU Unit stopped operation because of a hardware error. Other than hardware failures, this error also occurs at the following times.

- The power supply to an Expansion Rack is OFF.
- The I/O Connecting Cable is incorrectly installed.
  - The IN and OUT connectors are reversed.
  - The connectors are not mated properly.
- There is more than one I/O Control Unit on the CPU Rack or there is an I/O Control Unit on an Expansion Rack.

#### ● Incorrect Power Supply Unit Connected

There is a CJ-series Power Supply Unit connected to the CPU Rack. The operation of the Controller is stopped.

#### ● CPU Unit Watchdog Timer Error

This error occurs in the CPU Unit. This error occurs when the watchdog timer times out because of a hardware failure or when temporary data corruption causes the CPU Unit to hang.

### Checking for Fatal Errors

You can identify fatal errors based on the status of the PWR indicator on the Power Supply Unit and the RUN and ERROR indicators on the CPU Unit, as well as by the ability to connect communications to the Sysmac Studio.

| Indicator | | | Communications with Sysmac Studio | CPU Unit operating status |
|---|---|---|---|---|
| PWR (green) | RUN (green) | ERROR (red) | | |
| Not lit | Not lit | Not lit | Not possible.* | Power Supply Error |
| Lit | Not lit | Not lit | | CPU Unit Reset |
| Lit | Flashing (3-s intervals) | Lit | | Incorrect Power Supply Unit Connected |
| Lit | Not lit | Lit | | CPU Unit Watchdog Timer Error |

* Power Supply Errors and Incorrect Power Supply Unit Connected errors can be differentiated with the indicators. There is no need to check communications with the Sysmac Studio.

## 12-1-3 Non-fatal error in CPU Unit

### Event Levels

Non-fatal errors that occur are managed as Controller events in the NJ-series Controller. Controller events are classified into levels according to the degree of the effect that the events have on control. When an event occurs, the Sysmac Studio or PT will display the level. Refer to the *NJ-series Troubleshooting Manual* (Cat. No. W503) for details on Controller events.

- Major Fault Level
  These errors prevent control operations for the entire Controller. If a major fault level error is detected, user program execution is stopped immediately and the loads for all slaves (including remote I/O) are turned OFF. With EtherCAT slaves and some CJ-series Special Units, you can set the slave settings or Unit settings to select whether outputs will go OFF or retain their previous status. You cannot reset major fault level errors from the user program, the Sysmac Studio, or an NS-series PT. To recover from a major fault level error, remove the cause of the error, and either cycle the power supply to the Controller or reset the Controller from the Sysmac Studio.
- Partial Fault Level
  These errors prevent control operations in a certain function module in the Controller. The NJ-series CPU Unit continues to execute the user program even after a partial fault level error occurs. You can include error processing in the user program to safely stop any devices in operation. After you remove the cause of the error, execute one of the following to return to normal status.
  - Reset the error from the user program, the Sysmac Studio, or an NS-series PT.
  - Cycle the power supply.
  - Reset the Controller from the Sysmac Studio.
- Minor Fault Level
  These errors prevent part of the control operations in a certain function module in the Controller. The troubleshooting for minor fault level errors is the same as the processing for partial fault level errors.
- Observations
  These errors do not affect the control operations of the Controller. Observations serve as warnings to the user so that the error does not develop into an error at a higher level.
- Information
  Events that are classified as information do not indicate errors.

### Operation for Each Level

The operation that is performed when an error occurs depends on the error level of the Controller event.

| Event level / Item | | Controller errors: Major fault level | Controller errors: Partial fault level | Controller errors: Minor fault level | Controller errors: Observation | Controller information: Information |
|---|---|---|---|---|---|---|
| **Definition** | | These errors are serious errors that prevent control operations for the entire Controller. | These errors prevent all of the control in a function module other than PLC Function Module. | Errors that prevent a portion of control in one of the function modules. | Errors that do not affect control. | Information level events are not errors, but information provided to the user in the event log. |
| **Event examples (Only a few examples are provided here. Refer to the *NJ-series Troubleshooting Manual* (Cat. No. W503) for a complete list of errors.)** | | • I/O Bus Check Error (PLC Function Module) | • Motion Control Period Exceeded (Motion Control Function Module)<br>• Communications Controller Error (EtherCAT Master Function Module) | • Positive Limit Input Detected (Motion Control Function Module)<br>• Analog Input Disconnection Detected (CJ-series Unit)<br>• Low Battery Voltage (PLC Function Module) | • Packet Discarded Due to Full Receive Buffer (EtherNet/IP Function Module) | • Power ON<br>• Power Interrupted<br>• Memory All Clear |
| **Front-panel indicators*1** | **PWR (green)** | Lit. | Lit. | Lit. | Lit. | Lit. |
| | **RUN (green)** | Not lit. | Lit. | Lit. | Lit. | Lit. |
| | **ERROR (red)** | Lit. | Flashes at 1-s intervals. | Flashes at 1-s intervals. | Not lit. | Not lit. |

| Event level | | Controller errors | | | | Controller information |
|---|---|---|---|---|---|---|
| **Item** | | **Major fault level** | **Partial fault level** | **Minor fault level** | **Observation** | **Information** |
| **Operation of NJ-series CPU Unit** | **RUN output on Power Supply Unit** | OFF | ON | ON | ON | ON |
| | **User program execution status** | Stops. | Continues.*2 | Continues. | Continues. | Continues. |
| | **Outputs turned OFF** | Yes | No | No | No | No |
| | **Error reset** | Not possible. | Depends on the nature of the error. | Depends on the nature of the error. | --- | --- |
| | **Event logs** | Recorded. (Some errors are not recorded.) | Recorded. | Recorded. | Recorded. | Recorded. |
| **Outputs from EtherCAT slaves and Basic Output Units** | | Refer to the *I/O Operation for a Major Fault Level Controller Error* on page 12-7. | • Errors in EtherCAT Master Function Module: Depends on settings in the slave.<br>• Errors in other function modules: Depends on user program. | Depends on the user program. | Depends on the user program. | Depends on the user program. |
| **Sysmac Studio display (while online)** | | Error messages are automatically displayed. You can display detailed information in the Troubleshooting Dialog Box. | | | These items are not displayed on the error display. | |

*1 If multiple Controller errors have occurred, the indicators show the error with the highest error level.

*2 Operation stops in the function module (Motion Control Function Module, EtherCAT Master Function Module, or EtherNet/IP Function Module) in which the error occurred.

### Operation in the Function Module Where an Error Event Occurred

| Event level / Function module | Major fault level | Partial fault level | Minor fault level | Observation |
|---|---|---|---|---|
| **PLC Function Module** | Operation stops. | --- | Operation continues. | |
| **Motion Control Function Module** | | All axes stop. (The stop method depends on the error.) | • The affected axis/axes group stops. (The stop method depends on the settings.)<br>• The motion control instructions that are related to axis operation are not executed. | • Axis operation continues.<br>• The motion control instructions that are not related to axis operation are not executed. |
| **EtherCAT Master Function Module** | | EtherCAT communications stop. | EtherCAT communications stop or continue depending on the fail-soft operation settings. | EtherCAT communications continue. |
| **EtherNet/IP Function Module** | | EtherNet/IP communications stop. (The Sysmac Studio and NS-series PT cannot connect communications.) | Part of the EtherNet/IP communications stop. (It is possible to connect communications when the Sysmac Studio or NS-series PT communications connection is not the cause of the error.) | EtherNet/IP communications continue. |

### I/O Operation for a Major Fault Level Controller Error

- The following table gives the operation for the following errors.
  - Unsupported Unit Detected
  - I/O Bus Check Error
  - End Cover Missing
  - Incorrect Unit/Expansion Rack Connection
  - Duplicate Unit Number
  - Too Many I/O Points
  - I/O Setting Check Error

| Unit | CPU Unit operation | Unit or slave operation |
|---|---|---|
| EtherCAT slave | The slave is placed in the Safe-Operational state. | Depends on the slave settings.* |
| CJ-series Basic I/O Unit | Refreshing is stopped. | • All outputs are turned OFF.<br>• All inputs are turned OFF. |
| CJ-series Special Unit | Refreshing is stopped. | Depends on the Unit operating specifications (the ERH indicator lights). |
| Servo Drive | Updating the command values is stopped. | All axes stop immediately. |

* Settings and setting methods depend on the slave. Refer to the manual for the slave. For a Servo Drive, operation depends on the setting of object 605E hex (Fault Reaction Option Code).

- The following table gives the operation for all other errors.

| Unit | CPU Unit operation | Unit or slave operation |
|---|---|---|
| EtherCAT slave | The slave is placed in the Safe-Operational state. | Depends on the slave settings.* |
| CJ-series Basic I/O Unit | • All outputs are turned OFF.<br>• Input refreshing continues. | • All outputs are turned OFF.<br>• External inputs are refreshed. |
| CJ-series Special Unit | Refreshing continues. | Depends on the Unit operating specifications. |
| Servo Drive | Updating the command values is stopped. | All axes stop immediately. |

* Settings and setting methods depend on the slave. Refer to the manual for the slave. For a Servo Drive, operation depends on the setting of object 605E hex (Fault Reaction Option Code).

## Checking for Non-fatal Errors

Use the following methods to check for non-fatal errors.

| Checking method | What you can check |
|---|---|
| Checking the indicators | You can use the indicators to confirm the Controller error level, the error status of the EtherCAT Master Function Module, and the error status of the EtherNet/IP Function Module. |
| Checking with the troubleshooting function of Sysmac Studio | You can check for current Controller errors, a log of past Controller errors, error sources, error causes, and corrections. |
| Checking with the Troubleshooter of an NS-series PT | You can check for current Controller errors, a log of past Controller errors, error sources, error causes, and corrections. |
| Checking with instructions that read function module error status | You can check the highest-level status and highest-level event code in the current Controller errors. |
| Checking with system-defined variables | You can check the current Controller error status for each function module. |

This section describes the above checking methods.

## Checking the Indicators

### ● Checking the Level of a Controller Error

You can use the PWR indicator on the Power Supply Unit and the RUN and ERROR indicators on the CPU Unit to determine the event level for an error. The following table shows the relationship between the Controller's indicators and the event level.

| Indicator | | | Event level |
|---|---|---|---|
| PWR (green) | RUN (green) | ERROR (red) | |
| Lit | Not lit | Lit | Major fault level |
| Lit | Lit | Flashing (1-s intervals) | Partial fault level |
| | | | Minor fault level |
| Lit | Lit | Not lit | Observation |

### Checking Errors in the EtherCAT Master Function Module and EtherNet/IP Function Module

For the EtherCAT Master Function Module and EtherNet/IP Function Module, use the EtherCAT and EtherNet/IP NET ERR indicators to determine whether a minor fault level error or higher-level error has occurred. The indicator lets you check the status given in the following table.

| Indicator | Indicated status |
|---|---|
| EtherCAT NET ERR | EtherCAT Master Function Module Status<br>• Lit: An error for which normal status cannot be recovered through user actions (i.e., errors for which you must replace the CPU Unit or contact your OMRON representative) has occurred.<br>• Flashing: An error for which normal status can be recovered through user actions has occurred.<br>• Not lit: There is no minor fault level or higher-level error. |
| EtherNet/IP NET ERR | EtherNet/IP Function Module Status<br>• Lit: An error for which normal status cannot be recovered through user actions (i.e., errors for which you must replace the CPU Unit or contact your OMRON representative) has occurred.<br>• Flashing: An error for which normal status can be recovered through user actions has occurred.<br>• Not lit: There is no minor fault level or higher-level error. |

## Checking with the Troubleshooting Function of Sysmac Studio

When an error occurs, you can connect the Sysmac Studio online to the Controller to check current Controller errors and the log of past Controller errors.

### Current Errors

Open the Sysmac Studio's Controller Error Tab Page to check the current error's level, source, source details, event name, event code, cause, and correction. Errors are not displayed for observations.

### Log of Past Errors

Open the Sysmac Studio's Controller Log Tab Page to check the time of occurrence, level, source, source details, event name, event code, details, attached information 1 to 4, and corrections for past errors.

Refer to the *NJ-Series Sysmac Studio Version 1 Operation Manual* (Cat. No. W504) for details on troubleshooting with the Sysmac Studio.

## Checking with the Troubleshooter of an NS-series PT

If you can connect communications between an NS-series PT and the Controller when an error occurs, you can check for current Controller errors and the log of past Controller errors.

### Current Errors

Open the Controller Error Tab Page on the NS-series PT's Troubleshooter to check the current error's event name, event code, level, source, source details, details, and attached information 1 to 4. Observations are not displayed as errors.

- **Log of Past Errors**

Open the Controller Event Log Tab Page on the NS-series PT's Troubleshooter to check the time of occurrence, level, source, event name, event code, details, and attached information 1 to 4 for past errors.

Refer to the *NS-series Programmable Terminals Programming Manual* (Cat. No. V073) for details on the NS-series PT's Troubleshooter.

## Checking with Instructions That Read Function Module Error Status

Instructions are provided that allow you to read the error status of each function module from the user program. These instructions get the status and the event code of the error with the highest level.

| Applicable function module | Instruction name | Instruction |
|---|---|---|
| PLC Function Module | Get PLC Controller Error Status | GetPLCError |
| | Get I/O Bus Error Status | GetCJBError |
| Motion Control Function Module | Get Motion Control Error Status | GetMCError |
| EtherCAT Function Module | Get EtherCAT Error Status | GetECError |
| EtherNet/IP Function Module | Get EtherNet/IP Error Status | GetEIPError |

For details on the instructions that get error status, refer to the *NJ-series Instructions Reference Manual* (Cat. No. W502).

## Checking with System-defined Variables

You can check the error status variables in the system-defined variables to determine the status of errors in a Controller. You can read the error status variables from an external device by using communications. Refer to *A-3 System-defined Variables* for the system-defined variables.

# 12-2 Troubleshooting

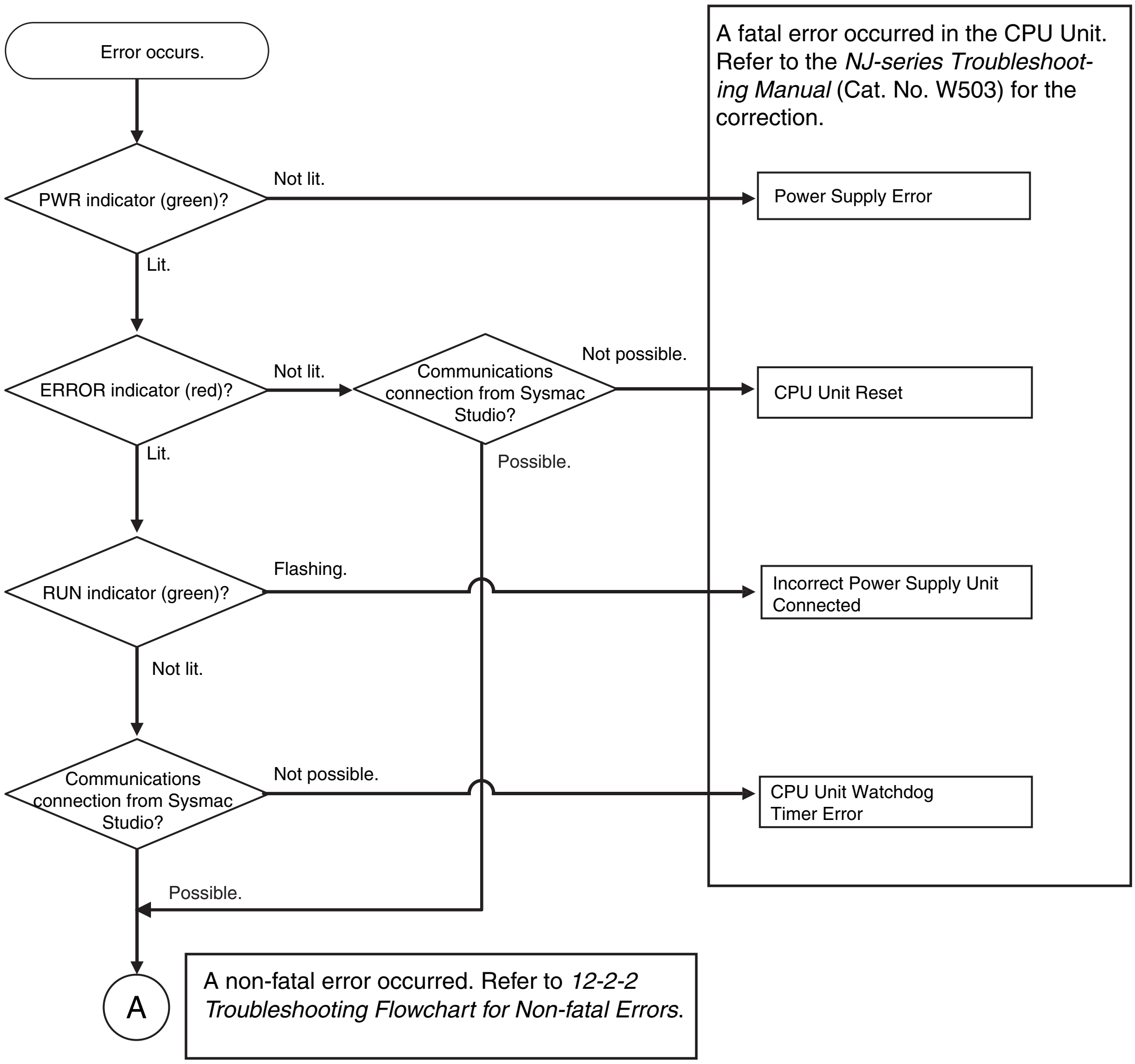
This section provides basic error identification and troubleshooting flowcharts. Use them when an error occurs in the NJ-series Controller. This section also describes the software errors that are related to the PLC Function Module and corrections for those errors.



## 12-2-1 Checking to See If the CPU Unit Is Operating

When an error occurs in the NJ-series Controller, use the following flowchart to determine whether the error is a fatal error or a non-fatal error.

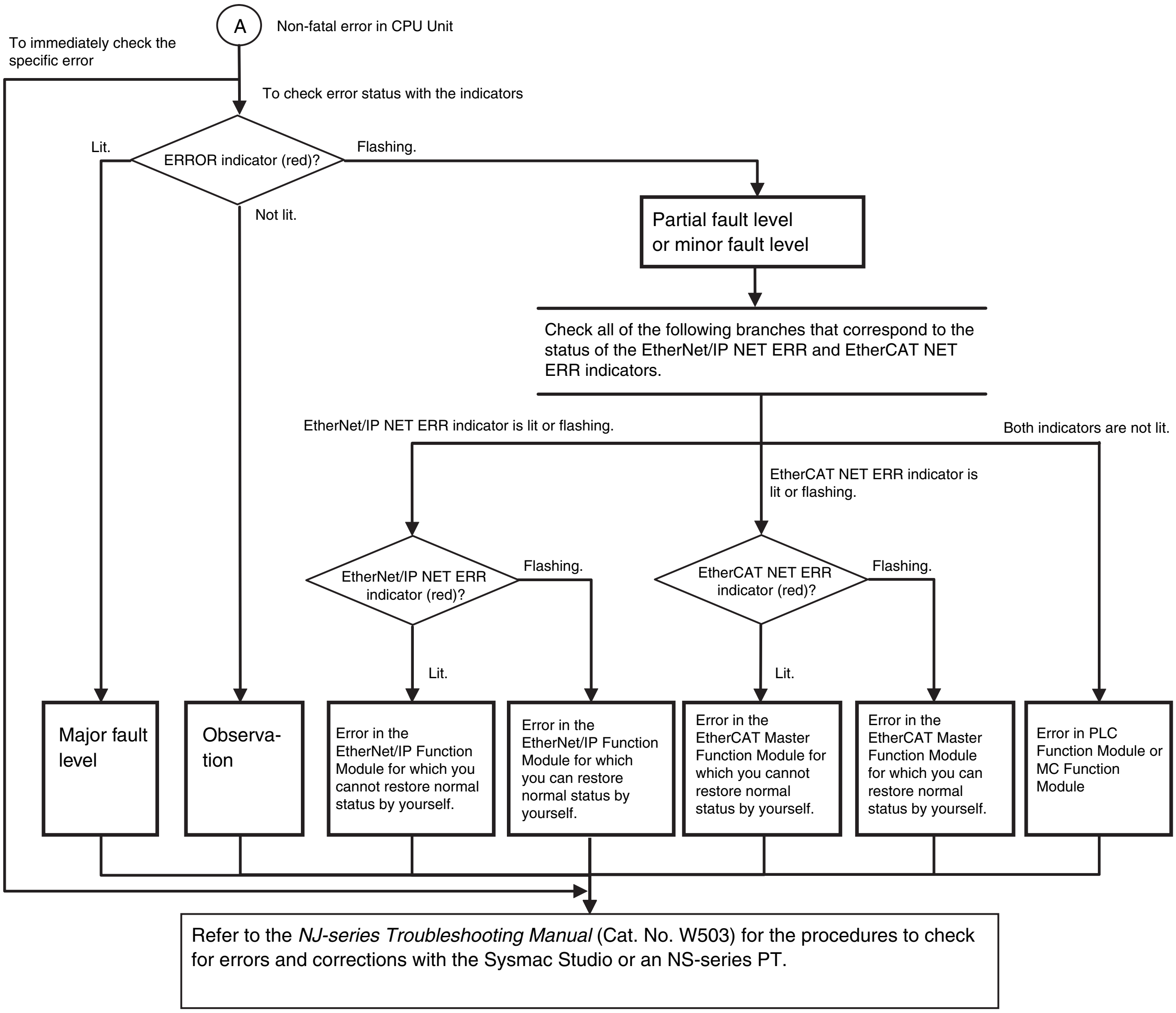
Whenever possible, set the Sysmac Studio's communications connection in the flowchart to a direct USB connection. If you use Ethernet, there are many reasons that prevent a communications connection for the Sysmac Studio, so time is required to determine if a fatal or non-fatal error has occurred. If a communications connection from the Sysmac Studio is not possible, perform the troubleshooting procedure that is provided in the *NJ-series Troubleshooting Manual* (Cat. No. W503) before you assume that the error is a fatal error.



## 12-2-2 Troubleshooting Flowchart for Non-fatal Errors

For a non-fatal error, use the Sysmac Studio or an NS-series PT to troubleshoot the error with the following flowchart. You can use the indicators to check the following:

- Level
- Whether the error is in the EtherNet/IP Function Module or the EtherCAT Master Function Module
- If the source of the error is the EtherNet/IP Function Module or the EtherCAT Master Function Module, whether you can restore normal status yourself




## 12-2-3 Error Table

The errors (i.e., events) that can occur in the PLC Function Module are given on the following pages. Event levels are given as following in the tables:

Maj: Major fault level

Par: Partial fault level

Min: Minor fault level

Obs: Observation

Info: Information

Refer to the *NJ-series Troubleshooting Manual* (Cat. No. W503) for all NJ-series event codes.

## Errors Related to Tasks

| Event code | Event name | Meaning | Assumed cause | Level | | | | | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Maj | Prt | Min | Obs | Info | |
| 60020000 hex | Task Execution Timeout | Task execution exceeded the timeout detection time. | • The timeout detection time setting is too short.<br>• The task period setting is too short.<br>• A user program is too large.<br>• The number of times that processing is repeated is larger than expected.<br>• The priority of the periodic task is incorrect. | √ | | | | | page 12-18 |
| 60030000 hex | I/O Refreshing Timeout Error | Two consecutive I/O refresh failures occurred during the primary periodic task or periodic task period. | • The task period setting is too short.<br>• The priority of the periodic task is incorrect.<br>• There are too many Units and slaves that perform I/O refresh in the task period. | √ | | | | | page 12-19 |
| 60040000 hex | Insufficient System Service Time Error | The specified system service execution time could not be obtained. | • There is no unused time available for task execution.<br>• The system service execution interval is too short or the system service execution time ratio is too long in the system service execution time settings. | √ | | | | | page 12-19 |
| 60010000 hex | Task Period Exceeded | Task execution was not completed during the set task period for the primary periodic task or a periodic task. | • The task period setting is too short.<br>• A user program is too large.<br>• The number of times that processing is repeated is larger than expected.<br>• The priority of the periodic task is incorrect. | | | √ | | | page 12-20 |
| 60050000 hex | Task Period Exceeded | Task execution was not completed during the set task period for the primary periodic task or fixed periodic task. | • The task period setting is too short.<br>• A user program is too large.<br>• The number of times that processing is repeated is larger than expected.<br>• The priority of the periodic task is incorrect. | | | | √ | | page 12-21 |

## Errors Related to Controller Operation

| Event code | Event name | Meaning | Assumed cause | Level | | | | | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Maj | Prt | Min | Obs | Info | |
| 10200000 hex | User Program/Controller Configurations and Setup Transfer Error | The user program or Controller Configurations and Setup were not transferred correctly. | • The user program or Controller Configurations and Setup are not correct because the power supply to the Controller was interrupted or communications with the Sysmac Studio were disconnected during a download of the user program or the Controller Configurations and Setup.<br>• The user program or Controller Configurations and Setup are not correct because the power supply to the Controller was interrupted during online editing.<br>• The user program or Controller Configurations and Setup are not correct because the power supply to the Controller was interrupted during a Clear All Memory operation.<br>• Non-volatile memory failed. | √ | | | | | page 12-22 |
| 10210000 hex | Illegal User Program Execution ID | The user program execution IDs set in the user program and in the CPU Unit do not match. | • The user program execution IDs set in the user program and in the CPU Unit do not match.<br>• A user program execution ID is set in the CPU Unit but not in the user program. | √ | | | | | page 12-23 |
| 10240000 hex | Illegal User Program | The user program is not correct. | • There are more than 8 nesting levels for functions or function blocks. | √ | | | | | page 12-23 |
| 10250000 hex | Illegal User Program/Controller Configurations and Setup | The user program or Controller Configurations and Setup is corrupted. | • Illegal data was transferred for the user program or Controller Configurations and Setup.<br>• Non-volatile memory is deteriorating or has failed. | √ | | | | | page 12-24 |
| 40160000 hex | Safe Mode | The Controller started in Safe Mode. | • The power supply was turned ON to the Controller when Safe Mode was set on the DIP switch on the CPU Unit. | √ | | | | | page 12-24 |
| 10230000 hex | Event Log Restoration Error | Restoring the event log failed. | • A low battery voltage prevented retention of memory during a power interruption. | | | | √ | | page 12-25 |
| 10260000 hex | Trace Setting Transfer Failure | The power supply was interrupted while transferring the trace settings. | • The power supply was interrupted while transferring the trace settings. | | | | √ | | page 12-25 |
| 90010000 hex | Clock Changed | The clock time was changed. | • The clock time was changed. | | | | | √ | page 12-25 |
| 90020000 hex | Time Zone Changed | The time zone was changed. | • The time zone was changed. | | | | | √ | page 12-26 |
| 90080000 hex | Variable Changed to TRUE with Forced Refreshing | Changing a variable to TRUE with forced refreshing was specified. | • Changing a variable to TRUE with forced refreshing was specified by the user. | | | | | √ | page 12-26 |

| Event code | Event name | Meaning | Assumed cause | Level | | | | | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Maj | Prt | Min | Obs | Info | |
| 90090000 hex | Variable Changed to FALSE with Forced Refreshing | Changing a variable to FALSE with forced refreshing was specified. | • Changing a variable to FALSE with forced refreshing was specified by the user. | | | | | √ | page 12-26 |
| 900A0000 hex | All Forced Refreshing Cleared | Clearing all forced refreshing values was specified. | • Clearing all forced refreshing values was specified by the user. | | | | | √ | page 12-27 |
| 900B0000 hex | Memory All Cleared | All of memory was cleared. | • A user with Administrator rights cleared all of the memory. | | | | | √ | page 12-27 |
| 900C0000 hex | Event Log Cleared | The event log was cleared. | • The event log was cleared by the user. | | | | | √ | page 12-27 |
| 90110000 hex | Power Turned ON | The power supply was turned ON. | • The power supply was turned ON. | | | | | √ | page 12-28 |
| 90120000 hex | Power Interrupted | The power supply was interrupted. | • The power supply was interrupted. | | | | | √ | page 12-28 |
| 90130000 hex | Operation Started | Operation was started. | • A command to start operation was received. | | | | | √ | page 12-28 |
| 90140000 hex | Operation Stopped | Operation was stopped. | • A command to stop operation was received. | | | | | √ | page 12-29 |
| 90150000 hex | Reset Executed | A reset was executed. | • A reset command was received. | | | | | √ | page 12-29 |
| 90160000 hex | User Program Execution ID Write | The user program execution ID was set or changed in the CPU Unit. | • A user with Administrator rights changed the user program execution ID that is set in the CPU Unit. | | | | | √ | page 12-29 |
| 90180000 hex | All Controller Errors Cleared | All current errors were cleared. | • The user cleared all current errors. | | | | | √ | page 12-30 |
| 90190000 hex | Forced Refreshing Cleared | Clearing a forced refreshing value was specified. | • Clearing a forced refreshing value was specified by the user. | | | | | √ | page 12-30 |

## Errors Related to FINS Communications

| Event code | Event name | Meaning | Assumed cause | Level | | | | | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Maj | Prt | Min | Obs | Info | |
| 14010000 hex | CPU Bus Unit Setup Area Error | An error was detected in the memory check of the Setup Area for CPU Bus Units. | • The power supply to the Controller was interrupted or communications with the Sysmac Studio were disconnected while downloading the CPU Bus Unit Settings. | | | √ | | | page 12-31 |
| 34100000 hex | IP Address Table Setting Error | The IP address table settings are incorrect. | • The IP address conversion method is set to the combined method or the IP address table method, but the IP address table settings are incorrect. | | | √ | | | page 12-31 |
| 34110000 hex | Unknown Destination Node | The send destination node is not known. | • The send destination node was not found when a FINS message was sent. | | | √ | | | page 12-32 |
| 34130000 hex | FINS/TCP Connection Table Setting Error | The FINS/TCP connection table is incorrect. | • The power supply to the Controller was interrupted or communications with the Sysmac Studio were disconnected while downloading the FINS/TCP connection table. | | | √ | | | page 12-32 |

| Event code | Event name | Meaning | Assumed cause | Level | | | | | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Maj | Prt | Min | Obs | Info | |
| 80100000 hex | Packet Discarded | One or more packets were discarded. | • A FINS response addressed to the CPU Unit was received.<br>• The send designation Unit for the FINS response does not exist. | | | | √ | | page 12-33 |
| 80110000 hex | Packet Discarded | One or more packets were discarded. | • An attempt was made to send a FINS response with over 2002 bytes.<br>• An attempt was made to route a FINS response with over 2002 bytes.<br>• Packet was received with a No Such Unit routing error.<br>• Packet was received with a Routing Error routing error.<br>• Packet was received with a No Routing Table routing error.Packet was received with a No Routing Table routing error.<br>• Packet was received with an Event Area Size Over Limit routing error.<br>• There is insufficient space in the internal buffer.<br>• FINS message routing failed because the communications load is too high. | | | | √ | | page 12-34 |
| 80120000 hex | Packet Discarded | One or more packets were discarded. | • A FINS response was received in which DNA was the local network but DA1 was not the local node.<br>• A FINS command or response was received in which the hub network address specification DNA was greater than or equal to 80 hex.<br>• There is insufficient space in the internal buffer.<br>• A FINS command that does not have the minimum command length was received.<br>• A FINS command that exceeded the maximum command length was received.<br>• Sending packets failed.<br>• FINS message routing failed because the communications load was too high. | | | | √ | | page 12-35 |

## 12-2-4 Error Descriptions

This section describes the information that is given for individual errors.

### Controller Error Descriptions

The items that are used to describe individual errors (events) are described in the following copy of an error table.

<table>
<tr><td>Event name</td><td colspan="3">Gives the name of the error.</td><td>Event code</td><td colspan="2">Gives the code of the error.</td></tr>
<tr><td>Meaning</td><td colspan="6">Gives a short description of the error.</td></tr>
<tr><td>Source</td><td colspan="2">Gives the source of the error.</td><td>Source details</td><td>Gives details on the source of the error.</td><td>Detection timing</td><td>Tells when the error is detected.</td></tr>
<tr><td>Error attributes</td><td>Level</td><td>Tells the level of influence on control.*1</td><td>Recovery</td><td>Gives the recovery method.*2</td><td>Log category</td><td>Tells which log the error is saved in.*3</td></tr>
<tr><td>Effects</td><td>User program</td><td>Tells what will happen to execution of the user program.*4</td><td>Operation</td><td colspan="3">Provides special information on the operation that results from the error.</td></tr>
<tr><td>Indicators</td><td colspan="6">Gives the status of the built-in EtherNet/IP port and built-in EtherCAT port indicators. Indicator status is given only for errors in the EtherCAT Master Function Module and the EtherNet/IP Function Module.</td></tr>
<tr><td rowspan="2">System-defined variables</td><td colspan="2">Variable</td><td colspan="2">Data type</td><td colspan="2">Name</td></tr>
<tr><td colspan="6">Lists the variable names, data types, and meanings for system-defined variables that provide direct error notification, that are directly affected by the error, or that contain settings that cause the error.</td></tr>
<tr><td rowspan="2">Cause and correction</td><td colspan="2">Assumed cause</td><td colspan="2">Correction</td><td colspan="2">Prevention</td></tr>
<tr><td colspan="6">Lists the possible causes, corrections, and preventive measures for the error.</td></tr>
<tr><td>Attached information</td><td colspan="6">This is the attached information that is displayed by the Sysmac Studio or an NS-series PT.</td></tr>
<tr><td>Precautions/ Remarks</td><td colspan="6">Provides precautions, restrictions, and supplemental information.</td></tr>
</table>

*1 One of the following:
Major fault: Major fault level
Partial fault: Partial fault level
Minor fault: Minor fault level
Observation
Information

*2 One of the following:
Automatic recovery: Normal status is restored automatically when the cause of the error is removed.
Error reset: Normal status is restored when the error is reset after the cause of the error is removed.
Cycle the power supply: Normal status is restored when the power supply to the Controller is turned OFF and then back ON after the cause of the error is removed.
Controller reset: Normal status is restored when the Controller is reset after the cause of the error is removed.
Depends on cause: The recovery method depends on the cause of the error.

*3 One of the following:
System: System event log
Access: Access event log

*4 One of the following:
Continues: Execution of the user program will continue.
Stops: Execution of the user program stops.
Starts: Execution of the user program starts.

## Errors Related to Tasks

<table>
<tr><td>Event name</td><td colspan="3">Task Execution Timeout</td><td>Event code</td><td colspan="2">60020000 hex</td></tr>
<tr><td>Meaning</td><td colspan="6">Task execution exceeded the timeout detection time.</td></tr>
<tr><td>Source</td><td colspan="2">PLC Function Module</td><td>Source details</td><td>None</td><td>Detection timing</td><td>Continuously</td></tr>
<tr><td>Error attributes</td><td>Level</td><td>Major fault</td><td>Recovery</td><td>Cycle the power supply or reset the Controller.</td><td>Log category</td><td>System</td></tr>
<tr><td>Effects</td><td>User program</td><td>Stops.</td><td>Operation</td><td colspan="3">All outputs are stopped.</td></tr>
<tr><td rowspan="5">System-defined variables</td><td colspan="2">Variable</td><td colspan="2">Data type</td><td colspan="2">Name</td></tr>
<tr><td colspan="2">_<<i>Task_name</i>>_Exceeded</td><td colspan="2">BOOL</td><td colspan="2">Task Period Exceeded Flag</td></tr>
<tr><td colspan="2">_<<i>Task_name</i>>_ExceedCount</td><td colspan="2">UDINT</td><td colspan="2">Task Period Exceeded Count</td></tr>
<tr><td colspan="2">_<<i>Task_name</i>>_LastExecTime</td><td colspan="2">TIME</td><td colspan="2">Last Task Execution Time</td></tr>
<tr><td colspan="2">_<<i>Task_name</i>>_MaxExecTime</td><td colspan="2">TIME</td><td colspan="2">Maximum Task Execution Time</td></tr>
<tr><td rowspan="6">Cause and correction</td><td colspan="2">Assumed cause</td><td colspan="2">Correction</td><td colspan="2">Prevention</td></tr>
<tr><td colspan="2">The timeout detection time setting is too short.</td><td colspan="2">Increase the timeout detection time.</td><td colspan="2" rowspan="5">Design the tasks considering the corrections that are given on the left.</td></tr>
<tr><td colspan="2">The task period setting is too short.</td><td colspan="2">Increase the task period.</td></tr>
<tr><td colspan="2">A user program is too large.</td><td colspan="2">Separate the processes into different tasks, for example move processes that need a short execution period to a periodic task with a lower priority.</td></tr>
<tr><td colspan="2">The number of times that processing is repeated is larger than expected.</td><td colspan="2">If there is a program with an extremely high number of repetitions, correct the program to achieve the correct number of repetitions. Set a trap in the user program that monitors the number of times a process is executed to check the number of repetitions.</td></tr>
<tr><td colspan="2">The priority of the periodic task is incorrect.</td><td colspan="2">Increase the priority of the periodic task.</td></tr>
<tr><td>Attached information</td><td colspan="6">Attached Information 1: Name of task where error occurred</td></tr>
<tr><td>Precautions/ Remarks</td><td colspan="6">None</td></tr>
</table>

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | I/O Refreshing Timeout Error | | | Event code | 60030000 hex | |
| Meaning | Two consecutive I/O refresh failures occurred during the primary periodic task or periodic task period. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | Continuously |
| Error attributes | Level | Major fault | Recovery | Cycle the power supply or reset the Controller. | Log category | System |
| Effects | User program | Stops. | Operation | All outputs are stopped. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | _<*Task_name*>_Exceeded | | BOOL | | Task Period Exceeded Flag | |
| | _<*Task_name*>_ExceedCount | | UDINT | | Task Period Exceeded Count | |
| | _<*Task_name*>_LastExecTime | | TIME | | Last Task Execution Time | |
| | _<*Task_name*>_MaxExecTime | | TIME | | Maximum Task Execution Time | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | The task period setting is too short. | | Check the task execution time and change the task period to an appropriate value. | | Design the tasks considering the corrections that are given on the left. | |
| | The priority of the periodic task is incorrect. | | Increase the priority of the periodic task. | | | |
| | There are too many Units and slaves that perform I/O refresh in the task period. | | Move the I/O refresh processes to other tasks, for example move I/O refresh processes within the task to other tasks. | | | |
| Attached information | Attached Information 1: Name of task where error occurred | | | | | |
| Precautions/ Remarks | None | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | Insufficient System Service Time Error | | | Event code | 60040000 hex | |
| Meaning | The specified system service execution time could not be obtained. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | Continuously |
| Error attributes | Level | Major fault | Recovery | Cycle the power supply or reset the Controller. | Log category | System |
| Effects | User program | Stops. | Operation | All outputs are stopped. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | _<*Task_name*>_Exceeded | | BOOL | | Task Period Exceeded Flag | |
| | _<*Task_name*>_ExceedCount | | UDINT | | Task Period Exceeded Count | |
| | _<*Task_name*>_LastExecTime | | TIME | | Last Task Execution Time | |
| | _<*Task_name*>_MaxExecTime | | TIME | | Maximum Task Execution Time | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | There is no unused time available for task execution. | | Check the time that is available for task execution and increase the task period to ensure that there is sufficient task execution time. | | Set the system service time according to the corrections that are given on the left. | |
| | The system service execution interval is too short or the system service execution time ratio is too long in the system service execution time settings. | | Check the effect on the processes executed by the system services with this operation and increase the system service execution interval or reduce the system service execution time ratio. | | | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

<table>
<tr><td>Event name</td><td colspan="3">Task Period Exceeded</td><td>Event code</td><td colspan="2">60010000 hex</td></tr>
<tr><td>Meaning</td><td colspan="6">Task execution was not completed during the set task period for the primary periodic task or a periodic task.</td></tr>
<tr><td>Source</td><td colspan="2">PLC Function Module</td><td>Source details</td><td>None</td><td>Detection timing</td><td>Continuously</td></tr>
<tr><td>Error attributes</td><td>Level</td><td>Minor fault</td><td>Recovery</td><td>Error reset</td><td>Log category</td><td>System</td></tr>
<tr><td>Effects</td><td>User program</td><td>Continues.</td><td>Operation</td><td colspan="3">If the task execution does not finish within the set task period, the I/O refresh operation will be as follows:<br>• CJ-series Units: No I/O refresh is executed. When task execution is completed, I/O refreshing for the next period is executed.<br>• EtherCAT slaves: The same values are output as for the previous output refresh.<br>If the task execution does not finish within the set task period, overall control of the equipment may become impossible.</td></tr>
<tr><td rowspan="5">System-defined variables</td><td colspan="2">Variable</td><td colspan="2">Data type</td><td colspan="2">Name</td></tr>
<tr><td colspan="2">_<Task_name>_Exceeded</td><td colspan="2">BOOL</td><td colspan="2">Task Period Exceeded Flag</td></tr>
<tr><td colspan="2">_<Task_name>_ExceedCount</td><td colspan="2">UDINT</td><td colspan="2">Task Period Exceeded Count</td></tr>
<tr><td colspan="2">_<Task_name>_LastExecTime</td><td colspan="2">TIME</td><td colspan="2">Last Task Execution Time</td></tr>
<tr><td colspan="2">_<Task_name>_MaxExecTime</td><td colspan="2">TIME</td><td colspan="2">Maximum Task Execution Time</td></tr>
<tr><td rowspan="5">Cause and correction</td><td colspan="2">Assumed cause</td><td colspan="2">Correction</td><td colspan="2">Prevention</td></tr>
<tr><td colspan="2">The task period setting is too short.</td><td colspan="2">Check the task execution time and change the task period to an appropriate value.</td><td colspan="2" rowspan="4">Design the tasks considering the corrections that are given on the left.</td></tr>
<tr><td colspan="2">A user program is too large.</td><td colspan="2">Separate the processes into different tasks, for example move processes that need a short execution period to a periodic task with a lower priority.</td></tr>
<tr><td colspan="2">The number of times that processing is repeated is larger than expected.</td><td colspan="2">If there is a program with an extremely high number of repetitions, correct the program to achieve the correct number of repetitions. Set a trap in the user program that monitors the number of times a process is executed to check the number of repetitions.</td></tr>
<tr><td colspan="2">The priority of the periodic task is incorrect.</td><td colspan="2">Increase the priority of the periodic task.</td></tr>
<tr><td>Attached information</td><td colspan="6">Attached Information 1: Name of task where error occurred</td></tr>
<tr><td>Precautions/ Remarks</td><td colspan="6">You can change the level of the error to an observation in the task settings.</td></tr>
</table>

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | Task Period Exceeded | | | Event code | 60050000 hex | |
| Meaning | Task execution was not completed during the set task period for the primary periodic task or fixed periodic task. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | Continuously |
| Error attributes | Level | Observation | Recovery | --- | Log category | System |
| Effects | User program | Continues. | Operation | If the task execution does not finish within the set task period, the I/O refresh operation will be as follows:<br>• CJ-series Units: No I/O refresh is executed.<br>When task execution is completed, I/O refreshing for the next period is executed.<br>• EtherCAT slaves: The same values are output as for the previous output refresh.<br>If the task execution does not finish within the set task period, overall control of the equipment may become impossible. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | _<*Task_name*>_Exceeded | | BOOL | | Task Period Exceeded Flag | |
| | _<*Task_name*>_ExceedCount | | UDINT | | Task Period Exceeded Count | |
| | _<*Task_name*>_LastExecTime | | TIME | | Last Task Execution Time | |
| | _<*Task_name*>_MaxExecTime | | TIME | | Maximum Task Execution Time | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | The task period setting is too short. | | Check the task execution time and change the task period to an appropriate value. | | Design the tasks considering the corrections that are given on the left. | |
| | A user program is too large. | | Separate the processes into different tasks, for example move processes that does not need a short execution period to a periodic task with a lower priority. | | | |
| | The number of times that processing is repeated is larger than expected. | | If there is a program with an extremely high number of repetitions, correct the program to achieve the correct number of repetitions. Set a trap in the user program that monitors the number of times a process is executed to check the number of repetitions. | | | |
| | The priority of the periodic task is incorrect. | | Increase the priority of the periodic task. | | | |
| Attached information | Attached Information 1: Name of task where error occurred | | | | | |
| Precautions/ Remarks | This error can occur if you change the level of the error to an observation in the task settings. | | | | | |

## Errors Related to Controller Operation

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | User Program/Controller Configurations and Setup Transfer Error | | | Event code | 10200000 hex | |
| Meaning | The user program or Controller Configurations and Setup were not transferred correctly. | | | | | |
| Source | PLC Function Module<br>Motion Control Function Module<br>EtherCAT Master Function Module<br>EtherNet/IP Function Module | | Source details | None | Detection timing | At power ON or Controller reset |
| Error attributes | Level | Major fault | Recovery | Cycle the power supply or reset the Controller. | Log category | System |
| Effects | User program | Stops. | Operation | All outputs are stopped. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | The user program or Controller Configurations and Setup are not correct because the power supply to the Controller was interrupted or communications with the Sysmac Studio were disconnected during a download of the user program or the Controller Configurations and Setup. | | Clear all of memory and then download the project from the Sysmac Studio. If attached information is registered, cycle the power supply to the Controller and then implement the above correction. | | Do not turn OFF the power supply to the Controller or disconnect communications with the Sysmac Studio during a download of the user program or the Controller Configurations and Setup. | |
| | The user program or Controller Configurations and Setup are not correct because the power supply to the Controller was interrupted during online editing. | | | | Do not interrupt the power supply to the Controller during online editing. | |
| | The user program or Controller Configurations and Setup are not correct because the power supply to the Controller was interrupted during a Clear All Memory operation. | | | | Do not interrupt the power supply to the Controller during a Clear All Memory operation. | |
| | Non-volatile memory failed. | | If the error persists even after you make the above correction, replace the CPU Unit. | | None | |
| Attached information | Attached Information 1: Cause Details<br>None: Power was interrupted or communications were disconnected during a download or power was interrupted during online editing.<br>Downloading/Predownloading: For other causes, the timing of error occurrence (during download or during download preparations) is given. | | | | | |
| Precautions/ Remarks | None | | | | | |

| Event name | Illegal User Program Execution ID | | | Event code | 10210000 hex |
|---|---|---|---|---|---|
| Meaning | The user program execution IDs set in the user program and in the CPU Unit do not match. | | | | |
| Source | PLC Function Module | Source details | None | Detection timing | At user program download, power ON, or Controller reset |
| Error attributes | Level | Major fault | Recovery | Cycle the power supply or reset the Controller. | Log category | System |
| Effects | User program | Stops. | Operation | All outputs are stopped. | |
| System-defined variables | Variable | Data type | Name | | |
| | None | --- | --- | | |
| Cause and correction | Assumed cause | Correction | Prevention | | |
| | The user program execution IDs set in the user program and in the CPU Unit do not match. | Set the same user program execution ID in the user program and CPU Unit. | Set the same user program execution ID in the user program and CPU Unit. Keep a record of the user program execution IDs set in the user program and in the CPU Unit. They are not displayed. | | |
| | A user program execution ID is set in the CPU Unit but not in the user program. | If user program execution ID is not set in the user program, clear the user program execution ID set in the CPU Unit by clearing all memory in the CPU Unit. | | | |
| Attached information | None | | | | |
| Precautions/ Remarks | None | | | | |

| Event name | Illegal User Program | | | Event code | 10240000 hex |
|---|---|---|---|---|---|
| Meaning | The user program is not correct. | | | | |
| Source | PLC Function Module | Source details | None | Detection timing | At download, power ON, or Controller reset |
| Error attributes | Level | Major fault | Recovery | Cycle the power supply or reset the Controller. | Log category | System |
| Effects | User program | Stops. | Operation | All outputs are stopped. | |
| System-defined variables | Variable | Data type | Name | | |
| | None | --- | --- | | |
| Cause and correction | Assumed cause | Correction | Prevention | | |
| | There are more than 8 nesting levels for functions or function blocks. | Find the location in the user program with more than 8 nesting levels for functions or function blocks and reduce the number of nesting levels to 8 or fewer. Then, download the user program again. | Write the user program so that there is never more than 8 nesting levels for functions or function blocks. Use the program check on the Sysmac Studio to confirm that there are not more than 8 nesting levels. | | |
| Attached information | None | | | | |
| Precautions/ Remarks | None | | | | |

| Event name | Illegal User Program/Controller Configurations and Setup | | | Event code | 10250000 hex | |
|---|---|---|---|---|---|---|
| Meaning | The user program or Controller Configurations and Setup is corrupted. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | At download, power ON, or Controller reset |
| Error attributes | Level | Major fault | Recovery | Cycle the power supply or reset the Controller. | Log category | System |
| Effects | User program | Stops. | Operation | All outputs are stopped. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | Illegal data was transferred for the user program or Controller Configurations and Setup. | | Download the user program or Controller Configurations and Setup again. Or clear all of memory. If this error persists, replace the CPU Unit. | | None | |
| | Non-volatile memory is deteriorating or has failed. | | | | | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| Event name | Safe Mode | | | Event code | 40160000 hex | |
|---|---|---|---|---|---|---|
| Meaning | The Controller started in Safe Mode. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | At power ON or Controller reset |
| Error attributes | Level | Major fault | Recovery | Cycle the power supply or reset the Controller. | Log category | System |
| Effects | User program | Stops. | Operation | All outputs are stopped. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | The power supply was turned ON to the Controller when Safe Mode was set on the DIP switch on the CPU Unit. | | --- | | --- | |
| Attached information | None | | | | | |
| Precautions/ Remarks | If the Controller starts in Safe Mode, the user program is not executed even if the startup mode is set to RUN mode. | | | | | |

<table>
<tr><td>Event name</td><td colspan="3">Event Log Restoration Error</td><td>Event code</td><td colspan="2">10230000 hex</td></tr>
<tr><td>Meaning</td><td colspan="6">Restoring the event log failed.</td></tr>
<tr><td>Source</td><td colspan="2">PLC Function Module</td><td>Source details</td><td>None</td><td>Detection timing</td><td>At power ON or Controller reset</td></tr>
<tr><td>Error attributes</td><td>Level</td><td>Observation</td><td>Recovery</td><td>---</td><td>Log category</td><td>System</td></tr>
<tr><td>Effects</td><td>User program</td><td>Starts.</td><td>Operation</td><td colspan="3">Not affected. However, the past event log cannot be checked.</td></tr>
<tr><td rowspan="2">System-defined variables</td><td colspan="2">Variable</td><td colspan="2">Data type</td><td colspan="2">Name</td></tr>
<tr><td colspan="2">None</td><td colspan="2">---</td><td colspan="2">---</td></tr>
<tr><td rowspan="2">Cause and correction</td><td colspan="2">Assumed cause</td><td colspan="2">Correction</td><td colspan="2">Prevention</td></tr>
<tr><td colspan="2">A low battery voltage prevented retention of memory during a power interruption.</td><td colspan="2">Replace the Battery.</td><td colspan="2">Replace the battery periodically.</td></tr>
<tr><td>Attached information</td><td colspan="6">Attached information 1: Error Details (0: Failure to restore all categories of logs, 1: Failure to restore system event log, 2: Failure to restore access event log, 100: Failure to restore user-defined event log)</td></tr>
<tr><td>Precautions/ Remarks</td><td colspan="6">None</td></tr>
</table>

<table>
<tr><td>Event name</td><td colspan="3">Trace Setting Transfer Failure</td><td>Event code</td><td colspan="2">10260000 hex</td></tr>
<tr><td>Meaning</td><td colspan="6">The power supply was interrupted while transferring the trace settings.</td></tr>
<tr><td>Source</td><td colspan="2">PLC Function Module</td><td>Source details</td><td>None</td><td>Detection timing</td><td>At power ON or Controller reset</td></tr>
<tr><td>Error attributes</td><td>Level</td><td>Observation</td><td>Recovery</td><td>Cycle the power supply or reset the Controller.</td><td>Log category</td><td>System</td></tr>
<tr><td>Effects</td><td>User program</td><td>Continues.</td><td>Operation</td><td colspan="3">Not affected.</td></tr>
<tr><td rowspan="2">System-defined variables</td><td colspan="2">Variable</td><td colspan="2">Data type</td><td colspan="2">Name</td></tr>
<tr><td colspan="2">None</td><td colspan="2">---</td><td colspan="2">---</td></tr>
<tr><td rowspan="2">Cause and correction</td><td colspan="2">Assumed cause</td><td colspan="2">Correction</td><td colspan="2">Prevention</td></tr>
<tr><td colspan="2">The power supply was interrupted while transferring the trace settings.</td><td colspan="2">Transfer the trace settings again.</td><td colspan="2">Do not interrupt the power supply while transferring the trace settings.</td></tr>
<tr><td>Attached information</td><td colspan="6">None</td></tr>
<tr><td>Precautions/ Remarks</td><td colspan="6">All trace settings are initialized when this error occurs.</td></tr>
</table>

<table>
<tr><td>Event name</td><td colspan="3">Clock Changed</td><td>Event code</td><td colspan="2">90010000 hex</td></tr>
<tr><td>Meaning</td><td colspan="6">The clock time was changed.</td></tr>
<tr><td>Source</td><td colspan="2">PLC Function Module</td><td>Source details</td><td>None</td><td>Detection timing</td><td>Commands from user</td></tr>
<tr><td>Error attributes</td><td>Level</td><td>Information</td><td>Recovery</td><td>---</td><td>Log category</td><td>Access</td></tr>
<tr><td>Effects</td><td>User program</td><td>Continues.</td><td>Operation</td><td colspan="3">Not affected.</td></tr>
<tr><td rowspan="2">System-defined variables</td><td colspan="2">Variable</td><td colspan="2">Data type</td><td colspan="2">Name</td></tr>
<tr><td colspan="2">_CurrentTime</td><td colspan="2">DATE_AND_TIME</td><td colspan="2">System Time</td></tr>
<tr><td rowspan="2">Cause and correction</td><td colspan="2">Assumed cause</td><td colspan="2">Correction</td><td colspan="2">Prevention</td></tr>
<tr><td colspan="2">The clock time was changed.</td><td colspan="2">---</td><td colspan="2">---</td></tr>
<tr><td>Attached information</td><td colspan="6">Attached information 1: Time before change</td></tr>
<tr><td>Precautions/ Remarks</td><td colspan="6">Clock changes by the Set Time instruction (SetTime) are not recorded in the event log.<br>The time stamp for this event will be for the time after the change.</td></tr>
</table>

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | Time Zone Changed | | | Event code | 90020000 hex | |
| Meaning | The time zone was changed. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | When downloading |
| Error attributes | Level | Information | Recovery | --- | Log category | Access |
| Effects | User program | Continues. | Operation | Not affected. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | _CurrentTime | | DATE_AND_TIME | | System Time | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | The time zone was changed. | | --- | | --- | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | Variable Changed to TRUE with Forced Refreshing | | | Event code | 90080000 hex | |
| Meaning | Changing a variable to TRUE with forced refreshing was specified. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | Commands from user |
| Error attributes | Level | Information | Recovery | --- | Log category | Access |
| Effects | User program | Continues. | Operation | Operation is performed according to the forced refreshing values. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | Changing a variable to TRUE with forced refreshing was specified by the user. | | --- | | --- | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | Variable Changed to FALSE with Forced Refreshing | | | Event code | 90090000 hex | |
| Meaning | Changing a variable to FALSE with forced refreshing was specified. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | Commands from user |
| Error attributes | Level | Information | Recovery | --- | Log category | Access |
| Effects | User program | Continues. | Operation | Operation is performed according to the forced refreshing values. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | Changing a variable to FALSE with forced refreshing was specified by the user. | | --- | | --- | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | All Forced Refreshing Cleared | | | Event code | 900A0000 hex | |
| Meaning | Clearing all forced refreshing values was specified. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | Commands from user |
| Error attributes | Level | Information | Recovery | --- | Log category | Access |
| Effects | User program | Continues. | Operation | Forced refreshing values are all cleared and operation is performed according to the user program. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | Clearing all forced refreshing values was specified by the user. | | --- | | --- | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | Memory All Cleared | | | Event code | 900B0000 hex | |
| Meaning | All of memory was cleared. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | Commands from user |
| Error attributes | Level | Information | Recovery | --- | Log category | Access |
| Effects | User program | --- | Operation | Operation returns to the factory state. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | A user with Administrator rights cleared all of the memory. | | --- | | --- | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | Event Log Cleared | | | Event code | 900C0000 hex | |
| Meaning | The event log was cleared. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | Commands from user |
| Error attributes | Level | Information | Recovery | --- | Log category | Access |
| Effects | User program | Continues. | Operation | Not affected. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | The event log was cleared by the user. | | --- | | --- | |
| Attached information | Attached information 1: Cleared events | | 0: All log categories were cleared<br>1: The system event log was cleared.<br>2: The access event log was cleared.<br>100: The user-defined event log was cleared. | | | |
| Precautions/ Remarks | None | | | | | |

| Event name | Power Turned ON | | | Event code | 90110000 hex | |
|---|---|---|---|---|---|---|
| Meaning | The power supply was turned ON. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | At power ON |
| Error attributes | Level | Information | Recovery | --- | Log category | System |
| Effects | User program | ---- | Operation | Operation starts. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | The power supply was turned ON. | | --- | | --- | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| Event name | Power Interrupted | | | Event code | 90120000 hex | |
|---|---|---|---|---|---|---|
| Meaning | The power supply was interrupted. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | At power interruption |
| Error attributes | Level | Information | Recovery | --- | Log category | System |
| Effects | User program | Stops. | Operation | All operations stops. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | The power supply was interrupted. | | --- | | --- | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| Event name | Operation Started | | | Event code | 90130000 hex | |
|---|---|---|---|---|---|---|
| Meaning | Operation was started. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | When changing to RUN mode |
| Error attributes | Level | Information | Recovery | --- | Log category | System |
| Effects | User program | Starts. | Operation | User program execution starts. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | A command to start operation was received. | | --- | | --- | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | Operation Stopped | | | Event code | 90140000 hex | |
| Meaning | Operation was stopped. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | When changing to PROGRAM mode |
| Error attributes | Level | Information | Recovery | --- | Log category | System |
| Effects | User program | Stops. | Operation | User program execution stops. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | A command to stop operation was received. | | --- | | --- | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | Reset Executed | | | Event code | 90150000 hex | |
| Meaning | A reset was executed. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | Commands from user |
| Error attributes | Level | Information | Recovery | --- | Log category | Access |
| Effects | User program | --- | Operation | Operation is started after a reset is executed. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | A reset command was received. | | --- | | --- | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | User Program Execution ID Write | | | Event code | 90160000 hex | |
| Meaning | The user program execution ID was set or changed in the CPU Unit. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | When download-ing |
| Error attributes | Level | Information | Recovery | --- | Log category | Access |
| Effects | User program | Continues. | Operation | Not affected. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | A user with Administrator rights changed the user program execution ID that is set in the CPU Unit. | | --- | | --- | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Event name | All Controller Errors Cleared | | | Event code | 90180000 hex |
| Meaning | All current errors were cleared. | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | Commands from user |
| Error attributes | Level | Information | Recovery | --- | Log category | Access |
| Effects | User program | Continues. | Operation | Clearing all errors for which the causes have been removed. | |
| System-defined variables | Variable | | Data type | | Name |
| | None | | --- | | --- |
| Cause and correction | Assumed cause | | Correction | | Prevention |
| | The user cleared all current errors. | | --- | | --- |
| Attached information | None | | | | |
| Precautions/ Remarks | None | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Event name | Forced Refreshing Cleared | | | Event code | 90190000 hex |
| Meaning | Clearing a forced refreshing value was specified. | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | Commands from user |
| Error attributes | Level | Information | Recovery | --- | Log category | Access |
| Effects | User program | Continues. | Operation | Forced refreshing values are cleared and operation is performed according to the user program. | |
| System-defined variables | Variable | | Data type | | Name |
| | None | | --- | | --- |
| Cause and correction | Assumed cause | | Correction | | Prevention |
| | Clearing a forced refreshing value was specified by the user. | | --- | | --- |
| Attached information | None | | | | |
| Precautions/ Remarks | None | | | | |

## Errors Related to FINS Communications

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | CPU Bus Unit Setup Area Error | | | Event code | 14010000 hex | |
| Meaning | An error was detected in the memory check of the Setup Area for CPU Bus Units. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | At power ON, at Controller reset, or when writing CPU Bus Unit Setup Area |
| Error attributes | Level | Minor fault | Recovery | Error reset or cycling power supply | Log category | System |
| Effects | User program | Continues. | Operation | The CPU Bus Unit may stop. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | The power supply to the Controller was interrupted or communications with the Sysmac Studio were discon-nected while downloading the CPU Bus Unit Settings. | | Clear all memory or download the CPU Bus Unit Settings. If this error persists, replace the CPU Unit. | | Do not interrupt the power supply to the Controller or disconnect commu-nications with the Sysmac Studio while downloading the CPU Bus Unit Settings. | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | IP Address Table Setting Error | | | Event code | 34100000 hex | |
| Meaning | The IP address table settings are incorrect. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | At power ON, Controller reset, or restart of built-in Ethernet port |
| Error attributes | Level | Minor fault | Recovery | Error reset | Log category | System |
| Effects | User program | Continues. | Operation | FINS/UDP communications will not operate. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | The IP address conversion method is set to the combined method or the IP address table method, but the IP address table settings are incorrect. | | Correct the IP address table settings. | | Set the IP address table correctly. | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| Event name | Unknown Destination Node | | | Event code | 34110000 hex | |
|---|---|---|---|---|---|---|
| Meaning | The send destination node is not known. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | At FINS message reception |
| Error attributes | Level | Minor fault | Recovery | Error reset | Log category | System |
| Effects | User program | Continues. | Operation | Not affected. Packets are discarded. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | The send destination node was not found when a FINS message was sent. | | Correct the setting of the send destination node for FINS/UDP communications. | | Set the send destination node for FINS/UDP communications correctly. | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| Event name | FINS/TCP Connection Table Setting Error | | | Event code | 34130000 hex | |
|---|---|---|---|---|---|---|
| Meaning | The FINS/TCP connection table is incorrect. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | At power ON, Controller reset, or restart of built-in Ethernet port |
| Error attributes | Level | Minor fault | Recovery | Error reset | Log category | System |
| Effects | User program | Continues. | Operation | FINS/UDP communications will not operate. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | The power supply to the Controller was interrupted or communications with the Sysmac Studio were disconnected while downloading the FINS/TCP connection table. | | Download the FINS/TCP connection table again. | | Do not interrupt the power supply to the Controller or disconnect communications with the Sysmac Studio while downloading the FINS/TCP connection table. | |
| Attached information | None | | | | | |
| Precautions/ Remarks | None | | | | | |

| Event name | Packet Discarded | | | Event code | 80100000 hex | |
|---|---|---|---|---|---|---|
| Meaning | One or more packets were discarded. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | At FINS message reception |
| Error attributes | Level | Observation | Recovery | --- | Log category | System |
| Effects | User program | Continues. | Operation | Not affected. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | A FINS response addressed to the CPU Unit was received. | | Correct the contents of the FINS message at the source. | | Set the FINS messages correctly. | |
| | The send designation Unit for the FINS response does not exist. | | | | | |
| Attached information | Attached information 1: Cause of packet discard (01 hex: FINS response addressed to CPU Unit received, 02 hex: Response send failed) | | | | | |
| Precautions/ Remarks | None | | | | | |

<table>
<tr><td>Event name</td><td colspan="3">Packet Discarded</td><td>Event code</td><td colspan="2">80110000 hex</td></tr>
<tr><td>Meaning</td><td colspan="6">One or more packets were discarded.</td></tr>
<tr><td>Source</td><td colspan="2">PLC Function Module</td><td>Source details</td><td>None</td><td>Detection timing</td><td>At FINS message reception</td></tr>
<tr><td>Error attributes</td><td>Level</td><td>Observation</td><td>Recovery</td><td>---</td><td>Log category</td><td>System</td></tr>
<tr><td>Effects</td><td>User program</td><td>Continues.</td><td>Operation</td><td colspan="3">Not affected.</td></tr>
<tr><td rowspan="2">System-defined variables</td><td colspan="2">Variable</td><td colspan="2">Data type</td><td colspan="2">Name</td></tr>
<tr><td colspan="2">None</td><td colspan="2">---</td><td colspan="2">---</td></tr>
<tr><td rowspan="9">Cause and correction</td><td colspan="2">Assumed cause</td><td colspan="2">Correction</td><td colspan="2">Prevention</td></tr>
<tr><td colspan="2">1. An attempt was made to send a FINS response with over 2002 bytes.</td><td colspan="2" rowspan="2">Do not send a FINS response with over 2002 bytes.</td><td colspan="2" rowspan="6">Set the FINS message at the source correctly.</td></tr>
<tr><td colspan="2">2. An attempt was made to route a FINS response with over 2002 bytes.</td></tr>
<tr><td colspan="2">3. Packet was received with a No Such Unit routing error.</td><td colspan="2">Check the FINS message at the source and correct the unit number in the response frame or a command frame that does not require a response.</td></tr>
<tr><td colspan="2">4. Packet was received with a Routing Error routing error.</td><td colspan="2">Check the FINS message at the source and correct the unit number in the response frame or a command frame that does not require a response to a unit number that is in the routing table.</td></tr>
<tr><td colspan="2">5. Packet was received with a No Routing Table routing error.</td><td colspan="2">Check the FINS message at the source, and correct the routing table to include the network address of the source network.</td></tr>
<tr><td colspan="2">6. Packet was received with an Event Area Size Over Limit routing error.</td><td colspan="2">Check the FINS message at the source and correct the event area size in the response frame or a command frame that does not require a response so that it does not exceed the limit.</td></tr>
<tr><td colspan="2">7. There is insufficient space in the internal buffer.</td><td colspan="2" rowspan="2">Reduce the frequency of sending FINS messages at the source.</td><td colspan="2" rowspan="2">Keep the frequency of sending FINS messages as low as possible.</td></tr>
<tr><td colspan="2">8. FINS message routing failed because the communications load is too high.</td></tr>
<tr><td>Attached information</td><td colspan="6">Attached information 1: Cause of discarding packets<br>1: 01 hex, 2: 02 hex, 3: 03 hex, 4: 04 hex, 5: 05 hex, 6: 06 hex, 7: 07 hex, 8: 08 hex<br>The numbers refer to the numbers of the above causes.</td></tr>
<tr><td>Precautions/ Remarks</td><td colspan="6">None</td></tr>
</table>

| | | | | | | |
|---|---|---|---|---|---|---|
| Event name | Packet Discarded | | | Event code | 80120000 hex | |
| Meaning | One or more packets were discarded. | | | | | |
| Source | PLC Function Module | | Source details | None | Detection timing | At FINS message reception |
| Error attributes | Level | Observation | Recovery | --- | Log category | System |
| Effects | User program | Continues. | Operation | Not affected. | | |
| System-defined variables | Variable | | Data type | | Name | |
| | None | | --- | | --- | |
| Cause and correction | Assumed cause | | Correction | | Prevention | |
| | 1. A FINS response was received in which DNA was the local network but DA1 was not the local node. | | Correct the IP address table settings. | | Make sure that the IP address table settings are correct. | |
| | 2. A FINS command or response was received in which the hub network address specification DNA was greater than or equal to 80 hex. | | Correct the FINS message at the source so that the hub network address specification DNA is not greater than or equal to 80 hex. | | Check the FINS message at the source to be sure that the hub network address specification DNA is not greater than or equal to 80 hex. | |
| | 3. There is insufficient space in the internal buffer. | | Reduce the frequency of sending FINS messages at the source. | | Keep the frequency of sending FINS messages as low as possible. | |
| | 4. A FINS command that does not have the minimum command length was received. | | Correct the FINS command at the source so that it has at least the minimum command length. | | Set the FINS commands at the sources so that they have at least the minimum command length. | |
| | 5. A FINS command that exceeded the maximum command length was received. | | Correct the FINS command at the source so that it does not exceed the maximum command length. | | Set the FINS commands at the sources so that they do not exceed the maximum command length. | |
| | 6. Sending packets failed. | | If the destination node is not in the network, add it to the network. | | Confirm that the destination node is in the network. | |
| | 7. FINS message routing failed because the communications load was too high. | | Reduce the frequency of sending FINS messages at the sources. | | Keep the frequency of sending FINS messages as low as possible. | |
| Attached information | Attached information 1: Cause of discarding packets<br>1: 01 hex, 2: 02 hex, 3: 03 hex, 4: 04 hex, 5: 05 hex, 6: 06 hex, 7: 07 hex<br>The numbers refer to the numbers of the above causes. | | | | | |
| Precautions/ Remarks | None | | | | | |

## 12-2-5 Troubleshooting Errors That Are Not in the CPU Unit

### Security Errors

| No. | Problem | Correction |
|---|---|---|
| 1 | Forgot the Administrator password. | You cannot access the Administrator's password. Always record the Administrator password so that you do not forget it. |
| 2 | Cannot release the operation lock with the Sysmac Studio. | Log in with verification authority that is equal to or higher than the verification rights when you connected online. |
| 3 | Operation was locked when verifying operation authority on the Sysmac Studio. | If the password for verification of operation authority is entered incorrectly five time in row, operation is locked for 10 minutes. Wait until the operation lock is released. |
| 4 | An online connection was made with the operation authority that is required for operation, but operation authority verification was requested for a specific operation. | Verification of operation authority is required every time for the following functions to prevent hazards to equipment and people.<br>• Operating mode change by a Maintainer<br>• Online editing by a Maintainer |
| 5 | Cannot release the operation lock with the Sysmac Studio after the operator left the Sysmac Studio unattended. | You can release the operation lock with an operation authority that is equal to or higher than the operator. The required operation authority will be that of an operator (the operation authority that was verified when going online with the Sysmac Studio). |
| 6 | Some of the user program data cannot be read for certain operations.<br>• Monitoring<br>Variables<br>• Operation Commands<br>SET/RESET, forced refreshing, online editing, data tracing, MC Trial Run, and setting the user program execution ID in the CPU Unit<br>• Synchronizing, Uploading, Verification, and Backup<br>POU algorithms | The source data was not downloaded along with the user program. You will be able to read the data if you download the user program normally. |
| 7 | Writing to the CPU Unit is not possible for some operations.<br>• Names<br>CPU Unit name<br>• Operation Commands<br>Online editing, Memory All Clear, event log clearing, and setting the user program execution ID in the CPU Unit<br>• Synchronizing and Downloading<br>User program, CPU/Expansion Rack Configuration and Setup, EtherCAT Settings, Controller Setup, Axis Settings, Cam Table Settings, Data Trace Settings, User-defined Event Setup, restoring | The CPU Unit is write protected. Release the write protection. |

| No. | Problem | Correction |
|---|---|---|
| 8 | I do not know how to change the user program execution ID. | The user program execution ID cannot be changed or deleted after it is set. |
| 9 | I forgot the user program execution ID assigned to user program. | There is no way to access the user program execution ID that is set. Always record the user program execution ID so that you do not forget it. |
| 10 | I forgot the user program execution ID that is registered in the CPU Unit. | This is no way to access the user program execution ID that is set. Set the user program execution ID again. You can also clear the user program execution ID if you execute the Memory All Clear operation. |

# App

# Appendices

The appendices provide the CPU Unit specifications, task execution times, system-defined variable lists, data attribute lists, CJ-series Unit memory information, CJ-series Unit memory allocation methods, and data type conversion information.

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# A-1 Specifications

This section gives the specifications of the NJ-series Controllers.

## A-1-1 General Specifications

| Item | | NJ501-1300 | NJ501-1400 | NJ501-1500 |
|---|---|---|---|---|
| Enclosure | | Mounted in a panel | | |
| Grounding method | | Ground to less than 100 Ω. | | |
| Dimensions | | 90 mm × 90 mm × 90 mm | | |
| Weight | | 550 g (including the End Cover) | | |
| Current consumption | | 5 VDC 1.90 A (including SD Memory Card and End Cover) | | |
| Operating environment | Ambient operating temperature | 0 to 55°C | | |
| | Ambient operating humidity | 10% to 90% (with no condensation) | | |
| | Atmosphere | Must be free from corrosive gases. | | |
| | Ambient storage temperature | –20 to 75°C (excluding battery) | | |
| | Altitude | 2,000 m max. | | |
| | Pollution degree | 2 or less: Conforms to JIS B3502 and IEC 61131-2. | | |
| | Noise immunity | 2 kV on power supply line (Conforms to IEC 61000-4-4.) | | |
| | Overvoltage category | Category II: Conforms to JIS B3502 and IEC 61131-2. | | |
| | EMC immunity level | Zone B | | |
| | Vibration resistance | Conforms to JIS C60068-2-6.<br>5 to 8.4 Hz with 3.5-mm amplitude, 8.4 to 150 Hz, Acceleration of 9.8 $m/s^2$, 100 min in X, Y, and Z directions (10 sweeps of 10 min each = 100 min total) | | |
| | Shock resistance | Conforms to JIS C60068-2-27.<br>147 $m/s^2$, 3 times in X, Y, and Z directions (100 $m/s^2$ for Relay Output Units) | | |
| Battery | Life | 5 years at 25°C | | |
| | Model | CJ1W-BAT01 | | |
| Applicable standards | | Conforms to cULus, EC Directives, NK, and LR. | | |

## A-1-2 Performance Specifications

| Item | | | NJ501-1300 | NJ501-1400 | NJ501-1500 |
|---|---|---|---|---|---|
| Program-ming | Program capacity | | 20 MB (execution objects and variable tables (including variable names)) | | |
| | Memory capacity for variables | Variables with Retain attribute (Does not include Holding, DM, and EM Area memory for CJ-series Units.) | 2 MB | | |
| | | Variables without Retain attribute (Does not include CIO and Work Area memory for CJ-series Units.) | 4 MB | | |
| | Memory for CJ-series Units (Can be specified with AT specifica-tions for vari-ables.)*1 | CIO Area | 6,144 words (CIO 0 to CIO 6143) | | |
| | | Work Area | 512 words (W0 to W511) | | |
| | | Holding Area | 1,536 words (H0 to H1535) | | |
| | | DM Area | 32,768 words (D0 to D32767) | | |
| | | EM Area | 32,768 words × 25 banks (E0_00000 to E18_32767) | | |
| Unit con-figuration | Maximum number of connectable Units | | Maximum per CPU Rack or Expansion Rack: 10 Units<br>Entire Controller: 40 Units | | |
| | Number of Expansion Racks | | 3 max. | | |
| | I/O capacity | | 2,560 points max. plus EtherCAT slave I/O capacity | | |
| | Power Supply to CPU Rack and Expansion Racks | | NJ-P□3001 Power Supply Unit | | |
| Motion control | Recommended Servo Drives | | OMRON G5-series Servo Drives with Built-in EtherCAT Communica-tions<br>Recommended unit version: Version 2.1 or later | | |
| | Recommended encoder input terminals | | OMRON GX-series GX-EC0211/EC0241 EtherCAT Remote I/O Termi-nals<br>Recommended unit version: Version 1.1 or later | | |
| | Control method | | Control commands using EtherCAT communications | | |
| | Control modes | | Position control (Cyclic Synchronous Position Control Mode)<br>Velocity control (Cyclic Synchronous Velocity Control Mode)<br>Torque control (Cyclic Synchronous Torque Control Mode) | | |
| | Number of controlled axes | Maximum number of controlled axes | 16 axes | 32 axes | 64 axes |
| | | Single-axis control | 16 axes max. | 32 axes max. | 64 axes max. |
| | | Linear interpolation control | 4 axes max. per axes group | | |
| | | Circular interpolation control | 2 axes per axes group | | |
| | Number of axes groups | | 32 axes groups max. | | |
| | Unit of Display | | Pulses, millimeters, micrometers, nanometers, inches, or degrees | | |
| | Electronic gear ratio | | Command pulses per motor rotation/Work travel distance per motor rotation | | |
| | Positions that can be managed | | Command positions and actual positions | | |
| | Position command values | | Negative, positive, or 0 long real data (LREAL) (command units*)<br>* Positions can be set within a 40-bit signed integer range when con-verted to pulses. | | |
| | Velocity command values | | Negative, positive, or 0 long real data (LREAL) (command units/s) | | |

| Item | | | NJ501-1300 | NJ501-1400 | NJ501-1500 |
|---|---|---|---|---|---|
| Motion control | Acceleration command values and deceleration command values | | Positive or 0 long real data (LREAL) (command units/$s^2$) | | |
| | Jerk command values | | Positive or 0 long real data (LREAL) (command units/$s^3$) | | |
| | Override factors | | 0.00% or 0.01% to 500.00% | | |
| | Axis types | | Servo axes, virtual servo axes, encoder axes, and virtual encoder axes | | |
| | Motion control period | | Same as process data communications cycle of EtherCAT communications | | |
| | Cams | Number of cam data points | 65,535 points max. per cam table<br>1,048,560 points max. for all cam tables | | |
| | | Number of cam tables | 640 tables max. | | |
| Communications | Peripheral USB port | Supported services | Sysmac Studio connection | | |
| | | Physical layer | USB 2.0-compliant B-type connector | | |
| | | Transmission distance | 5 m max. | | |
| | Built-in EtherNet/IP port | Communications protocol | TCP/IP, UDP/IP, and BOOTP client | | |
| | | Supported services | Sysmac Studio connection, tag data link, CIP message communications, socket service, FTP server, automatic clock adjustment (NTP client), SNMP agent, and DNS client | | |
| | | Physical layer | 10Base-T or 100Base-TX | | |
| | | Media access method | CSMA/CD | | |
| | | Modulation | Baseband | | |
| | | Topology | Star | | |
| | | Baud rate | 100 Mbps (100Base-TX) | | |
| | | Transmission media | Shielded, twisted-pair cable (STP): Category 5, 5e or higher | | |
| | | Transmission distance | 100 m max. (distance between hub and node) | | |
| | | Number of cascade connections | There are no restrictions if a switching hub is used. | | |

| Item | | | | NJ501-1300 | NJ501-1400 | NJ501-1500 |
|---|---|---|---|---|---|---|
| Communi-cations | Built-in Ether-Net/IP port | CIP service: Tag data links (cyclic communications) | | --- | | |
| | | | Number of connections | 32 | | |
| | | | Packet interval | 10 to 10,000 ms in 1.0-ms increments<br>Can be set for each connection. (Data will be refreshed at the set interval, regardless of the number of nodes.) | | |
| | | | Permissible communications band | 1,000 pps*2 including heartbeat | | |
| | | | Number of tag sets | 32 | | |
| | | | Tag types | Network variables (CIO, Work, Holding, DM, and EM Areas) | | |
| | | | Number of tags per connection (i.e., per tag set) | 8 (Seven tags if Controller status is included in the tag set.) | | |
| | | | Maximum link data size per node (total size for all tags) | 19,200 bytes | | |
| | | | Maximum data size per connection | 600 bytes (Note: Data concurrency is maintained within each connection.) | | |
| | | | Number of registrable tag sets | 32 (1 connection = 1 tag set) | | |
| | | | Maximum tag set size | 600 bytes (Two bytes are used if Controller status is included in the tag set.) | | |
| | | | Changing tag data link parameters when Controller is in RUN mode | Supported.*3 | | |
| | | | Multi-cast packet filter*4 | Supported. | | |
| | | CIP message service: Explicit messages | | --- | | |
| | | | Class 3 (number of connections) | 32 (clients plus server) | | |
| | | | UCMM (non-connection type) | Number of clients that can communicate at one time: 32 max.<br>Number of servers that can communicate at one time: 32 max. | | |
| | | | CIP routing | Supported.<br>Units through which CIP routing is supported: CS1W-EIP21, CJ1W-EIP21, CJ2H-CPU□□-EIP, and CJ2M-CPU3□ | | |
| | Built-in EtherCAT port | Communications standard | | IEC 61158, Type 12 | | |
| | | EtherCAT master specifications | | Class B (Feature Pack Motion Control compliant) | | |
| | | Communications protocol | | Special protocol for EtherCAT | | |
| | | Supported services | | CoE (PDO communications and SDO communications) | | |
| | | Synchronized communications | | DC (distributed clock) | | |
| | | Physical layer | | 100Base-TX | | |
| | | Modulation | | Baseband | | |
| | | Baud rate | | 100 Mbps (100Base-TX) | | |
| | | Duplex mode | | Automatic | | |
| | | Topology | | Line, daisy chain, and branching | | |
| | | Transmission media | | Twisted-pair cable of category 5 or higher (double-shielded straight cable with aluminum tape and braiding) | | |

| Item | | | NJ501-1300 | NJ501-1400 | NJ501-1500 |
|---|---|---|---|---|---|
| Communi-cations | Built-in EtherCAT port | Transmission distance | Distance between nodes: 100 m max. | | |
| | | Maximum number of slaves | 192 | | |
| | | Maximum process data size | Inputs: 5,736 bytes<br>Outputs: 5,736 bytes<br>However, the maximum number of process data frames is 4. | | |
| | | Maximum process data size per slave | Inputs: 1,434 bytes<br>Outputs: 1,434 bytes | | |
| | | Communications cycle | 500, 1,000, 2,000, or 4,000 µs | | |
| | | Minimum communications cycle | 500 µs | | |
| | | Maximum communications cycle | 4,000 µs | | |
| | | Sync jitter | 1 µs max. | | |
| Internal clock | | | At ambient temperature of 55°C: –3.5 to +0.5 min error per month<br>At ambient temperature of 25°C: –1.5 to +1.5 min error per month<br>At ambient temperature of 0°C: –3 to +1 min error per month | | |

*1 Timers, counters, index registers, data registers, and Task Flags cannot be specified.

*2 Means packets per second, i.e., the number of communications packets that can be sent or received in one second.

*3 However, if port parameters are changed, the relevant EtherNet/IP port is restarted.
Communications for the nodes that were communicating with that port will time out, and then they will be automatically restored.

*4 An IGMP client is mounted for the EtherNet/IP port. If a switching hub that supports IGMP snooping is used, filtering of unnecessary multicast packets is performed.

## A-1-3 Function Specifications

| Item | | | | NJ501 |
|---|---|---|---|---|
| **Tasks** | **Function** | | | I/O refresh and the user program are executed in units that are called tasks. Tasks are used to specify execution conditions and execution priority. Tasks are executed periodically as described below.<br>• Primary periodic task: This task has the highest priority. It is always executed in the specified period. There is only one primary periodic task.<br>• Periodic tasks: Periodic tasks are executed during the unused time between executions of the primary periodic task. There can be three periodic tasks. |
| | **Setup** | **System Service Monitoring Settings** | | The execution interval and the percentage of the total user program execution time are monitored for the system services (processes that are executed by the CPU Unit separate from task execution). |
| | | **I/O refresh settings** | | EtherCAT Slaves:<br>Axes assigned to Servo Drives and encoder input slaves: Assigned to the primary periodic task.<br>Other Slaves: Assigned as required to the primary periodic task or a periodic task.<br>CJ-series Units:<br>I/O refreshing is set as required for each Unit in the primary periodic task or a periodic task. |
| **Programming** | **POUs (program organization units)** | **Programs** | | POUs that are assigned to tasks.<br>There are no restrictions to the number of definitions. (There are capacity restrictions.) |
| | | **Function blocks** | | POUs that are used to create objects with specific conditions. |
| | | **Functions** | | POUs that are used to create an object that determine unique outputs for the inputs, such as for data processing. |
| | **Programming languages** | **Types** | | Ladder diagrams (see note) and structured text (ST)<br>**Note** Inline ST is supported. (Inline ST is ST that is written as an element in a ladder diagram.) |
| | **Variables** | **External access of variables** | | Network variables (This is set as an attribute of the variable.) |
| | | **Initial values** | **Variables without Retain attribute** | Initial values are set when the user program is transferred. |
| | | | **Variables with Retain attribute** | Whether to set initial values can be selected when the user program is transferred. |
| | **Array attribute** | **Array variables** | **Function** | An array groups data with the same attributes so that it can be handled as a single unit of data.<br>Number of dimensions: 3 max.<br>Maximum number of elements: 65,535 |
| | | | **Array specifications for FB instances** | Supported. (Execution of multiple instances is possible with one instance by using a variable to indirectly specify an array element number.) |

| Item | | | | NJ501 |
|---|---|---|---|---|
| Program-ming | Data types | Basic data types | | BOOL,<br>BYTE, WORD, DWORD, LWORD,<br>INT, SINT, DINT, LINT<br>UINT, USINT, UDINT, ULINT,<br>REAL, LREAL,<br>TIME (durations), DATE, TIME_OF_DAY, DATE_AND_TIME, and STRING (text strings) |
| | | Derivative data types | | Structures, unions, and enumerations |
| | | Structures | Function | A derivative data type that groups together data with different data types.<br>Number of members: 2,048 max.<br>Nesting levels: 8 max. |
| | | | Member data types | Basic data types, structures, enumerations, unions, or array variables |
| | | Unions | Function | A derivative data type that enables access to the same data with different data types.<br>Number of members: 4 max. |
| | | | Member data types | BOOL, BYTE, WORD, DWORD, or LWORD |
| | | Enumerations | Function | A derivative data type that uses text strings called enumerators to express variable values. |
| | | Data type attributes | Array specifications | An array is a group of elements with the same data type. You specify the number (subscript) of the element from the first element to specify the element. You can specify arrays for both basic data types and derivative data types. |
| | | | Range specifications | You can specify a range for a data type in advance. The data type can take only values that are in the specified range. You can specify a range for any integer basic data type. |
| | Program checks | | | Programming is checked offline with the Sysmac Studio and when instructions are executed. |

| Item | | | | NJ501 |
|---|---|---|---|---|
| Motion control functions* | Single axes | Single-axis position control | Absolute positioning | Positioning is performed for a target position that is specified with an absolute value. |
| | | | Relative positioning | Positioning is performed for a specified travel distance from the command current position. |
| | | | Interrupt feeding | Positioning is performed for a specified travel distance from the position where an interrupt input was received from an external input. |
| | | Single-axis velocity control | Velocity control | Velocity control is performed in Position Control Mode. |
| | | | Cyclic synchronous velocity control | A velocity command is output each control period in Velocity Control Mode. |
| | | Single-axis torque control | Torque control | The torque of the motor is controlled. |
| | | Single-axis synchronized control | Starting cam operation | A cam motion is performed using the specified cam table. |
| | | | Ending cam operation | The cam motion for the axis that is specified with the input parameter is ended. |
| | | | Starting gear operation | A gear motion with the specified gear ratio is performed between a master axis and slave axis. |
| | | | Positioning gear operation | A gear motion with the specified gear ratio and sync position is performed between a master axis and slave axis. |
| | | | Ending gear operation | The specified gear motion or positioning gear motion is ended. |
| | | | Synchronous positioning | Positioning is performed in sync with a specified master axis. |
| | | | Master axis phase shift | The phase of a master axis in synchronized control is shifted. |
| | | | Combining axes | The command positions of two axes are added or subtracted and the result is output as the command position. |
| | | Single-axis manual operation | Powering the Servo | The Servo in the Servo Drive is turned ON to enable axis motion. |
| | | | Jogging | An axis is jogged at a specified target velocity. |

| Item | | | | NJ501 |
|---|---|---|---|---|
| Motion control functions* | Single axes | Auxiliary functions for single-axis control | Resetting axis errors | Axes errors are cleared. |
| | | | Homing | A motor is operated and the limit signals, home proximity signal, and home signal are used to define home. |
| | | | High-speed homing | Positioning is performed for an absolute target position of 0 to return to home. |
| | | | Stopping | An axis is decelerated to a stop at the specified rate. |
| | | | Immediately stopping | An axis is stopped immediately. |
| | | | Setting override factors | The target velocity of an axis can be changed. |
| | | | Changing the current position | The command current position or actual current position of an axis can be changed to any position. |
| | | | Enabling external latches | The position of an axis is recorded when a trigger occurs. |
| | | | Disabling external latches | The current latch is disabled. |
| | | | Zone monitoring | You can monitor the command position or actual position of an axis to see when it is within a specified range (zone). |
| | | | Monitoring axis following error | You can monitor whether the difference between the command positions or actual positions of two specified axes exceeds a threshold value. |
| | | | Resetting the following error | The error between the command current position and actual current position is set to 0. |
| | | | Torque limit | The torque control function of the Servo Drive can be enabled or disabled and the torque limits can be set to control the output torque. |
| | Axes groups | Multi-axes coordinated control | Absolute linear interpolation | Linear interpolation is performed to a specified absolute position. |
| | | | Relative linear interpolation | Linear interpolation is performed to a specified relative position. |
| | | | Circular 2D interpolation | Circular interpolation is performed for two axes. |
| | | Auxiliary functions for multi-axes coordinated control | Resetting axes group errors | Axes group errors and axis errors are cleared. |
| | | | Enabling axes groups | Motion of an axes group is enabled. |
| | | | Disabling axes groups | Motion of an axes group is disabled. |
| | | | Stopping axes groups | All axes in interpolated motion are decelerated to a stop. |
| | | | Immediately stopping axes groups | All axes in interpolated motion are stopped immediately. |
| | | | Setting axes group override factors | The blended target velocity is changed during interpolated motion. |
| | Common items | Cams | Setting cam table properties | The end point index of the cam table that is specified in the input parameter is changed. |
| | | | Saving cam tables | The cam table that is specified with the input parameter is saved in non-volatile memory in the CPU Unit. |
| | | Parameters | Writing MC settings | Some of the axis parameters or axes group parameters are overwritten temporarily. |

| Item | | | | NJ501 |
|---|---|---|---|---|
| **Motion control functions*** | **Auxiliary functions** | **Count modes** | | You can select either Linear Mode (finite length) or Rotary Mode (infinite length). |
| | | **Unit conversions** | | You can set the display unit for each axis according to the machine. |
| | | **Acceleration/ deceleration control** | **Automatic acceleration/ deceleration control** | Jerk is set for the acceleration/deceleration curve for an axis motion or axes group motion. |
| | | | **Changing the acceleration and deceleration rates** | You can change the acceleration or deceleration rate even during acceleration or deceleration. |
| | | **In-position check** | | You can set an in-position range and in-position check time to confirm when positioning is completed. |
| | | **Stop method** | | You can set the stop method to the immediate stop input signal or limit input signal. |
| | | **Re-execution of motion control instructions** | | You can change the input variables for a motion control instruction during execution and execute the instruction again to change the target values during operation. |
| | | **Multi-execution of motion control instructions (Buffer Mode)** | | You can specify when to start execution and how to connect the velocities between operations when another motion control instruction is executed during operation. |
| | | **Continuous axes group motions (Transition Mode)** | | You can specify the Transition Mode for multi-execution of instructions for axes group operation. |
| | | **Monitoring functions** | **Software limits** | Software limits are set for each axis. |
| | | | **Following error** | The error between the command current value and the actual current value is monitored for each axis. |
| | | | **Velocity, acceleration rate, deceleration rate, torque, interpolation velocity, interpolation acceleration rate, and interpolation deceleration rate** | You can set warning values for each axis and each axes group. |
| | | **Absolute encoder support** | | You can use an OMRON G5-series Servomotor with an Absolute Encoder to eliminate the need to perform homing at startup. |
| | **External interface signals** | | | The following Servo Drive input signals are used.<br>Home signal, home proximity signal, positive limit signal, negative limit signal, immediate stop signal, and interrupt input signal |

| Item | | | | NJ501 |
|---|---|---|---|---|
| **Unit (I/O) management** | **CJ-series Units** | **I/O allocations** | | Use one of the following procedures.<br>• Creating the Unit configuration offline with Sysmac Studio<br>• Creating the Unit configuration online by reading the actual Unit configuration with the Sysmac Studio |
| | | **Number of Units** | | 40 |
| | | **Basic I/O Units** | **Chattering and noise countermeasures** | Input response times are set. |
| | | | **Load short-circuit protection and I/O disconnection detection** | Alarm information for Basic I/O Units is read. |
| | | **Special Units** | **Special Unit Setup** | Special Units can be set up with Unit settings from the Sysmac Studio or by setting device variables. |
| | **EtherCAT slaves** | **Number of slaves** | | 192 |
| | | **Basic I/O** | **Chattering and noise countermeasures** | Input response times are set. |
| **Communications** | **Peripheral USB port** | | | A port for communications with various kinds of Support Software running on a personal computer. |
| | **EtherNet/IP port** | **CIP communications service** | **Tag data links** | Programless cyclic data exchange is performed with the devices on the EtherNet/IP network. |
| | | | **Message communications** | CIP commands are sent to or received from the devices on the EtherNet/IP network. |
| | | | **Socket services** | Data is sent to and received from any node on Ethernet using the UDP or TCP protocol. Socket communications instructions are used. |
| | | | **FTP server** | Files can be read from or written to the SD Memory Card in the CPU Unit from computers at other Ethernet nodes. |
| | | | **Automatic clock adjustment** | Clock information is read from the NTP server at the specified time or at a specified interval after the power supply to the CPU Unit is turned ON. The internal clock time in the CPU Unit is updated with the read time. |
| | | | **SNMP agent** | Built-in EtherNet/IP port internal status information is provided to network management software that uses an SNMP manager. |
| | **EtherCAT port** | **Process data communications** | | Control information is exchanged in cyclic communications between the EtherCAT master and slaves. |
| | | **SDO communications** | | Control information is exchanged in noncyclic event communications between the EtherCAT master and slaves.<br>The following application protocol is supported.<br>CoE (CANopen over EtherCAT) |
| | | **Network scanning** | | Information is read from connected slave devices and the slave configuration is automatically generated. |
| | | **DC (distributed clock)** | | Time is synchronized by sharing the EtherCAT system time among all EtherCAT devices (including the master). To implement the distributed clock, propagation delay compensation, drift compensation, and offset compensation are performed. |
| | **Communications instructions** | | | The following instructions are supported.<br>CIP communications instructions, SDO message instructions, no-protocol communications instructions, and protocol macro instructions |
| **Operation management** | **RUN output contacts** | | | The output on the NJ-P□3001 Power Supply Unit turns ON in RUN mode. |
| **System management functions** | **Log management** | **Event logs** | | The following events are recorded.<br>• Events for the operation of the NJ-series system itself<br>• Communications events<br>• Security events<br>• Events for the operation of user-designed device applications |

| Item | | | | NJ501 |
|---|---|---|---|---|
| Debugging | Online editing | | | Programs, function blocks, functions, and global variables can be changed online. |
| | Forced refreshing | | | The user can force specific variables to TRUE or FALSE.<br>Device variables for CJ-series Units and variables with AT specifications: 64 variables max.<br>Device variables for EtherCAT slaves: 64 variables max. |
| | MC Test Run | | | Motor operation and wiring can be checked from the Sysmac Studio. |
| | Synchronizing | | | The project file in the Sysmac Studio and the data in the CPU Unit can be made the same when online. |
| | Data tracing | | | The specified variables are sampled and stored in trace memory when the specified conditions are met. No programming is required.<br>Maximum number of records: 10,000 records<br>Maximum number of sampled variables 192 variables |
| | | Timing of sampling | | Sampling is performed for the specified task period, at the specified time, or when a sampling instruction is executed. |
| | | Starting tracing | | When specified from the Sysmac Studio or automatically at startup |
| | | Triggered traces | | Trigger conditions are set to record data before and after an event. |
| | | | Trigger conditions | When BOOL variable changes to TRUE or FALSE<br>Comparison of non-BOOL variable with a constant<br>Comparison Method: Equals (=), Greater than (>), Greater than or equals (≥), Less Than (<), Less than or equals (≤), Not equal (≠) |
| | | | Delay | Trigger position setting: A slider is used to set the percentage of sampling before and after the trigger condition is met. (Example: 20%/80%) |
| | | Continuous tracing | | Data tracing is executed continuously and the trace data is collected by the Sysmac Studio. |
| | Simulation | | | The operation of the CPU Unit is emulated in the Sysmac Studio.<br>The following can be emulated: user program execution (including partial emulation), debugging (including step execution and breakpoints), monitoring, tracing, estimating execution times, and Servo Drive signals.<br>(Emulation is possible on the Simulator that is included with the Sysmac Studio integrated software package.) |
| Maintenance | Connections to HMIs | Connected port | | Built-in EtherNet/IP port |
| | Sysmac Studio connection | Connected port | | Peripheral USB port or built-in EtherNet/IP port |
| | | Remote programming and monitoring | | Connection is possible through the peripheral USB port to other nodes that are connected to the built-in EtherNet/IP port. |
| | ID information | Production information | | Individual identifiers, lot numbers, and other information is accessed from the Sysmac Studio. |
| Reliability functions | Self-diagnosis | Controller errors | | • Major faults: Internal bus check errors, main memory check errors, etc.<br>• Partial faults: Motion control period exceeded, slave initialization error, etc.<br>• Minor faults: Battery-backed-up memory check errors, clock oscillation stopped, etc. |
| | | User-defined errors | | User-defined errors are registered in advance and then generated by executing an instruction.<br>Error registration, error resetting, error information registration |
| | | User-defined error messages | | User-defined error messages can be specified in up to nine languages, including Japanese and English. |
| | Power supply management | Power OFF detection time | | AC power supply: 30 to 45 ms<br>DC power supply: 22 to 25 ms |

| Item | | | | NJ501 | |
|---|---|---|---|---|---|
| Security | Protecting software assets and preventing operating mistakes | CPU Unit names and serial IDs | | When going online to a CPU Unit from the Sysmac Studio, the CPU Unit name in the project is compared to the name of the CPU Unit being connected to. | |
| | | Protection | Protection for online operations from the Sysmac Studio | User program transfers with no restoration information | Prevents reading data in the CPU Unit from the Sysmac Studio. |
| | | | | CPU Unit write-protection | Prevents writing data to the CPU Unit from the Sysmac Studio. |
| | | | Protection for offline operations from the Sysmac Studio | Protection of all project files | The project file is coded by using a password when the project is exported (when an .smc file is created). |
| | | Verification of operation authority | | Online operations are restricted by operation rights to prevent damage to equipment or injuries that may be caused by operating mistakes. | |
| | | Hardware identification (user program execution ID) | | The user program cannot be executed without entering a user program execution ID from the Sysmac Studio for the specific hardware (CPU Unit). | |
| SD Memory Card functions | Storage type | | | SD Memory Card (2 GB max.) | |
| | Application | SD Memory Card operation instructions | | You can access SD Memory Cards from instructions in the user program. | |
| | | FTP server | | You can use FTP commands from an FTP client on an intranet to read and write large files in the SD Memory Card through EtherNet/IP. | |
| | | File operations from the Sysmac Studio | | You can perform file operations for Controller files in the SD Memory Card and read/write general-purpose document files on the computer. | |
| | | SD Memory Card life expiration detection | | Notification of the expiration of the life of the SD Memory Card is provided in a system-defined variable and event log. | |

* When connected to an OMRON G5-series Servo Drive with built-in EtherCAT communications

**Note** You can use FINS message communications with NJ-series Controllers. However, not all memory areas in the NJ-series CPU Unit can be accessed. If you require this functionality, e.g., to connect to existing systems, consult with your OMRON representative.

# A-2 Calculating Guidelines for Task Execution Times

This section describes how to calculate guidelines for average task execution times on paper.

You must use the physical Controller to check the maximum values of task execution times. For details, refer to *5-3 Task Design Example and I/O Response Times*.

**Precautions for Safe Use**

The execution times in the physical Controller depends on the logic operations that are performed in the user program, the presence of communications commands and data links, on whether data tracing is performed, and on other factors.
Before starting actual operation, you must test performance under all foreseeable conditions on the actual system and make sure that the task periods are not exceeded and that suitable communications performance is achieved.

## A-2-1 Calculating the Average Task Execution Times

The task execution time is the total of the following processing times.

Task execution time =
I/O refresh processing time + User program execution time + Motion control processing time
+ Common processing time

The following processing is performed.

| Processing | | Processing contents | Primary periodic task | Priority-16 periodic task | Priority-17 and priority-18 periodic tasks |
|---|---|---|---|---|---|
| I/O refresh processing | | I/O is refreshed for CJ-series Units (Basic I/O Units, Special I/O Units, and CPU Bus Units) and EtherCAT slaves. | Performed. | Performed. | Not performed. |
| User program execution | | • Programs assigned to tasks are executed in the order that they are assigned. | Performed. | Performed. | Performed. |
| Motion control processing | | • Motion control commands from the user program are executed.<br>• Motion control outputs are processed. | Performed. | Not performed. | Not performed. |
| Common processing time | System common processing 1 | • Variable refresh processing (if there are accessing tasks) is performed.<br>• Motion input processing<br>• Data trace processing | Performed. | Performed. | Performed. |
| | System common processing 2 | • Variable refresh processing (if there are refreshing tasks) is performed.<br>• Variable access processing external to the Controller to ensure concurrency with task execution | Performed. | Performed. | Performed. |
| | System overhead time | Other system common processing | Performed. | Performed. | Performed. |

Guidelines are provided below for calculating the various processing times.

## I/O Refresh Processing Time

The I/O refresh processing time is the total of the following times.

I/O refresh processing time =
(A) I/O refresh overhead time +
(B) Larger of the EtherCAT slave processing time and the CJ-series Unit processing time.

### ● (A) I/O Refresh Overhead Time

As shown by the following table, if there are EtherCAT slaves, the I/O refresh overhead time is 60 μs regardless of whether there are CJ-series Units. If there are only CJ-series Units, the I/O refresh overhead time is 30 μs.

| EtherCAT slaves | CJ-series Units | I/O refresh overhead time |
|---|---|---|
| Present | None | 60 μs |
| | Present | 60 μs |
| None | | 30 μs |

### ● (B) Larger of the EtherCAT Slave Processing Time and the CJ-series Unit Processing Time

**EtherCAT Slave Processing Time**

(I/O refresh time for each EtherCAT slave × Number of slaves) − 70 μs
However, if the above value is negative, use 0 μs.

**CJ-series Unit Processing Time**

(I/O refresh time for each CJ-series Unit × Number of Units) − 230 μs
However, if the above value is negative, use 0 μs.
If more than one of the following CJ-series Units is used, add 230 μs to the above value regardless of the number of Units.

- CJ1W-PH41U Analog Input Unit with Universal Inputs
- CJ1W-AD04U Analog Input Unit with Universal Inputs
- CJ1W-PDC15 Analog Input Unit with Universal Inputs
- CJ1W-V680C11 ID Sensor Unit
- CJ1W-V680C12 ID Sensor Unit

## I/O Refresh Times for Typical EtherCAT Slaves and Units

### ● EtherCAT slaves

The following refresh times are for the default PDO mapping parameters.

| Slave name | Model | I/O refresh time per slave [μs] |
|---|---|---|
| Input slave (16 points) | GX-ID1611 | 1.5 |
| Output slave (32 points) | GX-OD1611 | 1.5 |
| Analog Input Slave | GX-AD0471 | 2.5 |
| Analog Output Slave | GX-DA0271 | 2 |
| Encoder Input Slave | GX-EC | 5 |
| Servomotor | R88D-□□ | 6 |
| Expansion Unit | XWT□□□ | 1.5 |

## ● CJ-series Units

### Basic I/O Units

| Unit name | Model | I/O refresh time per Unit [µs] | |
|---|---|---|---|
| | | On CPU Rack | On Expansion Rack |
| 8/16-point DC Input Units | CJ1W-ID201/211/212 | 1 | 1.5 |
| 32-point DC Input Units | CJ1W-ID231/232/233 | 2 | 3 |
| 64-point DC Input Units | CJ1W-ID261/262 | 4 | 6 |
| 8/16-point AC Input Units | CJ1W-IA201/111 | 1 | 1.5 |
| 16-point Quick-response Input Unit | CJ1W-IDP01 | 1 | 1.5 |
| 8/16-point Transistor Output Units | CJ1W-OD201/202/203/204//211/212/213 | 1 | 1.5 |
| 32-point Transistor Output Units | CJ1W-OD231/232/233/234 | 2 | 3 |
| 64-point Transistor Output Units | CJ1W-OD261/262/263 | 4 | 6 |
| Relay Contact Output Units | CJ1W-OC201/OC211 | 1 | 1.5 |
| Triac Output Unit | CJ1W-OA201 | 1 | 1.5 |
| 24-VDC Input/Transistor Output Units (16 inputs/16 outputs) | CJ1W-MD231/232/233 | 1 | 1.5 |
| 24-VDC Input/Transistor Output Units (32 inputs/32 outputs) | CJ1W-MD261/263 | 2 | 3 |
| TTL Input/Output Units (16 inputs/16 outputs) | CJ1W-MD563 | 4 | 6 |
| B7A Interface Unit | CJ1W-B7A04 | 4 | 6 |
| | CJ1W-B7A14 | 4 | 6 |
| | CJ1W-B7A22 | 4 | 6 |

### Special I/O Units

| Unit name | Model | I/O refresh time per Unit [µs] | |
|---|---|---|---|
| | | On CPU Rack | On Expansion Rack |
| Analog Input Units | CJ1W-AD041-V1/081-V1<br>CJ1W-AD042 | 24 | 36 |
| Analog Output Units | CJ1W-DA021/041/08V | 24 | 36 |
| Analog I/O Unit | CJ1W-MAD42 | 24 | 36 |
| High-speed Counter Unit | CJ1W-CT021 | 54 | 81 |
| Temperature Control Units | CJ1W-TC□□□ | 114 | 171 |
| Analog Input Unit with Universal Inputs | CJ1W-PH41U | 80 (When using expansion allocation area: 180) | 120 (When using expansion allocation area: 270) |
| ID Sensor Units | CJ1W-V680C11 | 76 | 114 |
| | CJ1W-V680C12 | 86 | 129 |

**CPU Bus Units**

| Unit name | Model | I/O refresh time per Unit [µs] | |
|---|---|---|---|
| | | On CPU Rack | On Expansion Rack |
| Serial Communications Units | CJ1W-SCU42<br>CJ1W-SCU32<br>CJ1W-SCU22 | 2.5<br>Add up to the following maximum time when a protocol macro is executed:<br>0.1 × Number of refresh words | 3.8<br>Add up to the following maximum time when a protocol macro is executed:<br>0.15 × Number of refresh words |
| DeviceNet Unit | CJ1W-DRM21 | 2.5 + 0.1 × Number of allocated words<br>The number of allocated words is the total number of words allocated to all the slaves. | 3.8 + 0.17 × Number of allocated words<br>The number of allocated words is the total number of words allocated to all the slaves. |

## User Program Execution Time

The user program execution time depends on the specific instructions multiplied by the numbers of instructions used.

As a guideline, instructions are divided into three groups and the number of instructions in each group is used for measurements and estimates.

- Standard instructions
- Arithmetic instructions for LREAL data
- Trigonometric instructions for LREAL data

### Simple Estimate

For the number of instructions in each group, read the execution time for each group from the following graphs and calculate the total.

- Execution time for standard instructions
- Execution time for arithmetic instructions for LREAL data
- Execution time for trigonometric instructions for LREAL data

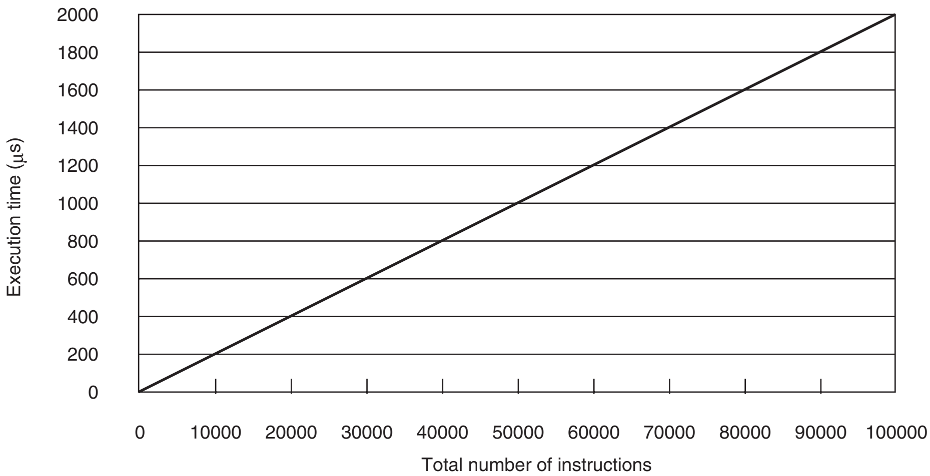
This will allow you to estimate the execution time of the user program.

The instruction execution times are different for ladder diagrams and structured text.

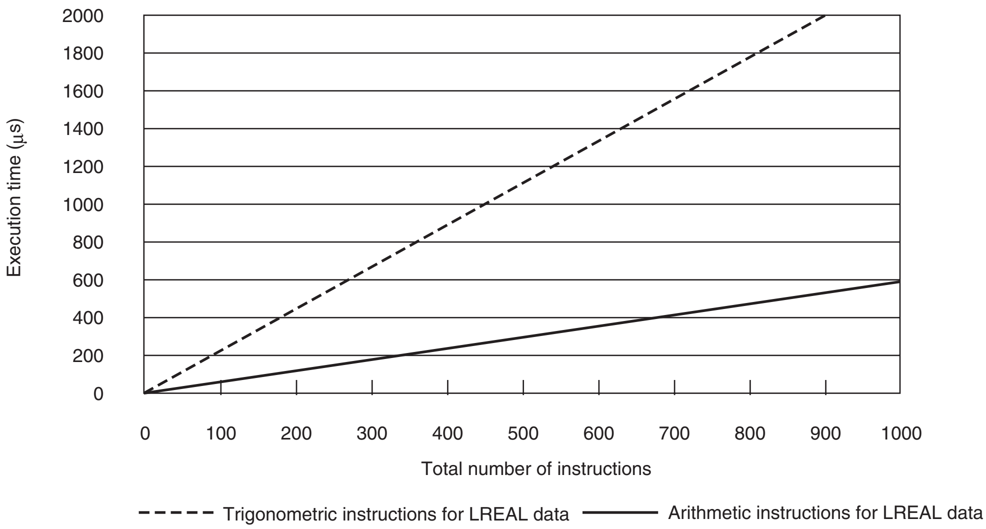
### Ladder Diagrams

Find the execution times from the following graphs and calculate the total.

- Execution Time for Standard Instructions



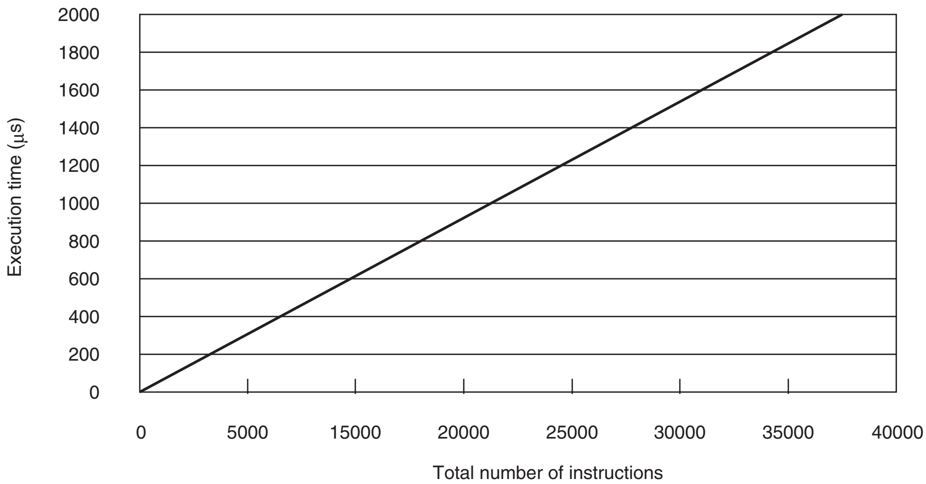

- Execution Times for Arithmetic and Trigonometric Instructions for LREAL Data



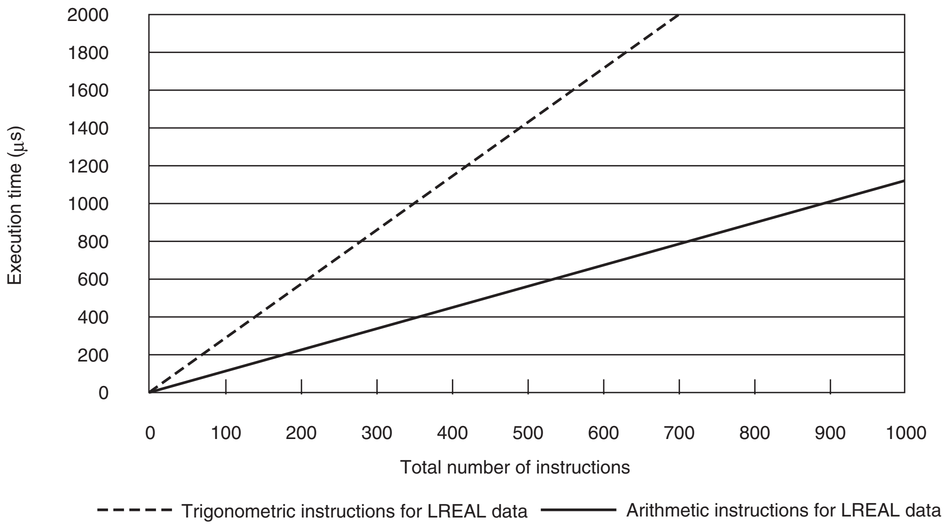
### Structured Text

Find the execution times from the following graphs and calculate the total.

- Execution Time for Standard Instructions




- Execution Times for Arithmetic and Trigonometric Instructions for LREAL Data



## Instruction Configuration for Each Group

### Instruction Configuration for Standard Instructions

Ladder Diagrams

| Types of instructions | Instructions | Percent of instructions | Percent of execution time in instruction group |
|---|---|---|---|
| Ladder diagram instructions | LD, AND, OUT, SET, and RESET | 81.0% | 40.2% |
| Comparison instructions | EQ and LT | 4.1% | 8.3% |
| Timer and counter instructions | Timer, TON/TOF, and CTU/CTD | 1.6% | 7.3% |
| Math instructions | +, -, *, /, ADD, SUB, MUL, and DIV | 2.4% | 6.5% |
| BCD conversion instructions and data conversion instructions | INT_TO_DINT and WORD_BCD_TO_UINT | 0.2% | 1.2% |
| Bit string processing instructions | AND and OR | 6.2% | 13.0% |
| Data movement instructions | MOVE | 4.6% | 23.5% |
| Total | | 100.0% | 100.0% |

Structured Text

| Types of instructions | Instructions | Percent of instructions | Percent of execution time in instruction group |
|---|---|---|---|
| ST constructs | IF ELSEIF END_IF | 75.4% | 41.6% |
| Comparison instructions | EQ and LT | 5.2% | 8.7% |
| Timer and counter instructions | Timer, TON/TOF, and CTU/CTD | 2.1% | 18.8% |
| Math instructions | +, -, *, and / | 3.1% | 10.2% |
| BCD conversion instructions and data conversion instructions | INT_TO_DINT and WORD_BCD_TO_UINT | 0.2% | 1.6% |
| Bit string processing instructions | AND and OR | 8.0% | 11.7% |
| Data movement instructions | := | 5.9% | 7.3% |
| Total | | 100.0% | 100.0% |

### Configuration of Arithmetic Instructions for LREAL Data

| Instructions | Percent of instructions |
|---|---|
| Addition instructions for LREAL data | 20.0% |
| Subtraction instructions for LREAL data | 20.0% |
| Multiplication instructions for LREAL data | 30.0% |
| Division instructions for LREAL data | 30.0% |
| Total | 100.0% |

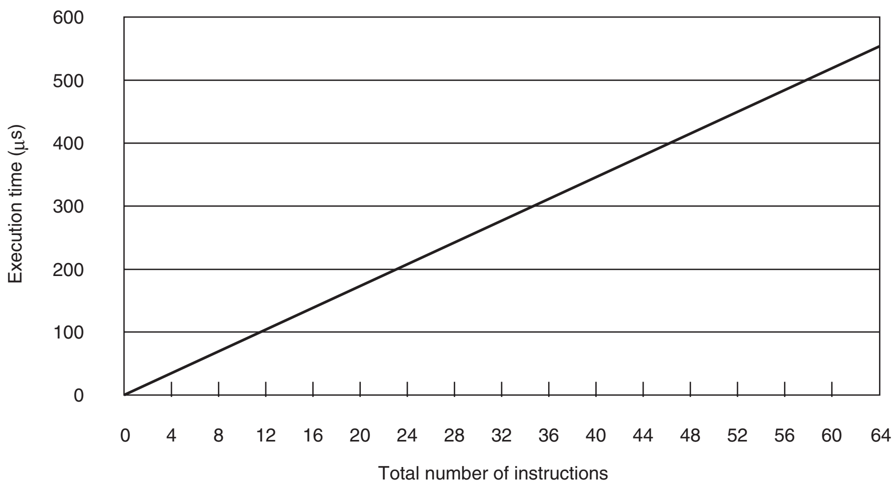
### Configuration of Trigonometric Instructions for LREAL Data

| Instructions | Percent of instructions |
|---|---|
| Sin of LREAL data | 16.7% |
| Cos of LREAL data | 16.7% |
| Tan of LREAL data | 16.7% |
| $\mathrm{Sin}^{-1}$ of LREAL data | 16.7% |

| Instructions | Percent of instructions |
|---|---|
| $Cos^{-1}$ of LREAL data | 16.7% |
| $Tan^{-1}$ of LREAL data | 16.7% |
| Total | 100.0% |

## Motion Control Processing

The motion control processing time depends on the number of servo axes and virtual servo axes that are used. For the number of servo and virtual servo axes, read the motion control processing time from the following graph.




## Common Processing Time

The total time for system overhead, system common processing 1, and system common processing 2 is as follows: The common processing time depends on the type of task.

| Type of task | Common processing time |
|---|---|
| Primary periodic task | Always 265 μs |
| Periodic task | 10 μs |

## A-2-2 Example of Calculating the Average Task Execution Time and Setting the Task Period

### Calculating the Average Task Execution Time

First we find the average task execution time for the following conditions. The task is the primary periodic task.

| Item | | Conditions |
|---|---|---|
| Slaves/Units that are used | EtherCAT slaves | • GX-ID1611 Input Slave: 1<br>• GX-OD1611 Output Slave: 1<br>• R88D-□□ Servomotors: 4 |
| | CJ-series Units (on CPU Rack) | • CJ1W-ID211 DC Input Unit: 1<br>• CJ1W-OD211 Transistor Output Unit: 1<br>• CJ1W-AD042 Analog Input Unit: 1<br>• CJ1W-DA021 Analog Output Unit: 1<br>• CJ1W-SCU42 Serial Communications Unit: 1 (Protocol macros are not used.) |
| User program | Language | Ladder diagrams |
| | Standard instruction configuration | Number of instructions: 5,000 |
| | Arithmetic instructions for LREAL data | Number of instructions: 200 |
| | Trigonometric instructions for LREAL data | Number of instructions: 100 |
| Motion control processing | Number of axes | 4 |

#### ● I/O Refresh Time

- I/O Refresh Overhead Time:
  60 µs
- EtherCAT slave processing time:
  1.5 + 1.5 + (6 × 4) µs – 70 µs = 27 µs – 70 µs = –43 µs
  Therefore, 0 µs is used.
- CJ-series Unit processing time:
  1 + 1 + 24 + 24 + 2.5 – 230 µs = 52.5 – 230 µs = –177.5 µs
  Therefore, 0 µs is used.

Therefore, the I/O refresh time is 60 µs + 0 µs = 60 µs

#### ● User Program Execution Time

The graphs show the following values.

- Standard instruction configuration: 5,000 instructions = 100 µs
- Arithmetic instructions for LREAL data: 200 instructions = 175 µs
- Trigonometric instructions for LREAL data: 100 instructions = 220 µs

The total is 495 µs.

#### ● Motion Control Processing

The graphs show 25 µs for four axes.

### Common Processing Time

This is the primary periodic task, so the common processing time is 265 μs.

Therefore,

| |
|---|
| Average value of the task execution time is 60 + 495 + 25 + 265 = 845 μs |

## Setting the Task Period

The task period is set based on the average value of the task execution time.

| |
|---|
| Average task execution time 845 μs ≤ Task execution time × 0.9 |

A task period of 1 ms satisfies the above formula.

The execution times in the physical Controller depends on the operations that are performed in the user program, the presence of communications commands and data links, on whether data tracing is perform, and on other factors. Use the physical Controller and verify performance with the Task Execution Time Monitor.

# A-3 System-defined Variables

System-defined variables are assigned specific functions by the system. They are registered in the global variable table, or the local variable table for each POU, in advance.

These variables cannot be changed. Some of the variables start with an underbar and some start with ”P_”.

Some of the system-defined variables are read-only and some are read/write.

You read and write the variables with the user program, with communications from external devices, with the Sysmac Studio, or with an NS-series PT.

Basically, system-defined variables are classified according to the function modules. The variables start with the following category names.

| Function module | Category name |
|---|---|
| System-defined variables for the overall NJ-series Controller | None |
| PLC Function Module | _PLC |
| | _CJB |
| Motion Control Function Module | _MC |
| EtherCAT Master Function Module | _EC |
| EtherNet/IP Function Module | _EIP |

The variables are described in the tables of this appendix as shown below.

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| This is the system-defined variable name. The prefix gives the category name. | This is the meaning of the variable. | The function of the variable is described. | The data type of the variable is given. | The range of values that the variable can take is given. | The page of the individual system-defined variable specifications table is given. |

## A-3-1 System-defined Variables for the Overall NJ-series Controller (No Category)

### ● Functional Classification: Clock

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _CurrentTime | System Time | Contains the CPU Unit’s internal clock data. | DATE_ AND_ TIME | DT#1970-01-01-00:00:00 to DT#2106-02-06-23:59:59 | page A-47 |

### Functional Classification: Tasks

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| *_TaskName_* Active | Task Active Flag | TRUE during task execution.<br>FALSE when task execution is not in progress.<br>**Note** You cannot use this system-defined variable in the user program. It is used only to access task status for data tracing from the Sysmac Studio. | BOOL | TRUE or FALSE | page A-47 |
| *_TaskName_* LastExecTime | Last Task Execution Time | Contains the task execution time the last time the task was executed (unit: 0.1 µs).<br>**Note** You cannot use this system-defined variable in the user program. It is used only to access task status for data tracing from the Sysmac Studio. | TIME | Depends on data type. | page A-48 |
| *_TaskName_* MaxExecTime | Maximum Task Execution Time | Contains the maximum value of the task execution time (unit: 0.1 µs).<br>**Note** You cannot use this system-defined variable in the user program. It is used only to access task status for data tracing from the Sysmac Studio. | TIME | Depends on data type. | page A-48 |
| *_TaskName_* MinExecTime | Minimum Task Execution Time | Contains the minimum value of the task execution time (unit: 0.1 µs).<br>**Note** You cannot use this system-defined variable in the user program. It is used only to access task status for data tracing from the Sysmac Studio. | TIME | Depends on data type. | page A-48 |
| *_TaskName_* ExecCount | Task Execution Count | Contains the number of executions of the task.<br>If 4294967295 is exceeded, the value returns to 0 and counting is continued.<br>**Note** You cannot use this system-defined variable in the user program. It is used only to access task status for data tracing from the Sysmac Studio. | UDINT | Depends on data type. | page A-48 |
| *_TaskName_* Exceeded | Task Exceeded Flag | TRUE if the task period was exceeded.<br>FALSE if task execution was completed within the task period.<br>**Note** You cannot use this system-defined variable in the user program. It is used only to access task status for data tracing from the Sysmac Studio. | BOOL | TRUE or FALSE | page A-49 |
| *_TaskName_* ExceedCount | Task Period Exceeded Count | Contains the number of times that the period was exceeded.<br>If the present value exceeds the maximum value of the data type, the present value returns to 0 and the count is continued.<br>If 4294967295 is exceeded, the value returns to 0 and counting is continued.<br>**Note** You cannot use this system-defined variable in the user program. It is used only to access task status for data tracing from the Sysmac Studio. | UDINT | Depends on data type. | page A-49 |

## ● Functional Classification: Errors

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _ErrSta | Controller Error Status | TRUE if there is a Controller error.<br>FALSE if there is no Controller error.<br>**Note** Do not use this variable in the user program. There may be a delay in updating it and concurrency problems in relation to the error status of the function module. Use this variable only to access status through communications from an external device. Refer to information on the meanings of the error status bits at the end of this appendix for details. | WORD | 16#0000 to 16#C0F0 | page A-49 |
| _AlarmFlag | User-defined Error Status | The bit corresponding to the event level is TRUE while there is a user-defined error. Bits 00 to 07 correspond to user fault levels 1 to 8. This variable contains 0000 hex when there is no user-defined error. | WORD | 16#0000 to 16#00FF | page A-50 |

## ● Functional Classification: SD Memory Card

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _Card1Ready | SD Memory Card Ready Flag | TRUE when the SD Memory Card is recognized.<br>FALSE when the SD Memory Card is not recognized.<br>TRUE: The Card can be used.<br>FALSE: The Card cannot be used. | BOOL | TRUE or FALSE | page A-50 |
| _Card1Protect | SD Memory Card Write Protected Flag | TRUE when the SD Memory Card is write-protected with the LOCK switch.<br>TRUE: Write protected.<br>FALSE: Not write protected. | BOOL | TRUE or FALSE | page A-50 |
| _Card1Err | SD Memory Card Error Flag | TRUE when an unusable SD Memory Card is inserted or a format error occurs.<br>TRUE: There is an error<br>FALSE: There is no error | BOOL | TRUE or FALSE | page A-50 |
| _Card1Access | SD Memory Card Access Flag | TRUE during SD Memory Card access.<br>TRUE: Card is being accessed.<br>FALSE: Card is not being accessed.<br>The system updates the flag every 100 ms. Because of this, access to the SD Memory Card is shown by this flag with a delay of up to 100 ms. We therefore do not recommend the use of this variable in the user program. | BOOL | TRUE or FALSE | page A-51 |
| _Card1Deteriorated | SD Memory Card Life Warning Flag | TRUE when the life of the SD Memory Card is exceeded.<br>TRUE: The life of the Card has been exceeded.<br>FALSE: The Card can still be used. | BOOL | TRUE or FALSE | page A-51 |
| _Card1PowerFail | SD Memory Card Power Interruption Flag | TRUE when the power supply to the CPU Unit was interrupted during access to the SD Memory Card.<br>TRUE: Power was interrupted during SD Memory Card access.<br>FALSE: Normal | BOOL | TRUE or FALSE | page A-51 |

## ● Functional Classification: Power Supply

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _PowerOnHour | Total Power ON Time | Contains the total time that the power has been ON.<br>Contains the total time that the CPU Unit has been ON in 1-hour increments.<br>To reset this value, overwrite the current value with 0.<br>The value is not updated after it reaches 4294967295.<br>This variable is not initialized at startup. | UDINT | 0 to 4294967295 | page A-51 |
| _PowerOnCount | Power Interruption Count | Contains the number of times that the power supply has been interrupted. The value is incremented by 1 each time the power supply is interrupted after the first time that the power was turned ON.<br>To reset this value, overwrite the current value with 0.<br>The value is not updated after it reaches 4294967295.<br>This variable is not initialized at startup. | UDINT | 0 to 4294967295 | page A-52 |
| _RetainFail | Retention Failure Flag | TRUE at the following time (failure of retention during power interruptions).<br>• When an error is detected in the battery-backup memory check at startup.<br>FALSE at the following times (no failure of retention during power interruptions).<br>• When no error is detected in the battery-backup memory check at startup.<br>• When the user program is downloaded.<br>• When the Clear All Memory operation is performed.<br>**Note** When the encoder home offset data is not retained, the status is given in the error status of the axis variable, and not in this flag. | BOOL | TRUE or FALSE | page A-52 |

## ● Functional Classification: Programming

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| P_On | Always TRUE Flag | This flag is always TRUE. | BOOL | TRUE | page A-52 |
| P_Off | Always FALSE Flag | This flag is always FALSE. | BOOL | FALSE | page A-52 |
| P_CY | Carry Flag | This flag is updated by some instructions. | BOOL | TRUE or FALSE | page A-52 |
| P_First_RunMode | First RUN Period Flag | TRUE for one task period when PROGRAM mode changes to RUN mode.<br>Use this flag to perform initial processing when the CPU Unit begins operation. | BOOL | TRUE or FALSE | page A-53 |
| P_PRGER | Instruction Error Flag | This flag changes to and remains TRUE when an instruction error occurs. It remains TRUE until changed to FALSE from the user program. | BOOL | TRUE or FALSE | page A-53 |

### Functional Classification: Communications

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _Port_numUsingPort | Number of Used Ports | Gives the number of internal logical ports that are currently used. You can use this variable when you debug the user program. | USINT | 0 to 32 | page A-53 |
| _Port_isAvailable | Network Communications Instruction Enabled Flag | Indicates whether there is an available internal logical port.<br>TRUE when an internal logical port is available. Otherwise FALSE. | BOOL | FALSE or TRUE | page A-53 |
| _FINSTCPConnSta | FINS/TCP Connection Status | Gives the FINS/TCP connection status. | WORD | 16#0000 to 16#FFFF | page A-53 |

## A-3-2 PLC Function Module, Category Name: _PLC

### Functional Classification: Debugging

| Variable name | Member | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|---|
| _PLC_TraceSta[0..3] | | | | _sTRACE_STA | | page A-54 |
| | .IsStart | Trace Busy Flag | TRUE when a trace starts.<br>**Note** You cannot use this system-defined variable in the user program. It is used only to monitor the status of data tracing from the Sysmac Studio. | BOOL | TRUE or FALSE | page A-54 |
| | .IsComplete | Trace Completed Flag | TRUE when a trace is completed.<br>**Note** You cannot use this system-defined variable in the user program. It is used only to monitor the status of data tracing from the Sysmac Studio. | BOOL | TRUE or FALSE | page A-54 |
| | .IsTrigger | Trace Trigger Monitor Flag | TRUE when the trigger condition is met.<br>FALSE when the next trace starts.<br>**Note** You cannot use this system-defined variable in the user program. It is used only to monitor the status of data tracing from the Sysmac Studio. | BOOL | TRUE or FALSE | page A-54 |
| | .ParamErr | Trace Parameter Error Flag | TRUE when a trace starts, but there is an error in the trace settings.<br>FALSE when the settings are normal.<br>**Note** You cannot use this system-defined variable in the user program. It is used only to monitor the status of data tracing from the Sysmac Studio. | BOOL | TRUE or FALSE | page A-55 |

### Functional Classification: Errors

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _PLC_ErrSta | PLC Function Module Error Status | TRUE when there is a Controller error that involves the PLC Function Module.<br>FALSE when there is no Controller error that involves the PLC Function Module.<br>Refer to information on the meanings of the error status bits at the end of this appendix for details. | WORD | 16#0000 to 16#00F0 | page A-55 |

## A-3-3 PLC Function Module, Category Name: _CJB

### ● Functional Classification: I/O Bus Status

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _CJB_MaxRackNo | Largest Rack Number | Contains the largest rack number of the Expansion Racks that are detected by the Controller. | UINT | 0 to 3<br>0: Only CPU Rack. | page A-55 |
| _CJB_MaxSlotNo | Largest Slot Number | Contains one higher than the largest slot number with a CJ-series Unit on each of the Racks that are detected by the Controller. | ARRAY [0..3] OF UINT | 0 to 10<br>0: No CJ-series Unit mounted. | page A-55 |

### ● Functional Classification: I/O Bus Errors

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _CJB_ErrSta | I/O Bus Error Status | Gives the I/O bus error status.<br>**Note** Do not use this variable in the user program. There may be a delay in updating it. Use this variable only to access status through communications from an external device. Refer to information on the meanings of the error status bits at the end of this appendix for details. | WORD | 16#0000 to 16#C0F0 | page A-56 |
| _CJB_MstrErrSta | I/O Bus Master Error Status | Gives the I/O bus master error status.<br>**Note** Do not use this variable in the user program. There may be a delay in updating it. Use this variable only to access status through communications from an external device. Refer to information on the meanings of the error status bits at the end of this appendix for details. | WORD | 16#0000 to 16#00F0 | page A-56 |
| _CJB_UnitErrSta | I/O Bus Unit Error Status | Gives the error status of the I/O Bus Unit.<br>**Note** Do not use this variable in the user program. There may be a delay in updating it. Use this variable only to access status through communications from an external device. Refer to information on the meanings of the error status bits at the end of this appendix for details. | ARRAY [0..3, 0..9] OF WORD | 16#0000 to 16#80F0 | page A-56 |
| _CJB_InRespTm | Basic Input Unit Input Response Times | Contains the response times of the Basic Input Units. | ARRAY [0..3, 0..9] OF UNIT | 0 to 320 | page A-56 |

### ● Functional Classification: Auxiliary Area Bits for CJ-series Units

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _CJB_IOUnitInfo | Basic I/O Unit Information | Shows the status of the Basic I/O Unit alarm output (load short-circuit protection).<br>TRUE: Load short-circuit<br>FALSE: No load short-circuit | ARRAY [0..3, 0..9, 0..7] OF BOOL | TRUE or FALSE | page A-57 |
| _CJB_CBU00InitSta<br>to<br>_CJB_CBU15InitSta | CPU Bus Unit Initializing Flags | The corresponding variable is TRUE during initialization of the CPU Bus Unit.<br>The corresponding variable changes to FALSE when the initialization is completed.<br>The numbers in the variables indicate the unit numbers of the applicable Units. | BOOL | TRUE or FALSE | page A-57 |
| _CJB_SIO00InitSta<br>to<br>_CJB_SIO95InitSta | Special I/O Unit Initializing Flags | The corresponding variable is TRUE during initialization of the Special I/O Unit.<br>The corresponding variable changes to FALSE when the initialization is completed.<br>The numbers in the variables indicate the unit numbers of the applicable Units. | BOOL | TRUE or FALSE | page A-57 |
| _CJB_CBU00Restart<br>to<br>_CJB_CBU15Restart | CPU Bus Unit Restart Bits | The CPU Bus Unit is restarted when the corresponding variable changes to TRUE. (It is changed to FALSE by the system after the CPU Bus Unit is restarted.)<br>The numbers in the variables indicate the unit numbers of the applicable Units.<br>If you change the Restart Flag to TRUE with an instruction, the restart process begins from refresh processing in the next task period. | BOOL | TRUE or FALSE | page A-58 |
| _CJB_SIO00Restart<br>to<br>_CJB_SIO95Restart | Special I/O Unit Restart Bits | The Special I/O Unit is restarted when the corresponding variable changes to TRUE. (It is changed to FALSE by the system after the Special I/O Unit is restarted.)<br>The numbers in the variables indicate the unit numbers of the applicable Units.<br>If you change the Restart Flag to TRUE with an instruction, the restart process begins from refresh processing in the next task period. | BOOL | TRUE or FALSE | page A-58 |
| _CJB_SCU00P1ChgSta<br>to<br>_CJB_SCU00P2ChgSta | Serial Communications Unit 0, Port 1/2 Settings Changing Flags | TRUE when the parameters of the specified port are being changed. TRUE when the Change Serial Communications Parameter (SerialSetup) instruction is being executed.<br>FALSE after the parameters are changed.<br>It is also possible for the user to indicate a change in serial port settings by turning ON the corresponding flag through the execution of an instruction or a user operation. | BOOL | TRUE or FALSE | page A-59 |
| _CJB_SCU15P1ChgSta<br>to<br>_CJB_SCU15P2ChgSta | Serial Communications Units 1 to 15, Port 1/2 Settings Changing Flags | | BOOL | TRUE or FALSE | page A-59 |

## A-3-4 Motion Control Function Module, Category Name: _MC

### ● Functional Classification: Motion Control Functions

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _MC_ErrSta | Motion Control Function Module Error Status | Shows the status of errors that are detected in the Motion Control Function Module.<br>You can use this variable directly in the user program.<br>Refer to information on the meanings of the error status bits at the end of this appendix for details. | WORD | 16#0000 to 16#40F0 | page A-59 |
| _MC_ComErrSta | Common Error Status | Shows the status of errors that are detected in common processing for motion control.<br>You can use this variable directly in the user program.<br>Refer to information on the meanings of the error status bits at the end of this appendix for details. | WORD | 16#0000 to 16#00F0 | page A-59 |
| _MC_AX_ErrSta | Axis Error Status | Shows the error status for each axis. The status of up to 64 axes is shown.<br>You can use this variable directly in the user program. Refer to information on the meanings of the error status bits at the end of this appendix for details. | ARRAY [0..63]<br>OF WORD | 16#0000 to 16#00F0 | page A-60 |
| _MC_GRP_ErrSta | Axes Group Error Status | Shows the error status for each axes group. The error status for up to 32 axes groups is shown.<br>You can use this variable directly in the user program. Refer to information on the meanings of the error status bits at the end of this appendix for details. | ARRAY [0..31]<br>OF WORD | 16#0000 to 16#00F0 | page A-60 |
| _MC_COM | Common Variable | Shows the status that is common to the Motion Control Function Module.<br>Refer to the *NJ-series Motion Control Instructions Reference Manual* (Cat. No. W508) for details on structure members. | _sCOMMON_REF | --- | page A-60 |
| _MC_GRP[32] | Axes Group Variables | Used to specify axes groups and shows multi-axes coordinated control status, and multi-axes coordinated control settings for motion control instructions.<br>Normally, you use an Axes Group Variable with a different name.<br>When you create an axes group on the System Studio, a user-defined axes group variable with a different name is created.<br>Refer to the *NJ-series Motion Control Instructions Reference Manual* (Cat. No. W508) for details on structure members. | _sGROUP_REF | --- | page A-60 |
| _MC_AX[64] | Axis Variables | Used to specify axes and shows single-axis control status, and single-axis control settings for motion control instructions.<br>When you create an axis on the System Studio, a user-defined axis variable with a different name is created.<br>Normally, you use an Axis Variable with a different name.<br>Refer to the *NJ-series Motion Control Instructions Reference Manual* (Cat. No. W508) for details on structure members. | _sAXIS_REF | --- | page A-61 |

## A-3-5 EtherCAT Master Function Module, Category Name: _EC

### ● Functional Classification: EtherCAT Communications Errors

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _EC_ErrSta | Built-in EtherCAT Error | This system-defined variable provides the collective status of errors in the EtherCAT Master Function Module.<br>Refer to information on the meanings of the error status bits at the end of this appendix for details. | WORD | 16#0000 to 16#00F0 | page A-61 |
| _EC_PortErr | Communications Port Error | This system-defined variable provides the collective status of errors in the communications ports for the EtherCAT master.<br>Refer to information on the meanings of the error status bits at the end of this appendix for details. | WORD | 16#0000 to 16#00F0 | page A-61 |
| _EC_MstrErr | Master Error | This system-defined variable provides the collective status of EtherCAT master errors and slave errors detected by the EtherCAT master.<br>Refer to information on the meanings of the error status bits at the end of this appendix for details. | WORD | 16#0000 to 16#00F0 | page A-61 |
| _EC_SlavErr | Slave Error | This system-defined variable provides the collective status of all the error status for EtherCAT slaves.<br>Refer to information on the meanings of the error status bits at the end of this appendix for details. | WORD | 16#0000 to 16#00F0 | page A-62 |
| _EC_SlavErrTbl | Slave Error Table | This system-defined variable gives the error status for each EtherCAT slave. The error status is given for each slave in the actual system configuration. This variable array indicates slaves in which there are errors. Status is provided for each EtherCAT slave node address (1 to 192). Refer to information on the meanings of the error status bits at the end of this appendix for details. | ARRAY [1..192] OF WORD | 16#0000 to 16#00F0 | page A-62 |
| _EC_MacAdrErr | MAC Address Error | TRUE if there is an illegal MAC address. | BOOL | TRUE or FALSE | page A-62 |
| _EC_LanHwErr | Communications Controller Error | TRUE if there is a communications controller hardware error. | BOOL | TRUE or FALSE | page A-62 |
| _EC_LinkOffErr | Link OFF Error | TRUE if the communications controller link is not established. | BOOL | TRUE or FALSE | page A-62 |
| _EC_NetCfgErr | Network Configuration Information Error | TRUE if there is illegal network configuration information. | BOOL | TRUE or FALSE | page A-63 |
| _EC_NetCfgCmpErr | Network Configuration Verification Error | TRUE if the network configuration information does not match the actual network configuration. | BOOL | TRUE or FALSE | page A-63 |
| _EC_NetTopologyErr | Network Configuration Error | TRUE if there is a network configuration error (too many devices connected or ring connection). | BOOL | TRUE or FALSE | page A-63 |
| _EC_PDCommErr | Process Data Communications Error | TRUE if there is an unexpected slave disconnection or connection or if a slave WDT error is detected during process data communications. | BOOL | TRUE or FALSE | page A-63 |
| _EC_PDTimeoutErr | Process Data Reception Timeout | TRUE if a timeout occurs while receiving process data. | BOOL | TRUE or FALSE | page A-63 |

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _EC_PDSendErr | Process Data Transmission Error | TRUE if there is a process data transmission error (cannot send within the process data communications cycle or transmission jitter is over the limit). | BOOL | TRUE or FALSE | page A-63 |
| _EC_SlavAdrDupErr | Slave Node Address Duplicated Error | TRUE if the same node address is set for more than one slave. | BOOL | TRUE or FALSE | page A-64 |
| _EC_SlavInitErr | Slave Initialization Error | TRUE if there is an error in an initialization command addressed to a slave. | BOOL | TRUE or FALSE | page A-64 |
| _EC_SlavAppErr | Slave Application Error | TRUE if there is an error in the slave's application status register. | BOOL | TRUE or FALSE | page A-64 |
| _EC_MsgErr | EtherCAT Message Error | TRUE when a message is sent to a slave that does not support messages or when there is an error in the format of the response to a message that was sent to a slave. | BOOL | TRUE or FALSE | page A-64 |
| _EC_SlavEmergErr | Emergency Message Detected | TRUE if the master detects an emergency message that was sent by a slave. | BOOL | TRUE or FALSE | page A-64 |
| _EC_CommErrTbl | Communications Error Slave Table | Slaves are given in the table in the order of slave node addresses. The corresponding slave element is TRUE if the master detected an error for the slave. | ARRAY [1..192] OF BOOL | TRUE or FALSE | page A-65 |

### Additional Information

#### Typical Relationships for the Built-in EtherCAT Error Flags

| Variable Name | Meaning | Variable Name | Meaning | Variable Name | Meaning | Event level |
|---|---|---|---|---|---|---|
| _EC_ErrSta | Built-in EtherCAT Error | _EC_PortErr | Communications Port Error | _EC_MacAdrErr | MAC Address Error | Partial fault level |
| | | | | _EC_LanHwErr | Communications Controller Error | |
| | | | | _EC_LinkOffErr | Link OFF Error | Minor fault level |
| | | _EC_MstrErr | Master Error | _EC_NetCfgErr | Network Configuration Information Error | |
| | | | | _EC_NetCfgCmpErr | Network Configuration Verification Error | |
| | | | | _EC_NetTopologyErr | Network Configuration Error | |
| | | | | _EC_PDCommErr | Process Data Communications Error | |
| | | | | _EC_PDTimeoutErr | Process Data Reception Timeout | |
| | | | | _EC_PDSendErr | Process Data Transmission Error | |
| | | | | _EC_SlavAdrDupErr | Slave Node Address Duplicated Error | |
| | | | | _EC_SlavInitErr | Slave Initialization Error | |
| | | | | _EC_SlavAppErr | Slave Application Error | |
| | | | | _EC_CommErrTbl | Communications Error Slave Table | |
| | | | | _EC_MsgErr | EtherCAT Message Error | Observation |
| | | | | _EC_SlavEmergErr | Emergency Message Detected | |
| | | _EC_SlavErr | Slave Error | _EC_SlavErrTbl | Slave Error Table | Defined by the slave. |

**Note** The values of all system-defined variables that are related to errors in EtherCAT communications do not change until the cause of the error is removed and then the error in the Controller is reset with the troubleshooting functions of the Sysmac Studio or the ResetECError instruction.

## ● Functional Classification: EtherCAT Communications Status

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _EC_RegSlavTbl | Registered Slave Table | This table indicates the slaves that are registered in the network configuration information. Slaves are given in the table in the order of slave node addresses. The element for a slave is TRUE if the corresponding slave is registered. | ARRAY [1..192] OF BOOL | TRUE or FALSE | page A-65 |
| _EC_EntrySlavTbl | Network Connected Slave Table | This table indicates which slaves are connected to the network. Slaves are given in the table in the order of slave node addresses. The element for a slave is TRUE if the corresponding slave has entered the network. | ARRAY [1..192] OF BOOL | TRUE or FALSE | page A-65 |
| _EC_MBXSlavTbl | Message Communications Enabled Slave Table | This table indicates the slaves that can perform message communications. Slaves are given in the table in the order of slave node addresses.<br>The element for a slave is TRUE if message communications are enabled for it (pre-operational, safe-operation, or operational state).<br>**Note** Use this variable to confirm that message communications are possible for the relevant slave before you execute message communications with an EtherCAT slave. | ARRAY [1..192] OF BOOL | TRUE or FALSE | page A-65 |
| _EC_PDSlavTbl | Process Data Communicating Slave Table | This table indicates the slaves that are performing process data communications. Slaves are given in the table in the order of slave node addresses.<br>The element for a slave is TRUE if process data of the corresponding slave is enabled (operational) for both slave inputs and outputs.<br>**Note** Use this variable to confirm that the data for the relevant slave is valid before controlling an EtherCAT slave. | ARRAY [1..192] OF BOOL | TRUE or FALSE | page A-66 |
| _EC_DisconnSlavTbl | Disconnected Slave Table | Slaves are given in the table in the order of slave node addresses.<br>The element for a slave is TRUE if the corresponding slave was disconnected. | ARRAY [1..192] OF BOOL | TRUE or FALSE | page A-66 |
| _EC_DisableSlavTbl | Disabled Slave Table | Slaves are given in the table in the order of slave node addresses.<br>The element for a slave is TRUE if the corresponding slave is disabled. | ARRAY [1..192] OF BOOL | TRUE or FALSE | page A-66 |
| _EC_PDActive | Process Data Communications Status | TRUE when process data communications are performed with all slaves. | BOOL | TRUE or FALSE | page A-66 |
| _EC_PktMonStop | Packet Monitoring Stopped | TRUE when packet monitoring is stopped. | BOOL | TRUE or FALSE | page A-67 |
| _EC_LinkStatus | Link Status | TRUE if the communications controller link status is Link ON. | BOOL | TRUE or FALSE | page A-67 |
| _EC_PktSaving | Saving Packet Data File | Shows whether a packet data file is being saved.<br>TRUE: Packet data file being saved.<br>FALSE: Packet data file not being saved. | BOOL | TRUE or FALSE | page A-67 |
| _EC_InDataInvalid | Input Data Invalid | TRUE when process data communications are not normal and the input data is not valid. | BOOL | TRUE or FALSE | page A-67 |

**Note** All system-defined variables that are related to the status of EtherCAT communications give the current status.

## A-3-6 EtherNet/IP Function Module, Category Name: _EIP

### ● Functional Classification: EtherNet/IP Communications Errors

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _EIP_ErrSta | Built-in EtherNet/IP Error | This is the error status variable for the built-in EtherNet/IP port.<br>It represents the following error flags.<br>• *_EIP_PortErr* (Communications Port Error)<br>• *_EIP_CipErr* (CIP Communications Error)<br>• *_EIP_TcpAppErr* (TCP Application Communications Error)<br>**Note** Refer to information on the meanings of the error status bits at the end of this appendix for details. | WORD | 16#0000 to 16#00F0 | page A-68 |
| _EIP_PortErr | Communications Port Error | This is the error status variable for the communications port.<br>It represents the following error flags.<br>• *_EIP_MacAdrErr* (MAC Address Error)<br>• *_EIP_LanHwErr* (Communications Controller Error)<br>• *_EIP_EtnCfgErr* (Basic Ethernet Setting Error)<br>• *_EIP_IPAdrCfgErr* (TCP/IP Basic Setting Error)<br>• *_EIP_IPAdrDupErr* (IP Address Duplication Error)<br>• *_EIP_BootpErr* (BOOTP Server Error)<br>• *_EIP_IPRTblErr* (TCP/IP Advanced Setting Error)<br>**Note** If a Link OFF or Built-in EtherNet/IP Processing Error occurs, it is recorded in the event log and then the corresponding bit turns ON. Refer to information on the meanings of the error status bits at the end of this appendix for details. | WORD | 16#0000 to 16#00F0 | page A-68 |

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _EIP_CipErr | CIP Communications Error | This is the error status variable for CIP communications.<br>It represents the following error flags.<br>• *_EIP_IdentityErr* (Identity Error)<br>• *_EIP_TDLinkCfgErr* (Tag Data Link Setting Error)<br>• *_EIP_TDLinkOpnErr* (Tag Data Link Connection Failed)<br>• *_EIP_TDLinkErr* (Tag Data Link Communications Error)<br>• *_EIP_TagAdrErr* (Tag Name Resolution Error)<br>• *_EIP_MultiSwONErr* (Multiple Switches ON Error)<br>**Note** If a Tag Resolution Error occurs, it is recorded in the event log and this variable changes to TRUE. Refer to information on the meanings of the error status bits at the end of this appendix for details. | WORD | 16#0000 to 16#00F0 | page A-69 |
| _EIP_TcpAppErr | TCP Application Communications Error | This is the error status variable for TCP application communications.<br>It represents the following error flags.<br>• *_EIP_TopAppCfgErr* (TCP/IP Setting Error)<br>• *_EIP_NTPSrvErr* (NTP Server Connection Error)<br>• *_EIP_DNSSrvErr* (DNS Server Connection Error)<br>**Note** Refer to information on the meanings of the error status bits at the end of this appendix for details. | WORD | 16#0000 to 16#00F0 | page A-69 |
| _EIP_MacAdrErr | MAC Address Error | Indicates that an error occurred when the MAC address was read at startup.<br>TRUE: Error<br>FALSE: Normal | BOOL | TRUE or FALSE | page A-69 |
| _EIP_LanHwErr | Communications Controller Error | TRUE: The communications controller failed.<br>FALSE: Normal | BOOL | TRUE or FALSE | page A-69 |
| _EIP_EtnCfgErr | Basic Ethernet Setting Error | TRUE: The Ethernet communications speed setting (Speed/Duplex) is incorrect. Or, a read operation failed.<br>FALSE: Normal | BOOL | TRUE or FALSE | page A-70 |
| _EIP_IPAdrCfgErr | TCP/IP Basic Setting Error | TRUE:<br>• There is an illegal IP address setting.<br>• A read operation failed.<br>• The IP address obtained from the BOOTP server is inconsistent.<br>• The DNS settings are not correct.<br>FALSE: Normal | BOOL | TRUE or FALSE | page A-70 |
| _EIP_IPAdrDupErr | IP Address Duplication Error | TRUE: The same IP address is assigned to more than one node.<br>FALSE: Other than the above. | BOOL | TRUE or FALSE | page A-70 |
| _EIP_BootpErr | BOOTP Server Error | TRUE: There was a failure to connect to the BOOTP server (timeout).<br>FALSE: The BOOTP is not enabled, or BOOTP is enabled and an IP address was normally obtained from the BOOTP server. | BOOL | TRUE or FALSE | page A-70 |

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _EIP_IPRTblErr | TCP/IP Advanced Setting Error | TRUE: There is an error in one of the following settings. Or, a read operation failed.<br>• IP router table settings<br>• Hosts settings<br>FALSE: Normal | BOOL | TRUE or FALSE | page A-70 |
| _EIP_IdentityErr | Identity Error | TRUE: The identity information (which you cannot overwrite) is not correct. Or, a read operation failed.<br>FALSE: Normal | BOOL | TRUE or FALSE | page A-71 |
| _EIP_TDLinkCfgErr | Tag Data Link Setting Error | TRUE: The tag data link settings are incorrect. Or, a read operation failed.<br>FALSE: Normal | BOOL | TRUE or FALSE | page A-71 |
| _EIP_TDLinkOpnErr | Tag Data Link Connection Failed | TRUE: The connection was not established because the remote node information in the tag data link parameters was different from the actual node information.<br>**Note** This variable does not change to TRUE if there is no remote node when the power is turned ON.<br>FALSE: Other than the above. | BOOL | TRUE or FALSE | page A-71 |
| _EIP_TDLinkErr | Tag Data Link Communications Error | TRUE: A timeout occurred in a tag data link connection.<br>FALSE: Other than the above. | BOOL | TRUE or FALSE | page A-71 |
| _EIP_TagAdrErr | Tag Name Resolution Error | TRUE: Tag resolution failed (i.e., the address could not be identified from the tag name). The following causes are possible.<br>• The size of the network-published variable does not agree with the tag setting.<br>• The I/O direction that is set in the tag data link settings does not agree with the I/O direction of the variable in the CPU Unit.<br>• There is no network-published variable in the CPU Unit that corresponds to the tag setting.<br>FALSE: Other than the above. | BOOL | TRUE or FALSE | page A-71 |
| _EIP_MultiSwONErr | Multiple Switches ON Error | TRUE: More than one data link start/stop switch changed to TRUE at the same time.<br>FALSE: Other than the above. | BOOL | TRUE or FALSE | page A-72 |
| _EIP_TcpAppCfgErr | TCP/IP Setting Error | TRUE: At least one of the set values for a TCP/IP application (FTP, NTP, SNMP) is incorrect. Or, a read operation failed.<br>FALSE: Normal | BOOL | TRUE or FALSE | page A-72 |
| _EIP_NTPSrvErr | NTP Server Connection Error | TRUE: The NTP client failed to connect to the server (timeout).<br>FALSE: NTP is not set or the connection was successful. | BOOL | TRUE or FALSE | page A-72 |
| _EIP_DNSSrvErr | DNS Server Connection Error | TRUE: The DNS client failed to connect to the server (timeout).<br>FALSE: DNS is not enabled. Or, DNS is enabled and the connection was successful. | BOOL | TRUE or FALSE | page A-72 |

### Additional Information

**Typical Relationships for the Built-in EtherNet/IP Error Flags**

| Variable name | Meaning | Variable name | Meaning | Variable name | Meaning | Event level |
|---|---|---|---|---|---|---|
| _EIP_ErrSta | Built-in EtherNet/IP Error | _EIP_PortErr | Communications Port Error | _EIP_MacAdrErr | MAC Address Error | Partial fault level |
| | | | | _EIP_LanHwErr | Communications Controller Error | |
| | | | | _EIP_EtnCfgErr | Basic Ethernet Setting Error | |
| | | | | _EIP_IPAdrCfgErr | TCP/IP Basic Setting Error | |
| | | | | _EIP_IPAdrDupErr | IP Address Duplication Error | |
| | | | | _EIP_BootpErr | BOOTP Server Error | |
| | | | | _EIP_IPRTblErr | TCP/IP Advanced Setting Error | Minor fault level |
| | | _EIP_CipErr | CIP Communications Error | _EIP_IdentityErr | Identity Error | Minor fault level |
| | | | | _EIP_TDLinkCfgErr | Tag Data Link Setting Error | |
| | | | | _EIP_TDLinkOpnErr | Tag Data Link Connection Failed | |
| | | | | _EIP_TDLinkErr | Tag Data Link Communications Error | |
| | | | | _EIP_TagAdrErr | Tag Name Resolution Error | |
| | | | | _EIP_MultiSwONErr | Multiple Switches ON Error | Observation |
| | | _EIP_TcpAppErr | TCP Application Communications Error | _EIP_TcpAppCfgErr | TCP/IP Setting Error | Minor fault level |
| | | | | _EIP_NTPSrvErr | NTP Server Connection Error | |
| | | | | _EIP_DNSSrvErr | DNS Server Connection Error | |

**Additional Information**

**Relationships between the Target Node Information Tables**

| Registered Target Node Information (_EIP_RegTargetSta) | Registered Target Node Information Valid only when *_EIP_RegTargetSta* is TRUE<br>Normal Target Node Information (_EIP_EstbTargetSta) | Normal Target Node Information Valid only when *_EIP_EstbTargetSta* is TRUE<br>Target PLC Error Information (_EIP_EIP_TargetPLCErr) | Registered Target Node Information Valid only when *_EIP_RegTargetSta* is TRUE<br>Target Node Error Information (_EIP_TargetNodeErr) | Description |
|---|---|---|---|---|
| TRUE | TRUE | FALSE | FALSE | A connection with the target node was established normally and there is no error in the target PLC. |
| | | TRUE | TRUE | A connection with the target node was established but there is an error in the target PLC. |
| | FALSE | Disabled | TRUE | A connection with the target node was not established normally. |
| FALSE | Disabled | Disabled | Disabled | The information is not valid because the target node is not registered. |

### Functional Classification: EtherNet/IP Communications Status

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _EIP_EtnOnlineSta | Online | TRUE: The built-in EtherNet/IP port's communications can be used. (The link is ON and IP address is defined. Also, there are no errors.)<br>FALSE: The built-in EtherNet/IP port's communications is disabled due to an error in initial processing or restart processing. | BOOL | TRUE or FALSE | page A-72 |
| _EIP_TDLinkRunSta | Tag Data Link Communications Status | TRUE: At least one connection is in normal operation.<br>FALSE: Other than the above. | BOOL | TRUE or FALSE | page A-73 |
| _EIP_TDLinkAllRunSta | All Tag Data Link Communications Status | TRUE: Tag data links are communicating in all connections as the originator.<br>FALSE: An error occurred in at least one connection. | BOOL | TRUE or FALSE | page A-73 |
| _EIP_RegTargetSta [255] | Registered Target Node Information | This variable gives a list of nodes for which built-in EtherNet/IP connections are registered.<br>This variable is valid only when the built-in EtherNet/IP port is the originator.<br>*Array[x]* is TRUE: The connection to the node with a target node ID of x is registered.<br>*Array[x]* is FALSE: The connection to the node with a target node ID of x is not registered. | ARRAY [0..255] OF BOOL | TRUE or FALSE | page A-73 |
| _EIP_EstbTargetSta [255] | Normal Target Node Information | This variable gives a list of nodes that have normally established built-in EtherNet/IP connections.<br>*Array[x]* is TRUE: The connection to the node with a target node ID of x was established normally.<br>*Array[x]* is FALSE: The connection to the node with a target node ID of x was not established, or an error occurred. | ARRAY [0..255] OF BOOL | TRUE or FALSE | page A-73 |
| _EIP_TargetPLCModeSta [255] | Target PLC Operating Mode | This variable shows the operating status of the target node Controllers that are connected with the built-in EtherNet/IP port as the originator.<br>The array elements are valid only when the corresponding Normal Target Node Information is TRUE. If the corresponding Normal Target Node Information is FALSE, the Target Node Controller Operating Information indicates the previous operating status.<br>*Array[x]* is TRUE: This is the operating state of the target Controller with a node address of x.<br>*Array[x]* is FALSE: Other than the above. | ARRAY [0..255] OF BOOL | TRUE or FALSE | page A-73 |

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _EIP_TargetPLCErr [255] | Target PLC Error Information | This variable shows the error status (logical OR of fatal and non-fatal errors) of the target node Controllers that are connected with the built-in EtherNet/IP ports as the originator. The array elements are valid only when the corresponding Normal Target Node Information is TRUE. The immediately preceding value is retained if this variable is FALSE.<br>*Array[x]* is TRUE: A fatal or non-fatal error occurred in the target Controller with a target node ID of x.<br>*Array[x]* is FALSE: Other than the above. | ARRAY [0..255] OF BOOL | TRUE or FALSE | page A-74 |
| _EIP_TargetNodeErr [255] | Target Node Error Information | This variable indicates that the connection for the Registered Target Node Information was not established or that an error occurred in the target Controller. The array elements are valid only when the Registered Target Node Information is TRUE.<br>*Array[x]* is TRUE: A connection was not normally established with the target node for a target node ID of x (the Registered Target Node Information is TRUE and the Normal Target Node Information is FALSE), or a connection was established with the target node but an error occurred in the target Controller.<br>*Array[x]* is FALSE: The target node is not registered for a target node ID of x (the Registered Target Node Information is FALSE), or a connection was normally established with the target node (the Registered Target Node Information is TRUE and the Normal Target Node Information is TRUE).<br>An error occurred in the target Controller (the Target PLC Error Information is TRUE.). | ARRAY [0..255] OF BOOL | TRUE or FALSE | page A-74 |
| _EIP_NTPResult | NTP Operation Information | Use the GetNTPStatus instruction to read the NTP operation information from the user program. Direct access is not possible. | _sNTP_ RESULT | | page A-74 |
| .ExecTime | NTP Last Operation Time | Gives the last time that NTP processing ended normally. The time that was obtained from the NTP server is stored when the time is obtained normally. The time is not stored if it is not obtained from the NTP server normally.<br>**Note** Do not use this variable in the user program. There may be a delay in updating it. Use this variable only to access status through communications from an external device. | DATE_ AND_ TIME | Depends on data type. | page A-74 |
| .ExecNormal | NTP Operation Result | TRUE: Indicates an NTP normal end.<br>FALSE: Indicates that NTP operation ended in an error or has not been executed even once.<br>**Note** Do not use this variable in the user program. There may be a delay in updating it. Use this variable only to access status through communications from an external device. | BOOL | TRUE or FALSE | page A-75 |

### ● Functional Classification: EtherNet/IP Communications Switches

| Variable name | Meaning | Function | Data type | Range of values | Reference |
|---|---|---|---|---|---|
| _EIP_TDLinkStartCmd | Tag Data Link Communications Start Switch | This is the start switch for data links. | BOOL | TRUE or FALSE | page A-75 |
| _EIP_TDLinkStopCmd | Tag Data Link Communications Stop Switch | This is the stop switch for data links. | BOOL | TRUE or FALSE | page A-75 |

## A-3-7 Meanings of Error Status Bits

The meanings of the individual bits in the following error status are the same.

- *_ErrSta* (Controller Error Status)
- *_PLC_ErrSta* (PLC Function Module Error Status)
- *_CJB_ErrSta* (I/O Bus Error Status)
- *_CJB_MstrErrSta* (I/O Bus Master Error Status)
- *_CJB_UnitErrSta* (I/O Bus Unit Error Status)
- *_MC_ErrSta* (Motion Control Function Module Error Status)
- *_MC_ComErrSta* (MC Common Error Status)
- *_MC_AX_ErrSta* (Axis Error Status)
- *_MC_GRP_ErrSta* (Axes Group Error Status)
- *_EC_ErrSta* (Built-in EtherCAT Error)
- *_EC_PortErr* (Communications Port Error)
- *_EC_MstrErr* (Master Error)
- *_EC_SlavErr* (Slave Error)
- *_EC_SlavErrTbl* (Slave Error Table)
- *_EIP_ErrSta* (Built-in EtherNet/IP Error)
- *_EIP_PortErr* (Communications Port Error)
- *_EIP_CipErr* (CIP Communications Error)
- *_EIP_TcpAppErr* (TCP Application Communications Error)

The meaning of the bits are shown in the following table.
However, do not use the following variables in the user program:*_ErrSta* (Controller Error Status), *_CJB_ErrSta* (I/O Bus Error Status), *_CJB_MstrErrSta* (I/O Bus Master Error Status), and *_CJB_UnitErrSta* (I/O Bus Master Unit Status). There may be a delay in updating them and concurrency problems in relation to the error status of the function module.

Use these variables only to access status through communications from an external device.

| Bit: | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WORD | | | – | – | – | – | – | – | | | | | – | – | – | – |

| Bit | Meaning |
|---|---|
| 15 | Master-detected error: This bit indicates whether the master detected a Controller error in the Unit/slave for the error status of the Controller error.<br>TRUE: The master detected a Controller error.<br>FALSE: The master has not detected a Controller error.<br>(Valid for *_CJB_U_ErrSta* and *_EC_SlvErrTbl*.) |
| 14 | Collective slave error status: This bit indicates if a Controller error was detected for levels (e.g., a Unit, slave, axis, or axes group) that are lower than the event source (i.e., for a function module).<br>TRUE: A Controller error has occurred at a lower level.<br>FALSE: A Controller error has not occurred at a lower level.<br>(Valid for *_CJB_ErrSta, _MC_ErrSta,* and *_EC_ErrSta*.) |
| 8 to 13 | Not used. |

| Bit | Meaning |
|---|---|
| 7 | This bit indicates whether a major fault level Controller error has occurred.<br>TRUE: A major fault level Controller error has occurred.<br>FALSE: A major fault level Controller error has not occurred. |
| 6 | This bit indicates whether a partial fault level Controller error has occurred.<br>TRUE: A partial fault level Controller error has occurred.<br>FALSE: A partial fault level Controller error has not occurred. |
| 5 | This bit indicates whether a minor fault level Controller error has occurred.<br>TRUE: A minor fault level Controller error has occurred.<br>FALSE: A minor fault level Controller error has not occurred. |
| 4 | This bit indicates whether an observation level Controller error has occurred.<br>TRUE: An observation level Controller error has occurred.<br>FALSE: An observation level Controller error has not occurred. |
| 0 to 3 | Not used. |

# A-4 Specifications for Individual System-defined Variables

The specifications for each system-defined variable are given as described below.

| | | | | | |
|---|---|---|---|---|---|
| Variable name | This is the system-defined variable name. The prefix gives the category name. | | | Members | The member names are given for structure variables. |
| Meaning | This is the meaning of the variable. | | | Global/local | Global: Global variable, Local: Local variable |
| Function | The function of the variable is described. | | | | |
| Data type | The data type of the variable is given. | | | Range of values | The range of values that the variable can take is given. |
| R/W access | R: Read only,<br>RW: Read/write | Retained | The Retain attribute of the variable is given. | Network Publish | The Network Publish attribute of the variable is given. |
| Usage in user program | Whether you can use the variable directly in the user program is specified. | Related instructions | The instructions that are related to the variable are given.<br>If you cannot use the variable directly in the user program, the instructions that access the variable are given. | | |

## A-4-1 System-defined Variables for the Overall NJ-series Controller (No Category)

### ● Functional Classification: Clock

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _CurrentTime | | | | |
| Meaning | System Time | | | Global/local | Global |
| Function | This variable contains the CPU Unit's internal clock data. | | | | |
| Data type | DATE_AND_TIME | | | Range of values | DT#1970-01-01-00:00:00 to DT#2106-02-06-23:59:59 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Clock instructions | | |

### ● Functional Classification: Tasks

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _*TaskName*_Active | | | | |
| Meaning | Task Active Flag | | | Global/local | Global |
| Function | TRUE during task execution.<br>FALSE when task execution is not in progress.<br>**Note** You cannot use this system-defined variable in the user program. It is used only to access task status for data tracing from the Sysmac Studio. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Not published. |
| Usage in user program | Not possible. | Related instructions | ActEventTask<br>You can access this variable from the user program only with the following instruction.<br>• Task_IsActive | | |

<table>
<tr><td>Variable name</td><td colspan="5">_TaskName_LastExecTime</td></tr>
<tr><td>Meaning</td><td colspan="3">Last Task Execution Time</td><td>Global/local</td><td>Global</td></tr>
<tr><td>Function</td><td colspan="5">Contains the task execution time the last time the task was executed (unit: 0.1 µs).<br>Note You cannot use this system-defined variable in the user program. It is used only to access task status for data tracing from the Sysmac Studio.</td></tr>
<tr><td>Data type</td><td colspan="3">TIME</td><td>Range of values</td><td>Depends on data type.</td></tr>
<tr><td>R/W access</td><td>R</td><td>Retained</td><td>Not retained.</td><td>Network Publish</td><td>Not published.</td></tr>
<tr><td>Usage in user program</td><td>Not possible.</td><td>Related instructions</td><td colspan="3">You can access this variable from the user program only with the following instruction.<br>• GetMyTaskStatus</td></tr>
</table>

<table>
<tr><td>Variable name</td><td colspan="5">_TaskName_MaxExecTime</td></tr>
<tr><td>Meaning</td><td colspan="3">Maximum Task Execution Time</td><td>Global/local</td><td>Global</td></tr>
<tr><td>Function</td><td colspan="5">Contains the maximum value of the task execution time (unit: 0.1 µs).<br>Note You cannot use this system-defined variable in the user program. It is used only to access task status for data tracing from the Sysmac Studio.</td></tr>
<tr><td>Data type</td><td colspan="3">TIME</td><td>Range of values</td><td>Depends on data type.</td></tr>
<tr><td>R/W access</td><td>R</td><td>Retained</td><td>Not retained.</td><td>Network Publish</td><td>Not published.</td></tr>
<tr><td>Usage in user program</td><td>Not supported.</td><td>Related instructions</td><td colspan="3">You can access this variable from the user program only with the following instruction.<br>• GetMyTaskStatus</td></tr>
</table>

<table>
<tr><td>Variable name</td><td colspan="5">_TaskName_MinExecTime</td></tr>
<tr><td>Meaning</td><td colspan="3">Minimum Task Execution Time</td><td>Global/local</td><td>Global</td></tr>
<tr><td>Function</td><td colspan="5">Contains the minimum value of the task execution time (unit: 0.1 µs).<br>Note You cannot use this system-defined variable in the user program. It is used only to access task status for data tracing from the Sysmac Studio.</td></tr>
<tr><td>Data type</td><td colspan="3">TIME</td><td>Range of values</td><td>Depends on data type.</td></tr>
<tr><td>R/W access</td><td>R</td><td>Retained</td><td>Not retained.</td><td>Network Publish</td><td>Not published.</td></tr>
<tr><td>Usage in user program</td><td>Not possible.</td><td>Related instructions</td><td colspan="3">You can access this variable from the user program only with the following instruction.<br>• GetMyTaskStatus</td></tr>
</table>

<table>
<tr><td>Variable name</td><td colspan="5">_TaskName_ExecCount</td></tr>
<tr><td>Meaning</td><td colspan="3">Task Execution Count</td><td>Global/local</td><td>Global</td></tr>
<tr><td>Function</td><td colspan="5">Contains the number of executions of the task.<br>If 4294967295 is exceeded, the value returns to 0 and counting is continued.<br>Note You cannot use these system-defined variables in the user program. It is used only to access task status for data tracing from the Sysmac Studio.</td></tr>
<tr><td>Data type</td><td colspan="3">UDINT</td><td>Range of values</td><td>Depends on data type.</td></tr>
<tr><td>R/W access</td><td>R</td><td>Retained</td><td>Not retained.</td><td>Network Publish</td><td>Not published.</td></tr>
<tr><td>Usage in user program</td><td>Not possible.</td><td>Related instructions</td><td colspan="3">You can access this variable from the user program only with the following instruction.<br>• GetMyTaskStatus</td></tr>
</table>

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _*TaskName*_Exceeded | | | | |
| Meaning | Task Exceeded Flag | | | Global/local | Global |
| Function | TRUE if the task period was exceeded.<br>FALSE if task execution was completed within the task period.<br>**Note** You cannot use this system-defined variable in the user program. It is used only to access task status for data tracing from the Sysmac Studio. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Not published. |
| Usage in user program | Not possible. | Related instructions | You can access this variable from the user program only with the following instruction.<br>• GetMyTaskStatus | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _*TaskName*_ExceedCount | | | | |
| Meaning | Task Period Exceeded Count | | | Global/local | Global |
| Function | Contains the number of times that the period was exceeded.<br>If the present value exceeds the maximum value of the data type, the present value returns to 0 and the count is continued.<br>If 4294967295 is exceeded, the value returns to 0 and counting is continued.<br>**Note** You cannot use this system-defined variable in the user program. It is used only to access task status for data tracing from the Sysmac Studio. | | | | |
| Data type | UDINT | | | Range of values | Depends on data type. |
| R/W access | R | Retained | Not retained. | Network Publish | Not published. |
| Usage in user program | Not possible. | Related instructions | You can access this variable from the user program only with the following instruction.<br>• GetMyTaskStatus | | |

## ● Functional Classification: Errors

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _ErrSta | | | | |
| Meaning | Controller Error Status | | | Global/local | Global |
| Function | TRUE if there is a Controller error.<br>FALSE if there is no Controller error.<br>**Note** Do not use this variable in the user program. There may be a delay in updating it and concurrency problems in relation to the status of the function module. Use this variable only to access status through communications from an external device. Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#C0F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Not possible. | Related instructions | • ResetPLCError<br>• ResetCJBError<br>• ResetECError<br>• ResetMCError<br>• MC_Reset<br>• MC_GroupReset<br>You can access this variable from the user program only with the following instructions.<br>• GetPLCError<br>• GetCJBError<br>• GetECError<br>• GetMCError<br>• GetEIPError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _AlarmFlag | | | | |
| Meaning | User-defined Error Status | | | Global/local | Global |
| Function | The bit corresponding to the event level is TRUE while there is a user-defined error.<br>Bits 00 to 07 correspond to user fault levels 1 to 8.<br>This variable contains 0000 hex when there is no user-defined error. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#00FF |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | • SetAlarm<br>• ResetAlarm<br>• GetAlarm | | |

## ● Functional Classification: SD Memory Card

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _Card1Ready | | | | |
| Meaning | SD Memory Card Ready Flag | | | Global/local | Global |
| Function | TRUE when the SD Memory Card is recognized.<br>FALSE when an SD Memory Card is not recognized.<br>TRUE: The Card can be used.<br>FALSE: The Card cannot be used. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _Card1Protect | | | | |
| Meaning | SD Memory Card Write Protected Flag | | | Global/local | Global |
| Function | TRUE when the SD Memory Card is write-protected with the LOCK switch.<br>TRUE: Write protected.<br>FALSE: Not write protected. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _Card1Err | | | | |
| Meaning | SD Memory Card Error Flag | | | Global/local | Global |
| Function | TRUE when an unusable SD Memory Card is inserted or a format error occurs.<br>TRUE: There is an error<br>FALSE: There is no error | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _Card1Access | | | | |
| Meaning | SD Memory Card Access Flag | | | Global/local | Global |
| Function | TRUE during SD Memory Card access.<br>TRUE: Card is being accessed.<br>FALSE: Card is not being accessed.<br>The system updates the flag every 100 ms. Because of this, access to the SD Memory Card is shown by this flag with a delay of up to 100 ms. We therefore do not recommend the use of this variable in the user program. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _Card1Deteriorated | | | | |
| Meaning | SD Memory Card Life Warning Flag | | | Global/local | Global |
| Function | TRUE when the life of the SD Memory Card is exceeded.<br>If this variable changed to TRUE, replace the SD Memory Card.<br>Read/write operation may fail if the SD Memory Card is not replaced.<br>TRUE: The life of the Card has been exceeded.<br>FALSE: The Card can still be used. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _Card1PowerFail | | | | |
| Meaning | SD Memory Card Power Interruption Flag | | | Global/local | Global |
| Function | TRUE when the power supply to the CPU Unit was interrupted during access to the SD Memory Card.<br>TRUE: Power was interrupted during SD Memory Card access.<br>FALSE: Normal. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | RW | Retained | Retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

## ● Functional Classification: Power Supply

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _PowerOnHour | | | | |
| Meaning | Total Power ON Time | | | Global/local | Global |
| Function | Contains the total time that the power has been ON.<br>Contains the total time that the CPU Unit has been ON in 1-hour increments.<br>To reset this value, overwrite the current value with 0.<br>The value is not updated after it reaches 4294967295.<br>This variable is not initialized at startup. | | | | |
| Data type | UDINT | | | Range of values | 0 to 4294967295 |
| R/W access | RW | Retained | Retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| Variable name | _PowerOnCount | | | | |
|---|---|---|---|---|---|
| Meaning | Power Interruption Count | | | Global/local | Global |
| Function | Contains the number of times that the power supply has been interrupted.<br>The value is incremented by 1 each time the power supply is interrupted after the first time that the power was turned ON.<br>To reset this value, overwrite the current value with 0.<br>The value is not updated after it reaches 4294967295.<br>This variable is not initialized at startup. | | | | |
| Data type | UDINT | | | Range of values | 0 to 4294967295 |
| R/W access | R/W | Retained | Retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| Variable name | _RetainFail | | | | |
|---|---|---|---|---|---|
| Meaning | Retention Failure Flag | | | Global/local | Global |
| Function | TRUE at the following times (failure of retention during power interruptions).<br>• When an error is detected in the battery-backup memory check at startup.<br>FALSE at the following times (no failure of retention during power interruptions).<br>• When no error is detected in the battery-backup memory check at startup.<br>• When the user program is downloaded.<br>• When the Clear All Memory operation is performed.<br>**Note** When the encoder home offset data is not retained, the status is given in the error status of the axis variable, and not in this flag. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Not published. |
| Usage in user program | Possible. | Related instructions | --- | | |

## ● Functional Classification: Programming

| Variable name | P_On | | | | |
|---|---|---|---|---|---|
| Meaning | Always TRUE Flag | | | Global/local | Global |
| Function | This flag is always TRUE. | | | | |
| Data type | BOOL | | | Range of values | TRUE |
| R/W access | R | Retained | Not retained. | Network Publish | Not published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| Variable name | P_Off | | | | |
|---|---|---|---|---|---|
| Meaning | Always FALSE Flag | | | Global/local | Global |
| Function | This flag is always FALSE. | | | | |
| Data type | BOOL | | | Range of values | FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Not published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| Variable name | P_CY | | | | |
|---|---|---|---|---|---|
| Meaning | Carry Flag | | | Global/local | Local |
| Function | This flag is updated by some instructions. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Not published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | P_First_RunMode | | | | |
| Meaning | First RUN Period Flag | | | Global/local | Local |
| Function | TRUE for one task period when PROGRAM mode changes to RUN mode.<br>Use this flag to perform initial processing when the CPU Unit begins operation. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Not published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | P_PRGER | | | | |
| Meaning | Instruction Error Flag | | | Global/local | Local |
| Function | This flag changes to and remains TRUE when an instruction error occurs.<br>It remains TRUE until changed to FALSE from the user program. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | RW | Retained | Not retained. | Network Publish | Not published. |
| Usage in user program | Possible. | Related instructions | --- | | |

## ● Functional Classification: Communications

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _Port_numUsingPort | | | | |
| Meaning | Number of Used Ports | | | Global/local | Global |
| Function | Gives the number of internal logical ports that are currently used.<br>You can use this variable when you debug the user program. | | | | |
| Data type | USINT | | | Range of values | 0 to 32 |
| R/W access | R | Retained | Not retained. | Network Publish | Not published. |
| Usage in user program | Possible. | Related instructions | Communications instructions (ExecPMCR, SerialSend, SerialRcv, Send, Rcv, and SendCmd) | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _Port_isAvailable | | | | |
| Meaning | Network Communications Instruction Enabled Flag | | | Global/local | Global |
| Function | Indicates whether there is an available internal logical port.<br>TRUE when an internal logical port is available. Otherwise FALSE. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Not published. |
| Usage in user program | Possible. | Related instructions | Communications instructions (ExecPMCR, SerialSend, SerialRcv, Send, Rcv, and SendCmd) | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _FINSTCPConnSta | | | | |
| Meaning | FINS/TCP Connection Status | | | Global/local | Global |
| Function | Gives the FINS/TCP connection status. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#FFFF |
| R/W access | R | Retained | Not retained. | Network Publish | Not published. |
| Usage in user program | Possible. | Related instructions | --- | | |

## A-4-2 PLC Function Module, Category Name: _PLC

### ● Functional Classification: Debugging

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _PLC_TraceSta[0..3] | | | Members | .IsStart |
| Meaning | Trace Busy Flag | | | Global/local | Global |
| Function | TRUE when a trace starts.<br>**Note** You cannot use these system-defined variables in the user program. It is used only to monitor the status of data tracing from the Sysmac Studio. | | | | |
| Data type | Structure: _sTRACE_STA, Members: BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Retained. | Network Publish | Not published. |
| Usage in user program | Not possible. | Related instruc-tions | • TraceTrig<br>• TraceSamp<br>You can access this variable from the user program only with the following instruction.<br>• GetTraceStatus | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _PLC_TraceSta[0..3] | | | Members | .IsComplete |
| Meaning | Trace Completed Flag | | | Global/local | Global |
| Function | TRUE when a trace is completed.<br>**Note** You cannot use this system-defined variable in the user program. It is used only to monitor the status of data tracing from the Sysmac Studio. | | | | |
| Data type | Structure: _sTRACE_STA, Members: BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Retained. | Network Publish | Not published. |
| Usage in user program | Not possible. | Related instruc-tions | • TraceTrig<br>• TraceSamp<br>You can access this variable from the user program only with the following instruction.<br>• GetTraceStatus | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _PLC_TraceSta[0..3] | | | Members | .IsTrigger |
| Meaning | Trace Trigger Monitor Flag | | | Global/local | Global |
| Function | TRUE when the trigger condition is met.<br>FALSE when the next trace starts.<br>**Note** You cannot use these system-defined variables in the user program. It is used only to monitor the status of data tracing from the Sysmac Studio. | | | | |
| Data type | Structure: _sTRACE_STA, Members: BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Retained. | Network Publish | Not published. |
| Usage in user program | Not possible. | Related instruc-tions | • TraceTrig<br>• TraceSamp<br>You can access this variable from the user program only with the following instruction.<br>• GetTraceStatus | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _PLC_TraceSta[0..3] | | | Members | .ParamErr |
| Meaning | Trace Parameter Error Flag | | | Global/local | Global |
| Function | TRUE when a trace starts, but there is an error in the trace settings.<br>FALSE when the settings are normal.<br>**Note** You cannot use these system-defined variables in the user program. It is used only to monitor the status of data tracing from the Sysmac Studio. | | | | |
| Data type | Structure: _sTRACE_STA, Members: BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Retained. | Network Publish | Not published. |
| Usage in user program | Not possible. | Related instructions | You can access this variable from the user program only with the following instruction.<br>• GetTraceStatus | | |

- **Functional Classification: Errors**

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _PLC_ErrSta | | | | |
| Meaning | PLC Function Module Error Status | | | Global/local | Global |
| Function | TRUE when there is a Controller error that involves the PLC Function Module.<br>FALSE when there is no Controller error that involves the PLC Function Module.<br>Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#00F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | • GetPLCError<br>You can use the following instruction to clear this variable.<br>• ResetPLCError | | |

## A-4-3 PLC Function Module, Category Name: _CJB

- **Functional Classification: I/O Bus Status**

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _CJB_MaxRackNo | | | | |
| Meaning | Largest Rack Number | | | Global/local | Global |
| Function | Contains the largest rack number of the Expansion Racks that are detected by the Controller. | | | | |
| Data type | UINT | | | Range of values | 0 to 3<br>0: Only CPU Rack. |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _CJB_MaxSlotNo | | | | |
| Meaning | Largest Slot Number | | | Global/local | Global |
| Function | Contains one higher than the largest slot number with a CJ-series Unit on each of the Racks that are detected by the Controller. | | | | |
| Data type | ARRAY [0..3] OF UINT | | | Range of values | 0 to 10<br>0: No CJ-series Unit mounted. |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

## Functional Classification: I/O Bus Errors

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _CJB_ErrSta | | | | |
| Meaning | I/O Bus Error Status | | | Global/local | Global |
| Function | Gives the I/O bus error status.<br>**Note** Do not use this variable in the user program. There may be a delay in updating it and concurrency problems may occur. Use this variable only to access status through communications from an external device. Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#00F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Not possible. | Related instructions | You can access this variable from the user program only with the following instruction.<br>• GetCJBError<br>You can use the following instruction to clear this variable.<br>• ResetCJBError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _CJB_MstrErrSta | | | | |
| Meaning | I/O Bus Master Error Status | | | Global/local | Global |
| Function | Gives the I/O bus master error status.<br>**Note** Do not use this variable in the user program. There may be a delay in updating it and concurrency problems may occur. Use these variables only to access status through communications from an external device. Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#00F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Not possible. | Related instructions | You can access this variable from the user program only with the following instruction.<br>• GetCJBError<br>You can use the following instruction to clear this variable.<br>• ResetCJBError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _CJB_UnitErrSta | | | | |
| Meaning | I/O Bus Unit Error Status | | | Global/local | Global |
| Function | Gives the error status of the I/O Bus Unit.<br>**Note** Do not use this variable in the user program. There may be a delay in updating it and concurrency problems may occur. Use this variable only to access status through communications from an external device. Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | ARRAY [0..3, 0..9] OF WORD | | | Range of values | 16#0000 to 16#80F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Not possible. | Related instructions | You can access this variable from the user program only with the following instruction.<br>• GetCJBError<br>You can clear this variable with the following instruction.<br>• ResetCJBError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _CJB_InRespTm | | | | |
| Meaning | Basic Input Unit Input Response Times | | | Global/local | Global |
| Function | Contains the response times of the Basic I/O Units. | | | | |
| Data type | ARRAY [0..3, 0..9] OF UINT | | | Range of values | 0 to 320 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

### ● Functional Classification: Auxiliary Area Bits for CJ-series Units

| | | | | | |
|---|---|---|---|---|---|
| Variable name | | _CJB_IOUnitInfo | | | |
| Meaning | | Basic I/O Unit Information | | Global/local | Global |
| Function | | Shows the status of the Basic I/O Unit alarm output (load short-circuit protection).<br>TRUE: Load short-circuit<br>FALSE: No load short-circuit | | | |
| Data type | | ARRAY [0..3, 0..9, 0..7] OF BOOL | | Range of values | TRUE or FALSE |
| R/W access | | R | Retained | Not retained. | Network Publish | Not published. |
| Usage in user program | | Possible. | Related instructions | --- | |
| Auxiliary Area addresses | Words | A50 to A69 | | | |
| | Bits | A50.00 to A69.15 | | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | | _CJB_CBU00InitSta<br>to<br>_CJB_CBU15InitSta | | | |
| Meaning | | CPU Bus Unit Initializing Flags | | Global/local | Global |
| Function | | The corresponding variable is TRUE during initialization of the CPU Bus Unit.<br>The corresponding variable changes to FALSE when the initialization is completed.<br>The numbers in the variables indicate the unit numbers of the applicable Units. | | | |
| Data type | | BOOL | | Range of values | TRUE or FALSE |
| R/W access | | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | | Possible. | Related instructions | • ResetUnit | |
| Auxiliary Area addresses | Words | A302 | | | |
| | Bits | A302.00 to A302.15 | | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | | _CJB_SIO00InitSta<br>to<br>_CJB_SIO95InitSta | | | |
| Meaning | | Special I/O Unit Initializing Flags | | Global/local | Global |
| Function | | The corresponding variable is TRUE during initialization of the Special I/O Unit.<br>The corresponding variable changes to FALSE when the initialization is completed.<br>The numbers in the variables indicate the unit numbers of the applicable Units. | | | |
| Data type | | BOOL | | Range of values | TRUE or FALSE |
| R/W access | | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | | Possible. | Related instructions | • ResetUnit | |
| Auxiliary Area addresses | Words | A330 to A335 | | | |
| | Bits | A330.00 to A335.15 | | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _CJB_CBU00Restart<br>to<br>_CJB_CBU15Restart | | | | |
| Meaning | CPU Bus Unit Restart Bits | | | Global/local | Global |
| Function | The CPU Bus Unit is restarted when the corresponding variable changes to TRUE. (It is changed to FALSE by the system after the CPU Bus Unit is restarted.)<br>The numbers in the variables indicate the unit numbers of the applicable Units.<br>If you change the Restart Flag to TRUE with an instruction, the restart process begins from refresh processing in the next task period. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | RW | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | • ResetUnit | | |
| Auxiliary Area addresses: Words | A501 | | | | |
| Auxiliary Area addresses: Bits | A501.00 to A501.15 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _CJB_SIO00Restart<br>to<br>_CJB_SIO95Restart | | | | |
| Meaning | Special I/O Unit Restart Bits | | | Global/local | Global |
| Function | The Special I/O Unit is restarted when the corresponding variable changes to TRUE. (It is changed to FALSE by the system after the CPU Bus Unit is restarted.)<br>The numbers in the variables indicate the unit numbers of the applicable Units.<br>If you change the Restart Flag to TRUE with an instruction, the restart process begins from refresh processing in the next task period. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | RW | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | • ResetUnit | | |
| Auxiliary Area addresses: Words | A502 to A507 | | | | |
| Auxiliary Area addresses: Bits | A502.00 to A507.15 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Variable name | | _CJB_SCU00P1ChgSta<br>_CJB_SCU00P2ChgSta<br>to<br>_CJB_SCU15P1ChgSta<br>_CJB_SCU15P2ChgSta | | | | |
| Meaning | | Serial Communications Unit 0, Port 1/2 Settings Changing Flags<br>. . .<br>Serial Communications Units 1 to 15, Port 1/2 Settings Changing Flags | | | Global/local | Global |
| Function | | TRUE when the parameters of the specified port are being changed. TRUE when the Change Serial Communications Parameter (SerialSetup) instruction is being executed.<br>FALSE after the parameters are changed.<br>It is also possible for the user to indicate a change in serial port settings by turning ON the corresponding flag through the execution of an instruction or a user operation. | | | | |
| Data type | | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | | RW | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | | Possible. | Related instructions | • SerialSetUp | | |
| Auxiliary Area addresses | Words | Port on Serial Communications Unit with unit number 0: A620<br>Ports on Serial Communications Unit with unit numbers 1 to 15: A621 to A635 | | | | |
| | Bits | Port on Serial Communications Unit with unit number 0: A620.01 to A620.02<br>Ports on Serial Communications Unit with unit numbers 1 to 15: A621.01 to A635.02 | | | | |

## A-4-4 Motion Control Function Module, Category Name: _MC

### ● Functional Classification: Motion Control Functions

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _MC_ErrSta | | | | |
| Meaning | Motion Control Function Module Error Status | | | Global/local | Global |
| Function | Shows the status of errors that are detected in the Motion Control Function Module.<br>You can use this variable directly in the user program.<br>Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#40F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | • GetMCError<br>• ResetMCError<br>• MC_Reset<br>• MC_GroupReset | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _MC_ComErrSta | | | | |
| Meaning | Common Error Status | | | Global/local | Global |
| Function | Shows the status of errors that are detected in common processing for motion control.<br>You can use this variable directly in the user program.<br>Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#00F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | • GetMCError<br>• ResetMCError | | |

<table>
<tr><td>Variable name</td><td colspan="5">_MC_AX_ErrSta</td></tr>
<tr><td>Meaning</td><td colspan="3">Axis Error Status</td><td>Global/local</td><td>Global</td></tr>
<tr><td>Function</td><td colspan="5">Shows the error status for each axis.<br>The status of up to 64 axes is given.<br>You can use this variable directly in the user program.<br>Refer to A-3-7 Meanings of Error Status Bits for the meanings of the error status bits.</td></tr>
<tr><td>Data type</td><td colspan="3">ARRAY [0..63] OF WORD</td><td>Range of values</td><td>16#0000 to 16#00F0</td></tr>
<tr><td>R/W access</td><td>R</td><td>Retained</td><td>Not retained.</td><td>Network Publish</td><td>Published.</td></tr>
<tr><td>Usage in user program</td><td>Possible.</td><td>Related instructions</td><td colspan="3">• GetMCError<br>• ResetMCError<br>• MC_Reset</td></tr>
</table>

<table>
<tr><td>Variable name</td><td colspan="5">_MC_GRP_ErrSta</td></tr>
<tr><td>Meaning</td><td colspan="3">Axes Group Error Status</td><td>Global/local</td><td>Global</td></tr>
<tr><td>Function</td><td colspan="5">Shows the error status for each axes group.<br>The error status for up to 32 axes groups is shown.<br>You can use this variable directly in the user program.<br>Refer to A-3-7 Meanings of Error Status Bits for the meanings of the error status bits.</td></tr>
<tr><td>Data type</td><td colspan="3">ARRAY [0..31] OF WORD</td><td>Range of values</td><td>16#0000 to 16#00F0</td></tr>
<tr><td>R/W access</td><td>R</td><td>Retained</td><td>Not retained.</td><td>Network Publish</td><td>Published.</td></tr>
<tr><td>Usage in user program</td><td>Possible.</td><td>Related instructions</td><td colspan="3">• GetMCError<br>• ResetMCError<br>• MC_GroupReset</td></tr>
</table>

<table>
<tr><td>Variable name</td><td colspan="5">_MC_COM</td></tr>
<tr><td>Meaning</td><td colspan="3">Common Variable</td><td>Global/local</td><td>Global</td></tr>
<tr><td>Function</td><td colspan="5">Shows the status that is common to the Motion Control Function Module.<br>Refer to the NJ-series Motion Control Instructions Reference Manual (Cat. No. W508) for details on structure members.</td></tr>
<tr><td>Data type</td><td colspan="3">_sCOMMON_REF</td><td>Range of values</td><td>---</td></tr>
<tr><td>R/W access</td><td>R</td><td>Retained</td><td>Not retained.</td><td>Network Publish</td><td>Published.</td></tr>
<tr><td>Usage in user program</td><td>Possible.</td><td>Related instructions</td><td colspan="3">---</td></tr>
</table>

<table>
<tr><td>Variable name</td><td colspan="5">_MC_GRP[32]</td></tr>
<tr><td>Meaning</td><td colspan="3">Axes Group Variables</td><td>Global/local</td><td>Global</td></tr>
<tr><td>Function</td><td colspan="5">Used to specify axes groups and shows multi-axes coordinated control status, and multi-axes coordinated control settings for motion control instructions.<br>When you create an axes group on the System Studio, a user-defined axes group variable with a different name is created.<br>Normally, you use an Axes Group Variable with a different name.<br>Refer to the NJ-series Motion Control Instructions Reference Manual (Cat. No. W508) for details on structure members.</td></tr>
<tr><td>Data type</td><td colspan="3">_sGROUP_REF</td><td>Range of values</td><td>---</td></tr>
<tr><td>R/W access</td><td>R</td><td>Retained</td><td>Not retained.</td><td>Network Publish</td><td>Published.</td></tr>
<tr><td>Usage in user program</td><td>Possible.</td><td>Related instructions</td><td colspan="3">---</td></tr>
</table>

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _MC_AX[64] | | | | |
| Meaning | Axis Variables | | | Global/local | Global |
| Function | Used to specify axes and shows single-axis control status, and single-axis control settings for motion control instructions.<br>When you create an axis on the System Studio, a user-defined axis variable with a different name is created.<br>Normally, you use an Axis Variable with a different name.<br>Refer to the *NJ-series Motion Control Instructions Reference Manual* (Cat. No. W508) for details on structure members. | | | | |
| Data type | _sAXIS_REF | | | Range of values | --- |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

## A-4-5 EtherCAT Master Function Module, Category Name: _EC

### ● Functional Classification: EtherCAT Communications Errors

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_ErrSta | | | | |
| Meaning | Built-in EtherCAT Error | | | Global/local | Global |
| Function | This system-defined variable provides the collective status of errors in the EtherCAT Master Function Module.<br>Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#00F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Get EtherCAT Error Status<br>• GetECError<br>Reset EtherCAT Controller Error<br>• ResetECError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_PortErr | | | | |
| Meaning | Communications Port Error | | | Global/local | Global |
| Function | This system-defined variable provides the collective status of errors in the communications ports for the EtherCAT master.<br>Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#00F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Get EtherCAT Error Status<br>• GetECError<br>Reset EtherCAT Controller Error<br>• ResetECError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_MstrErr | | | | |
| Meaning | Master Error | | | Global/local | Global |
| Function | This system-defined variable provides the collective status of EtherCAT master errors and slave errors detected by the EtherCAT master.<br>Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#00F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Get EtherCAT Error Status<br>• GetECError<br>Reset EtherCAT Controller Error<br>• ResetECError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_SlavErr | | | | |
| Meaning | Slave Error | | | Global/local | Global |
| Function | This system-defined variable provides the collective status of all the error status for EtherCAT slaves.<br>Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#00F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Get EtherCAT Error Status<br>• GetECError<br>Reset EtherCAT Controller Error<br>• ResetECError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_SlavErrTbl | | | | |
| Meaning | Slave Error Table | | | Global/local | Global |
| Function | This system-defined variable gives the error status for each EtherCAT slave.<br>The error status is given for each slave in the actual system configuration.<br>This variable array indicates slaves in which there are errors. Status is provided for each EtherCAT slave node address (1 to 192).<br>Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | Array [1..192] OF WORD | | | Range of values | 16#0000 to 16#00F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Get EtherCAT Error Status<br>• GetECError<br>Reset EtherCAT Controller Error<br>• ResetECError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_MacAdrErr | | | | |
| Meaning | MAC Address Error | | | Global/local | Global |
| Function | TRUE if there is an illegal MAC address. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Reset EtherCAT Controller Error<br>• ResetECError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_LanHwErr | | | | |
| Meaning | Communications Controller Error | | | Global/local | Global |
| Function | TRUE if there is a communications controller hardware error. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Reset EtherCAT Controller Error<br>• ResetECError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_LinkOffErr | | | | |
| Meaning | Link OFF Error | | | Global/local | Global |
| Function | TRUE if the communications controller link is not established. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Reset EtherCAT Controller Error<br>• ResetECError | | |

| Variable name | _EC_NetCfgErr | | | | |
|---|---|---|---|---|---|
| Meaning | Network Configuration Information Error | | | Global/local | Global |
| Function | TRUE if there is illegal network configuration information. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Reset EtherCAT Controller Error<br>• ResetECError | | |

| Variable name | _EC_NetCfgCmpErr | | | | |
|---|---|---|---|---|---|
| Meaning | Network Configuration Verification Error | | | Global/local | Global |
| Function | TRUE if the network configuration information does not match the actual network configuration. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Reset EtherCAT Controller Error<br>• ResetECError | | |

| Variable name | _EC_NetTopologyErr | | | | |
|---|---|---|---|---|---|
| Meaning | Network Configuration Error | | | Global/local | Global |
| Function | TRUE if there is a network configuration error (too many devices connected or ring connection). | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Reset EtherCAT Controller Error<br>• ResetECError | | |

| Variable name | _EC_PDCommErr | | | | |
|---|---|---|---|---|---|
| Meaning | Process Data Communications Error | | | Global/local | Global |
| Function | TRUE if there is an unexpected slave disconnection or connection or if a slave WDT error is detected during process data communications. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Reset EtherCAT Controller Error<br>• ResetECError | | |

| Variable name | _EC_PDTimeoutErr | | | | |
|---|---|---|---|---|---|
| Meaning | Process Data Reception Timeout Error | | | Global/local | Global |
| Function | TRUE if a timeout occurs while receiving process data. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Reset EtherCAT Controller Error<br>• ResetECError | | |

| Variable name | _EC_PDSendErr | | | | |
|---|---|---|---|---|---|
| Meaning | Process Data Transmission Error | | | Global/local | Global |
| Function | TRUE if there is a process data transmission error (cannot send within the process data communications period or transmission jitter is over the limit). | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Reset EtherCAT Controller Error<br>• ResetECError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_SlavAdrDupErr | | | | |
| Meaning | Slave Node Address Duplicated Error | | | Global/local | Global |
| Function | TRUE if the same node address is set for more than one slave. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Reset EtherCAT Controller Error<br>• ResetECError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_SlavInitErr | | | | |
| Meaning | Slave Initialization Error | | | Global/local | Global |
| Function | TRUE if there is an error in an initialization command addressed to a slave. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Reset EtherCAT Controller Error<br>• ResetECError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_SlavAppErr | | | | |
| Meaning | Slave Application Error | | | Global/local | Global |
| Function | TRUE if there is an error in the slave's application status register. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Reset EtherCAT Controller Error<br>• ResetECError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_MsgErr | | | | |
| Meaning | EtherCAT Message Error | | | Global/local | Global |
| Function | TRUE when a message is sent to a slave that does not support messages or when there is an error in the format of the response to a message that was sent to a slave. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | CoE messages (Read CoE SDO)<br>• EC_CoESDORead<br>CoE messages (Write CoE SDO)<br>• EC_CoESDOWrite | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_SlavEmergErr | | | | |
| Meaning | Emergency Message Detected | | | Global/local | Global |
| Function | TRUE if the master detects an emergency message that was sent by a slave. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Reset EtherCAT Controller Error<br>• ResetECError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_CommErrTbl | | | | |
| Meaning | Communications Error Slave Table | | | Global/local | Global |
| Function | Slaves are given in the table in the order of slave node addresses.<br>The corresponding slave element is TRUE if the master detected an error for the slave. | | | | |
| Data type | Array [1..192] OF BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instruc-tions | Reset EtherCAT Controller Error<br>• ResetECError | | |

**Note** The values of all system-defined variables that are related to errors in EtherCAT communications do not change until the cause of the error is removed and then the error in the Controller is reset with the troubleshooting functions of the Sysmac Studio or the ResetECError instruction.

### ● Functional Classification: EtherCAT Communications Status

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_RegSlavTbl | | | | |
| Meaning | Registered Slave Table | | | Global/local | Global |
| Function | This table indicates the slaves that are registered in the network configuration information.<br>Slaves are given in the table in the order of slave node addresses.<br>The element for a slave is TRUE if the corresponding slave is registered. | | | | |
| Data type | Array [1..192] OF BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instruc-tions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_EntrySlavTbl | | | | |
| Meaning | Network Connected Slave Table | | | Global/local | Global |
| Function | This table indicates which slaves are connected to the network.<br>Slaves are given in the table in the order of slave node addresses.<br>The element for a slave is TRUE if the corresponding slave has entered the network. | | | | |
| Data type | Array [1..192] OF BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instruc-tions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_MBXSlavTbl | | | | |
| Meaning | Message Communications Enabled Slave Table | | | Global/local | Global |
| Function | This table indicates the slaves that can perform message communications.<br>Slaves are given in the table in the order of slave node addresses.<br>The element for a slave is TRUE if message communications are enabled for it (pre-operational, safe-operation, or operational state).<br>**Note** Use this variable to confirm that message communications are possible for the relevant slave before you execute message communications with an EtherCAT slave. | | | | |
| Data type | Array [1..192] OF BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instruc-tions | Disconnect EtherCAT Slave<br>• EC_DisconnectSlave<br>Connect EtherCAT Slave<br>• EC_ConnectSlave | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_PDSlavTbl | | | | |
| Meaning | Process Data Communicating Slave Table | | | Global/local | Global |
| Function | This is a table that indicates the slaves that are performing process data communications.<br>Slaves are given in the table in the order of slave node addresses.<br>The element for a slave is TRUE if process data of the corresponding slave is enabled (operational) for both slave inputs and outputs.<br>**Note** Use this variable to confirm that the data for the relevant slave is valid before controlling an EtherCAT slave. | | | | |
| Data type | Array [1..192] OF BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Disconnect EtherCAT Slave<br>• EC_DisconnectSlave<br>Connect EtherCAT Slave<br>• EC_ConnectSlave | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_DisconnSlavTbl | | | | |
| Meaning | Disconnected Slave Table | | | Global/local | Global |
| Function | Slaves are given in the table in the order of slave node addresses.<br>The element for a slave is TRUE if the corresponding slave was disconnected. | | | | |
| Data type | Array [1..192] OF BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Disconnect EtherCAT Slave<br>• EC_DisconnectSlave<br>Connect EtherCAT Slave<br>• EC_ConnectSlave | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_DisableSlavTbl | | | | |
| Meaning | Disabled Slave Table | | | Global/local | Global |
| Function | Slaves are given in the table in the order of slave node addresses.<br>The element for a slave is TRUE if the corresponding slave is disabled. | | | | |
| Data type | Array [1..192] OF BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_PDActive | | | | |
| Meaning | Process Data Communications Status | | | Global/local | Global |
| Function | TRUE when process data communications are performed with all slaves. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Disconnect EtherCAT Slave<br>• EC_DisconnectSlave<br>Connect EtherCAT Slave<br>• EC_ConnectSlave | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_PktMonStop | | | | |
| Meaning | Packet Monitoring Stopped | | | Global/local | Global |
| Function | TRUE when packet monitoring is stopped. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Stop Packet Monitor<br>• EC_StopMon<br>Start Packet Monitor<br>• EC_StartMon | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_LinkStatus | | | | |
| Meaning | Link Status | | | Global/local | Global |
| Function | TRUE if the communications controller link status is Link ON. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_PktSaving | | | | |
| Meaning | Saving Packet Data File | | | Global/local | Global |
| Function | Shows whether a packet data file is being saved.<br>TRUE: Packet data file being saved.<br>FALSE: Packet data file not being saved. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | Saving Packet Data File<br>• EC_SaveMon | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EC_InDataInvalid | | | | |
| Meaning | Input Data Invalid | | | Global/local | Global |
| Function | TRUE when process data communications are not normal and the input data is not valid. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

**Note** All system-defined variables that are related to the status of EtherCAT communications give the current status.

## A-4-6 EtherNet/IP Function Module, Category Name: _EIP

### ● Functional Classification: EtherNet/IP Communications Errors

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_ErrSta | | | | |
| Meaning | Built-in EtherNet/IP Error | | | Global/local | Global |
| Function | This is the error status variable for the built-in EtherNet/IP port.<br>It represents the following error flags.<br>• *_EIP_PortErr* (Communications Port Error)<br>• *_EIP_CipErr* (CIP Communications Error)<br>• *_EIP_TcpAppErr* (TCP Application Communications Error)<br>**Note** Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#00F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | You can access this variable from the user program with the following instruction.<br>• GetEIPError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_PortErr | | | | |
| Meaning | Communications Port Error | | | Global/local | Global |
| Function | This is the error status variable for the communications port.<br>It represents the following error flags.<br>• *_EIP_MacAdrErr* (MAC Address Error)<br>• *_EIP_LanHwErr* (Communications Controller Error)<br>• *_EIP_EtnCfgErr* (Basic Ethernet Setting Error)<br>• *_EIP_IPAdrCfgErr* (TCP/IP Basic Setting Error)<br>• *_EIP_IPAdrDupErr* (IP Address Duplication Error)<br>• *_EIP_BootpErr* (BOOTP Server Error)<br>• *_EIP_IPRTblErr* (TCP/IP Advanced Setting Error)<br>**Note** If a link OFF or Built-in EtherNet/IP Processing Error occurs, it is recorded in the event log and then corresponding bit turns ON. Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#00F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | You can access this variable from the user program with the following instruction.<br>• GetEIPError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_CipErr | | | | |
| Meaning | CIP Communications Error | | | Global/local | Global |
| Function | This is the error status variable for CIP communications.<br>It represents the following error flags.<br>• *_EIP_IdentityErr* (Identity Error)<br>• *_EIP_TDLinkCfgErr* (Tag Data Link Setting Error)<br>• *_EIP_TDLinkOpnErr* (Tag Data Link Connection Failed)<br>• *_EIP_TDLinkErr* (Tag Data Link Communications Error)<br>• *_EIP_TagAdrErr* (Tag Name Resolution Error)<br>• *_EIP_MultiSwOnErr* (Multiple Switches ON Error)<br>**Note** If a Tag Resolution Error occurs, it is recorded in the event log and this variable changes to TRUE. Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#00F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | You can access this variable from the user program with the following instruction.<br>• GetEIPError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_TcpAppErr | | | | |
| Meaning | TCP Application Communications Error | | | Global/local | Global |
| Function | This is the error status variable for TCP application communications.<br>It represents the following error flags.<br>• *_EIP_TcpAppCfgErr* (TCP/IP Setting Error)<br>• *_EIP_NTPSrvErr* (NTP Server Connection Error)<br>• *_EIP_DNSSrvErr* (DNS Server Connection Error)<br>**Note** Refer to *A-3-7 Meanings of Error Status Bits* for the meanings of the error status bits. | | | | |
| Data type | WORD | | | Range of values | 16#0000 to 16#00F0 |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | You can access this variable from the user program with the following instruction.<br>• GetEIPError | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_MacAdrErr | | | | |
| Meaning | MAC Address Error | | | Global/local | Global |
| Function | Indicates that an error occurred when the MAC address was read at startup.<br>TRUE: Error<br>FALSE: Normal | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_LanHwErr | | | | |
| Meaning | Communications Controller Error | | | Global/local | Global |
| Function | TRUE: The communications controller failed.<br>FALSE: Normal | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| Variable name | _EIP_EtnCfgErr | | | | |
|---|---|---|---|---|---|
| Meaning | Basic Ethernet Setting Error | | | Global/local | Global |
| Function | TRUE: The Ethernet communications speed setting (Speed/Duplex) is incorrect. Or, a read operation failed.<br>FALSE: Normal | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| Variable name | _EIP_IPAdrCfgErr | | | | |
|---|---|---|---|---|---|
| Meaning | TCP/IP Basic Setting Error | | | Global/local | Global |
| Function | TRUE:<br>• There is an illegal IP address setting.<br>• A read operation failed.<br>• The IP address obtained from the BOOTP server is inconsistent.<br>• The DNS settings are not correct.<br>FALSE: Normal | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| Variable name | _EIP_IPAdrDupErr | | | | |
|---|---|---|---|---|---|
| Meaning | IP Address Duplication Error | | | Global/local | Global |
| Function | TRUE: The same IP address is assigned to more than one node.<br>FALSE: Other than the above. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| Variable name | _EIP_BootpErr | | | | |
|---|---|---|---|---|---|
| Meaning | BOOTP Server Error | | | Global/local | Global |
| Function | TRUE: There was a failure to connect to the BOOTP server (timeout).<br>FALSE: The BOOTP is not enabled, or BOOTP is enabled and an IP address was normally obtained from the BOOTP server. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| Variable name | _EIP_IPRTblErr | | | | |
|---|---|---|---|---|---|
| Meaning | TCP/IP Advanced Setting Error | | | Global/local | Global |
| Function | TRUE: There is an error in one of the following settings. Or, a read operation failed.<br>• IP router table settings<br>• Hosts settings<br>FALSE: Normal. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_IdentityErr | | | | |
| Meaning | Identity Error | | | Global/local | Global |
| Function | TRUE: The identity information (which you cannot overwrite) is not correct. Or, a read operation failed.<br>FALSE: Normal. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_TDLinkCfgErr | | | | |
| Meaning | Tag Data Link Setting Error | | | Global/local | Global |
| Function | TRUE: The tag data link settings are incorrect. Or, a read operation failed.<br>FALSE: Normal. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_TDLinkOpnErr | | | | |
| Meaning | Tag Data Link Connection Failed | | | Global/local | Global |
| Function | TRUE: The connection was not established because the remote node information in the tag data link parameters was different from the actual node information.<br>**Note** This variable does not change to TRUE if there is no remote node when the power is turned ON.<br>FALSE: Other than the above. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_TDLinkErr | | | | |
| Meaning | Tag Data Link Communications Error | | | Global/local | Global |
| Function | TRUE: A timeout occurred in a tag data link connection.<br>FALSE: Other than the above. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_TagAdrErr | | | | |
| Meaning | Tag Name Resolution Error | | | Global/local | Global |
| Function | TRUE: Tag resolution failed (i.e., the address could not be identified from the tag name). The following causes are possible.<br>• The size of the network-published variable does not agree with the tag setting.<br>• The I/O direction that is set in the tag data link settings does not agree with the I/O direction of the variable in the CPU Unit.<br>• There is no network-published variable in the CPU Unit that corresponds to the tag setting.<br>FALSE: Other than the above. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_MultiSwONErr | | | | |
| Meaning | Multiple Switches ON Error | | | Global/local | Global |
| Function | TRUE: More than one data link start/stop switch changed to TRUE at the same time.<br>FALSE: Other than the above. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_TcpAppCfgErr | | | | |
| Meaning | TCP/IP Setting Error | | | Global/local | Global |
| Function | TRUE: At least one of the set values for a TCP/IP application (FTP, NTP, SNMP) is incorrect. Or, a read operation failed.<br>FALSE: Normal. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_NTPSrvErr | | | | |
| Meaning | NTP Server Connection Error | | | Global/local | Global |
| Function | TRUE: The NTP client failed to connect to the server (timeout).<br>FALSE: NTP is not set or the connection was successful. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_DNSSrvErr | | | | |
| Meaning | DNS Server Connection Error | | | Global/local | Global |
| Function | TRUE: The DNS client failed to connect to the server (timeout).<br>FALSE: DNS is not enabled. Or, DNS is enabled and the connection was successful. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

### ● Functional Classification: EtherNet/IP Communications Status

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_EtnOnlineSta | | | | |
| Meaning | Online | | | Global/local | Global |
| Function | TRUE: The built-in EtherNet/IP port's communications can be used. (The link is ON and IP address is defined. Also, there are no errors).<br>FALSE: The built-in EtherNet/IP port's communications is disabled due to an error in initial processing or restart processing. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_TDLinkRunSta | | | | |
| Meaning | Tag Data Link Communications Status | | | Global/local | Global |
| Function | TRUE: At least one connection is in normal operation.<br>FALSE: Other than the above. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_TDLinkAllRunSta | | | | |
| Meaning | All Tag Data Link Communications Status | | | Global/local | Global |
| Function | TRUE: Tag data links are communicating in all connections as the originator.<br>FALSE: An error occurred in at least one connection. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_RegTargetSta [255] | | | | |
| Meaning | Registered Target Node Information | | | Global/local | Global |
| Function | This variable gives a list of nodes for which built-in EtherNet/IP connections are registered.<br>This variable is valid only when the built-in EtherNet/IP port is the originator.<br>*Array[x]* is TRUE: The connection to the node with a target node ID of x is registered.<br>*Array[x]* is FALSE: The connection to the node with a target node ID of x is not registered. | | | | |
| Data type | ARRAY [0..255] OF BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_EstbTargetSta [255] | | | | |
| Meaning | Normal Target Node Information | | | Global/local | Global |
| Function | This variable gives a list of nodes that have normally established EtherNet/IP connections.<br>*Array[x]* is TRUE: The connection to the node with a target node ID of x was established normally.<br>*Array[x]* is FALSE: The connection to the node with a target node ID of x was not established, or an error occurred. | | | | |
| Data type | ARRAY [0..255] OF BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_TargetPLCModeSta [255] | | | | |
| Meaning | Target PLC Operating Mode | | | Global/local | Global |
| Function | This variable shows the operating status of the target node Controllers that are connected with the built-in EtherNet/IP port as the originator.<br>The array elements are valid only when the corresponding Normal Target Node Information is TRUE.<br>If the corresponding Normal Target Node Information is FALSE, the Target Node Controller Operating Information indicates the previous operating status.<br>*Array[x]* is TRUE: This is the operating state of the target Controller with a node address of x.<br>*Array[x]* is FALSE: Other than the above. | | | | |
| Data type | ARRAY [0..255] OF BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| Variable name | _EIP_TargetPLCErr [255] | | | | |
|---|---|---|---|---|---|
| Meaning | Target PLC Error Information | | | Global/local | Global |
| Function | This variable shows the error status (logical OR of fatal and non-fatal errors) of the target node Controllers that are connected with the built-in EtherNet/IP ports as the originator.<br>The array elements are valid only when the corresponding Normal Target Node Information is TRUE.<br>The immediately preceding value is retained if this variable is FALSE.<br>*Array[x]* is TRUE: A fatal or non-fatal error occurred in the target Controller with a target node ID of x.<br>*Array[x]* is FALSE: Other than the above. | | | | |
| Data type | ARRAY [0..255] OF BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| Variable name | _EIP_TargetNodeErr | | | | |
|---|---|---|---|---|---|
| Meaning | Target Node Error Information | | | Global/local | Global |
| Function | This variable indicates that the connection for the Registered Target Node Information was not established or that an error occurred in the target Controller.<br>The array elements are valid only when the Registered Target Node Information is TRUE.<br>*Array[x]* is TRUE: A connection was not normally established with the target node for a target node ID of x (the Registered Target Node Information is TRUE and the Normal Target Node Information is FALSE), or a connection was established with the target node but an error occurred in the target Controller.<br>*Array[x]* is FALSE: The target node is not registered for a target node ID of x (the Registered Target Node Information is FALSE), or a connection was normally established with the target node (the Registered Target Node Information is TRUE and the Normal Target Node Information is TRUE). An error occurred in the target Controller (the Target PLC Error Information is TRUE). | | | | |
| Data type | ARRAY [0..255] OF BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| Variable name | _EIP_NTPResult | | | Members | .ExecTime |
|---|---|---|---|---|---|
| Meaning | NTP Last Operation Time | | | Global/local | Global |
| Function | Gives the last time that NTP processing ended normally.<br>The time that was obtained from the NTP server is stored when the time is obtained normally.<br>The time is not stored if it is not obtained from the NTP server normally.<br>**Note** Do not use this variable in the user program. There may be a delay in updating it. Use this variable only to access status through communications from an external device. | | | | |
| Data type | Structure: _sNTP_RESULT<br>Members: DATE_AND_TIME | | | Range of values | Depends on data type. |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Not possible. | Related instructions | You can read the contents of this variable with the GetNTPStatus instruction. | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_NTPResult | | | Members | .ExecNormal |
| Meaning | NTP Operation Result | | | Global/local | Global |
| Function | This variable shows if the NTP operation ended normally.<br>TRUE: Indicates an NTP normal end.<br>FALSE: Indicates that NTP operation ended in an error or has not been executed even once.<br>**Note** Do not use this variable in the user program. There may be a delay in updating it. Use this variable only to access status through communications from an external device. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | R | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Not possible | Related instructions | You can read the contents of this variable with the GetNTPStatus instruction. | | |

### ● Functional Classification: EtherNet/IP Communications Switches

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_TDLinkStartCmd | | | | |
| Meaning | Tag Data Link Communications Start Switch | | | Global/local | Global |
| Function | This is the start switch for data links. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | RW | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

| | | | | | |
|---|---|---|---|---|---|
| Variable name | _EIP_TDLinkStopCmd | | | | |
| Meaning | Tag Data Link Communications Stop Switch | | | Global/local | Global |
| Function | This is the stop switch for data links. | | | | |
| Data type | BOOL | | | Range of values | TRUE or FALSE |
| R/W access | RW | Retained | Not retained. | Network Publish | Published. |
| Usage in user program | Possible. | Related instructions | --- | | |

# A-5 CPU Unit Data Retention and Other Attributes

The following table shows whether CPU Unit data is retained or cleared for the following: Power interruptions, startup, operating mode changes, major fault level Controller errors, and clearing memory.

| CPU Unit data | | | Data retention at power interruptions | When power is turned ON | Status changes | | Writing when write protection is enabled | Transferring data with the Sysmac Studio | Operating modes permitting writing | Overwriting in RUN mode |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Change between PROGRAM mode and RUN mode | When a Major Fault Level Controller Error occurs | | Synchronized data | | |
| **User program** | **POUs and user program execution ID in user program** | | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | PROGRAM/ RUN mode (online editing) | Supported.<br>Online editing |
| **Task Setup** | **Task Settings** | | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | PROGRAM mode | Not supported. |
| **Variables** | **Variable tables (but not variable values)** | **Device variable** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | PROGRAM mode | Not supported. |
| **Variables** | **Variable tables (but not variable values)** | **User-defined variables** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | PROGRAM/ RUN mode (online editing) | Supported.<br>Online editing |
| **Data type** | | **User-defined data types** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | PROGRAM/ RUN mode (online editing) | Supported.<br>Online editing |
| **Controller name** | | **CPU Unit name** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | PROGRAM/ RUN mode | Supported. |
| **Controller name** | | **Built-in EtherNet/IP port name** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Supported | Not retained. | PROGRAM/ RUN mode | Supported. |

| CPU Unit data | | | Data retention at power interruptions | When power is turned ON | Status changes | | Writing when write protection is enabled | Transferring data with the Sysmac Studio | Operating modes permitting writing | Overwriting in RUN mode |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Change between PROGRAM mode and RUN mode | When a Major Fault Level Controller Error occurs | | Synchronized data | | |
| **Controller Setup** | **Operation Settings** | **Operation Settings Error settings** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | CPU Unit name: RUN/PROGRAM mode, Other settings: PROGRAM mode | Not supported. |
| | **Security Settings** | **Protection Settings at Startup** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | Write Protection and other settings: PROGRAM mode | Supported. |
| | **Built-in EtherNet/IP Port Settings** | **TCP/IP Settings, Built-in EtherNet/IP Port Link Settings, Service Settings. SNMP Settings, SNMP Trap Settings, NTP Settings, FTP Settings, and IP Router Tables** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | PROGRAM mode | Not supported. |
| | | **Tag data link settings for built-in EtherNet/IP port** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Supported | Not retained. | PROGRAM/RUN | Not supported. |
| | **FINS Settings** | **Node Address Settings, FINS/UDP Settings, FINS/TCP Settings, FINS Routing Tables** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | PROGRAM mode | Not supported. |
| **Motion Control Setup** | **Axis assignments, axis parameter settings, axes group parameter settings, MC common parameter settings** | | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | PROGRAM mode | Not supported. |
| **Cam Data** | | | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | PROGRAM mode | Not supported. |
| **Event Setting Table** | **Event Setting Table** | **User-defined error messages** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | RUN/PROGRAM mode | Not supported. |
| **Bus configuration** | **CJ-series bus configuration** | **I/O table** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | PROGRAM mode | Not supported. |

| CPU Unit data | | | Data retention at power interruptions | When power is turned ON | Status changes | | Writing when write protection is enabled | Transferring data with the Sysmac Studio | Operating modes permitting writing | Overwriting in RUN mode |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Change between PROGRAM mode and RUN mode | When a Major Fault Level Controller Error occurs | | Synchronized data | | |
| **Special I/O Unit Settings/CPU Bus Unit Settings** | **CJ-series Unit Settings** | **Data in CJ-series Units, such as protocol macros** | Retained (in CJ-series Units). | --- | Retained. | Retained. | Supported. | Not retained. | Depends on the Unit. | |
| | | **Words allocated to CPU Bus Units, Example: Controller Link Data Link Tables.** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Supported. | Not retained. | RUN/PROGRAM mode | Supported. |
| | | **Words allocated in DM Area** | Retained (with Battery). | Same as before power interruption. | Retained. | Retained. | Supported | Retained. | RUN/PROGRAM mode | Supported. |
| **EtherCAT Configuration** | **EtherCAT Network Configuration** | **Network configuration information.** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | PROGRAM mode | Not supported. |
| **EtherCAT Settings** | **EtherCAT Settings** | **Master** | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Retained. | PROGRAM mode | Not supported. |
| | | **Settings in Slaves** | Retained (by slaves). | --- | Retained. | Retained. | Supported. | Retained. | RUN/PROGRAM mode | Supported. |
| **Operation Authority Verification** | | | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Not retained. | PROGRAM mode | Not supported. |
| **User program execution ID in CPU Unit** | | | Retained (with non-volatile memory). | Same as before power interruption. | Retained. | Retained. | Not supported. | Not retained. | PROGRAM mode | Not supported. |
| **Present values of variables** | **Values of non-retained variables** | **User-defined variables** | Not retained. | Initial values | Initial values | Initial values | Supported. | Not retained. | RUN/PROGRAM mode | Supported. |
| | **Values of retained variables** | **User-defined variables** | Retained (with Battery). | Initial values | Retained. | Retained. | Supported. | Not retained. | RUN/PROGRAM mode | Supported. |
| **Contents of memory used for CJ-series Units** | **CIO/WR** | | Not retained. | 16#0000 | 16#0000 | 16#0000 | Supported. | Not retained. | RUN/PROGRAM mode | Supported. |
| | **HR/DM/EM** | | Retained (with Battery). | Same as before power interruption. | Retained. | Retained. | Supported. | Not retained. | RUN/PROGRAM mode | Supported. |

| CPU Unit data | | | Data retention at power interruptions | When power is turned ON | Status changes | | Writing when write protection is enabled | Transferring data with the Sysmac Studio | Operating modes permitting writing | Overwriting in RUN mode |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Change between PROGRAM mode and RUN mode | When a Major Fault Level Controller Error occurs | | Synchronized data | | |
| **Event logs** | **Logs** | **System log User event log** | Retained (with Battery). | Same as before power interruption. | Retained. | Retained. | Supported. | Not retained. | | Supported. |
| **Internal clock** | **Depends on the specifications of each system-defined variable.** | | Retained (with Battery). | With Battery: Retained (continued), Without Battery: Not predictable (may stop). | Retained (continued). | Retained (continued). | Supported. | Not retained. | RUN/PROGRAM mode | Supported. |
| **Absolute encoder home offset** | | | Retained (with Battery). | Same as before power interruption. | Retained (continued). | Retained (continued). | Supported. | Not retained. | | Not supported. |

# A-6 Contents of Memory Used for CJ-series Units

You can specify addresses in the memory used for CJ-series Units for AT specifications for variables. Details on each area are provided below.

## A-6-1 CIO Area

### I/O Bits

#### ● Description

The bits in this area are allocated to input and output terminals on CJ-series Basic I/O Units. The number of words (16 bits each) that is required for each CJ-series Basic I/O Unit are allocated in order based on the position where the Units are connected (from left to right starting from the Unit that is closest to the CPU Unit). Data in this area is cleared when power is cycled or when the operating mode is changed between PROGRAM and RUN mode.

#### ● Addresses

| Addresses | Word addresses | Bit addresses |
|---|---|---|
| **Range** | CIO 0 to CIO 159 | 0.00 to 159.15 |

**Additional Information**

You can access this area on NJ-series CPU Units through device variables allocated to I/O ports. We therefore recommend that you do not use AT specifications to access this area. You should use AT specifications for the CIO Area only when you specify addresses for some of the Special Units.

### CPU Bus Unit Area

#### ● Description

The bits in this area are allocated to control and status information for CJ-series CPU Bus Units. Each Unit is allocated 25 words based on its unit number. Data in this area is cleared when power is cycled or when the operating mode is changed between PROGRAM and RUN mode.

#### ● Addresses

| Addresses | Word addresses | Bit addresses | Words per Unit |
|---|---|---|---|
| **Range** | CIO 1500 to CIO 1899 | CIO 1500.00 to CIO 1899.15 | 25 words |

The words that are allocated are listed in the following table.

| Word addresses | Unit Number |
|---|---|
| CIO 1500 to CIO 1524 | 0 |
| CIO 1525 to CIO 1549 | 1 |
| to | to |
| CIO 1875 to CIO 1899 | F |

For details on how to use the allocated words, refer to the operation manual for the CJ-series CPU Bus Unit.

**Precautions for Correct Use**

You can access the CPU Bus Unit Area in NJ-series CPU Units through the device variables that are allocated to I/O ports. We therefore recommend that you do not use AT specifications to access this area. You should use AT specifications for the CIO Area only when you specify addresses for some of the Special Units.

## Special I/O Unit Area

### ● Description

The bits in this area are allocated to control and status information for CJ-series Special I/O Units. Each Unit is allocated 10 words based on the unit number for up to a total of 96 Units (unit numbers 0 to 95). Data in this area is cleared when power is cycled or when the operating mode is changed between PROGRAM and RUN mode.

### ● Addresses

| Addresses | Word addresses | Bit addresses | Words per Unit |
|---|---|---|---|
| **Range** | CIO 2000 to CIO 2959 (10 words × 96 unit numbers) | CIO 2000.00 to CIO 2959.15 | 10 words |

The words that are allocated are listed in the following table.

| Word addresses | Unit Number |
|---|---|
| CIO 2000 to CIO 2009 | 0 |
| CIO 2010 to CIO 2019 | 1 |
| to | to |
| CIO 2950 to CIO 2959 | 95 |

For details on how to use the allocated words, refer to the operation manual for the CJ-series Special I/O Unit.

**Additional Information**

You can access the Special I/O Unit Area in NJ-series CPU Units through the device variables that are allocated to I/O ports. We therefore recommend that you do not use AT specifications to access this area.

## DeviceNet Area

### ● Description

The bits in this area are allocated to the slaves when the remote I/O master function of a DeviceNet Unit is used (fixed allocations only). Data in this area is cleared when power is cycled or when the operating mode is changed between PROGRAM and RUN mode.

### Addresses

| Addresses | Word addresses | Bit addresses |
|---|---|---|
| **Range** | CIO 3200 to CIO 3799 | CIO 3200.00 to CIO 3799.15 |

Words in this area are allocated to slaves for fixed allocations according to fixed allocation setting 1, 2, or 3 in the software switches in the CIO Area. Select one of these fixed areas.

| Addresses | Master to slave output area | Slave to master input area |
|---|---|---|
| **Fixed allocation area 1** | CIO 3200 to CIO 3263 | CIO 3300 to CIO 3363 |
| **Fixed allocation area 2** | CIO 3400 to CIO 3463 | CIO 3500 to CIO 3563 |
| **Fixed allocation area 3** | CIO 3600 to CIO 3663 | CIO 3700 to CIO 3763 |

You can allocate memory in the DeviceNet Area even if you use fixed allocations to use the remote I/O slave function of a DeviceNet Unit.

| Addresses | Master to slave output area | Slave to master input area |
|---|---|---|
| **Fixed allocation area 1** | CIO 3370 | CIO 3270 |
| **Fixed allocation area 2** | CIO 3570 | CIO 3470 |
| **Fixed allocation area 3** | CIO 3770 | CIO 3670 |

Refer to the *CS/CJ-series DeviceNet Unit Operation Manual* (Cat. No. W380) for details.

## CIO Area Work Areas

### Description

You use the bits in these areas only in programming. You cannot use them to input or output data through external I/O terminals. If you need work bits, you should normally use bits in this area. Data in this area is cleared when power is cycled or when the operating mode is changed between PROGRAM and RUN mode.

### Addresses

| Addresses | Word addresses | Bit addresses |
|---|---|---|
| **Range** | CIO 1300 to CIO 1499 and CIO 3800 to CIO 6143 | CIO 1300.00 to CIO 1499.15 and CIO 3800.00 to CIO 6143.15 |

# A-6-2 Auxiliary Area

### Description

You use the bits in these areas only in programming. You cannot use them to input or output data through external I/O terminals. If you need work bits, you should normally use bits in this area. Data in this area is cleared when power is cycled or when the operating mode is changed between PROGRAM and RUN mode.

- **Addresses**

| Addresses | Word addresses | Bit addresses |
|---|---|---|
| **Range** | W000 to W511 | W000.00 to W511.15 |

## A-6-3 Holding Area

- **Description**

You use the words and bits in this area only in programming. The status of the words and bits in this area are retained during power interruptions or when the operating mode is changed between PROGRAM and RUN mode.

- **Addresses**

| Addresses | Word addresses | Bit addresses |
|---|---|---|
| **Range** | H0 to H511 | H0.00 to H511.15 |

## A-6-4 DM Area

- **Description**

This is a general-purpose data area used to read and write 16-bit words. You can also add a bit number to address specify bits. Data in this area is retained during power interruption or when the operating mode is changed between PROGRAM and RUN mode.

- **Addresses**

| Addresses | Word addresses | Bit addresses |
|---|---|---|
| **Range** | D0 to D32767 | D0.00 to D32767.15 |

### DM Area Words for Special Units

- **Description**

The following words in the DM Area are allocated to initial settings for Special Units.

- **Addresses**

| Addresses | Type of CJ-series Special Unit | Word addresses | Words per Unit |
|---|---|---|---|
| **Range** | CJ-series Special I/O Units | D20000 to D29599 (100 words × 96 unit numbers) | 100 words |
| | CJ-series CPU Bus Units | D30000 to D31599 (100 words × 16 unit numbers) | 100 words |

The words that are allocated are listed in the following table.
CJ-series Special I/O Units

| Word addresses | Unit Number |
|---|---|
| D20000 to D20099 | 0 |
| D20100 to D20199 | 1 |
| to | to |
| D29500 to D29599 | 95 |

CJ-series CPU Bus Units

| Word addresses | Unit Number |
|---|---|
| D30000 to D30099 | 0 |
| D30100 to D30199 | 1 |
| to | to |
| D31500 to D31599 | F |

For details on how to use the allocated words, refer to the operation manual for the Special Unit.

**Additional Information**

You can access the DM Area words that are allocated to Special Units in NJ-series CPU Units through the device variables that are allocated to I/O ports. We therefore recommend that you do not use AT specifications to access this area.

## A-6-5 EM Area

### ● Description

This is a general-purpose data area used to read and write 16-bit words. You can also add a bit number to address specify bits. Data in this area is retained during power interruption or when the operating mode is changed between PROGRAM and RUN mode.

### ● Addresses

| Addresses | Word addresses | Bit addresses |
|---|---|---|
| **Range** | E0_0 to E18_32767 | E0_0.00 to E18_3276.15 |

**Note** The number of banks is given in hexadecimal.

# A-7 Variable Memory Allocation Methods

You must be aware of variable memory allocation methods when you need to match the memory locations of structure variable members with the memory locations in other devices. When you use structure variables to perform communications with other devices, you must align the data allocations.

- When you access variables through CIP messages or EtherNet/IP tag data links between an NJ-series CPU Unit and another CPU Unit.
- When you need to exchange structure variable data with ID Tags or any device other than the CPU Unit.

## A-7-1 Variable Memory Allocation Rules

Variables are stored at locations in memory that are multiples of the alignment values shown in the following table.

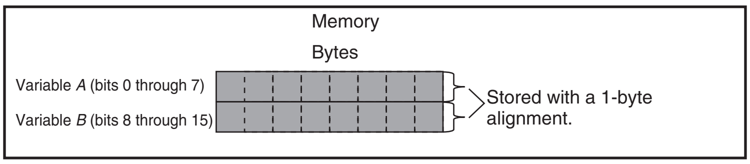
| Data type | Size | Alignment |
|---|---|---|
| BOOL | 16 bits | 2 bytes |
| BYTE, USINT, or SINT | 8 bits | 1 byte |
| WORD, UINT, or INT | 16 bits | 2 bytes |
| DWORD, UDINT, or DINT | 32 bits | 4 bytes |
| LWORD, ULINT, or LINT | 64 bits | 8 bytes |
| REAL data | 32 bits | 4 bytes |
| LREAL data | 64 bits | 8 bytes |
| TIME, DATE, TIME_OF_DAY, DATE_AND_TIME | 64 bits | 8 bytes |
| STRING[N] | (N+1) × 8 bits | 1 byte |
| Enumeration | 32 bits | 4 bytes |

### Basic Data Types

#### ● Variables with One-Byte Alignments (e.g., BYTE)

These variables are stored in memory with a one-byte alignment.

Example:



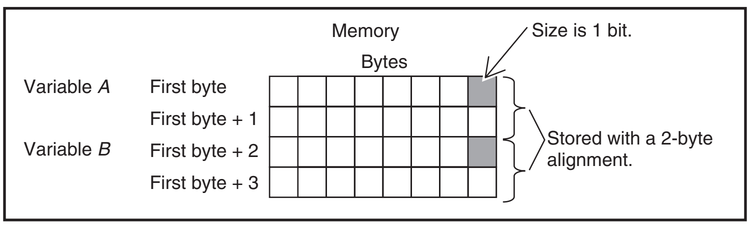

Variable Table

| Name | Data type |
|---|---|
| A | BYTE |
| B | BYTE |

#### ● Variables with Two-Byte Alignments (e.g., BOOL and WORD)

These variables are stored in memory with a two-byte alignment.

Example:



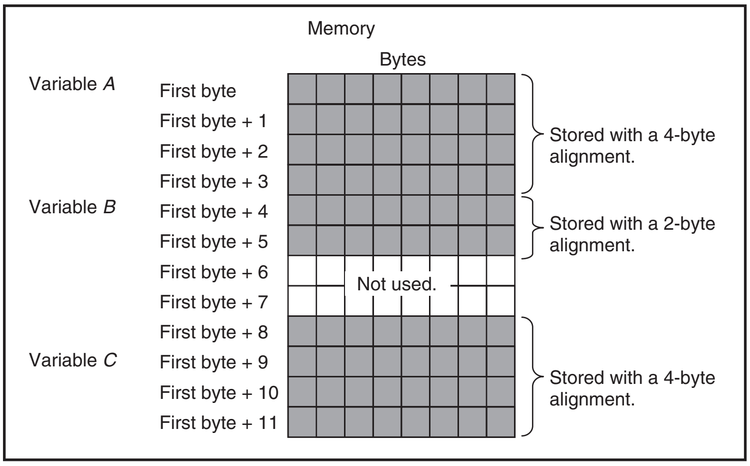

Variable Table

| Name | Data type |
|---|---|
| A | BOOL |
| B | BOOL |

## ● Variables with Four-Byte Alignments (e.g., DWORD)

These variables are stored in memory with a four-byte alignment. The first byte is the first of four bytes in memory. Therefore, if a variable with a two-byte alignment, such as WORD data, is inserted, two bytes of unused memory will remain.

Example:



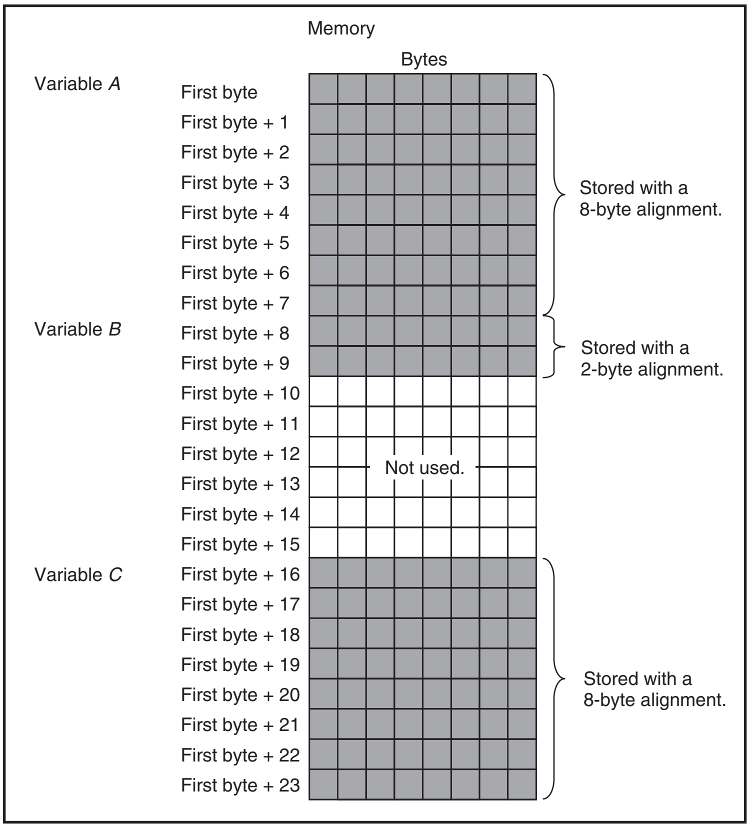

Variable Table

| Name | Data type |
|---|---|
| A | DWORD |
| B | WORD |
| C | DWORD |

## ● Variables with Eight-Byte Alignments (e.g., LWORD)

These variables are stored in memory with an eight-byte alignment. The first byte is the first of eight bytes in memory. Therefore, if a variable with a two-byte alignment, such as WORD data, is inserted, six bytes of unused memory will remain. If a variable with a four-byte alignment, such as DWORD data, is inserted, four bytes of unused memory will remain.

Example:



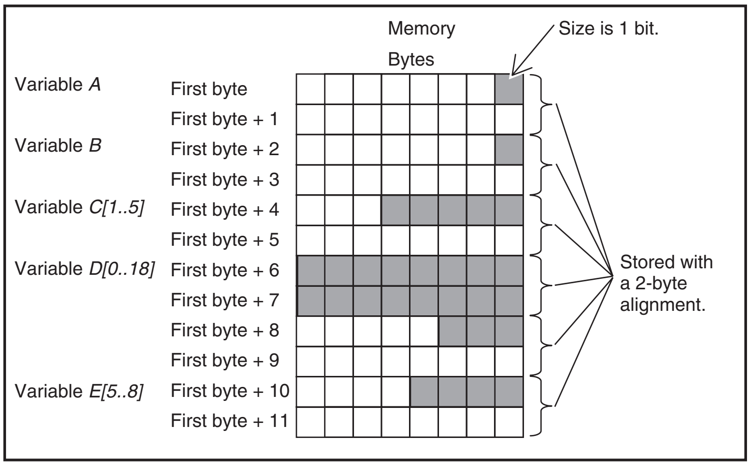

Variable Table

| Name | Data type |
|---|---|
| A | LWORD |
| B | WORD |
| C | LWORD |

## Array Variables

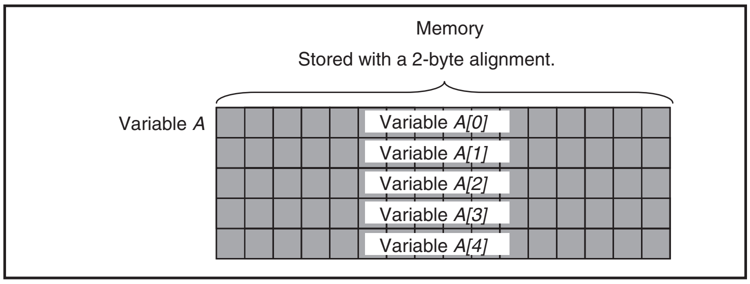
Array variables are stored in a continuous section of memory.

Example:




Variable Table

| Name | Data type |
|---|---|
| A | BOOL |
| B | BOOL |
| C | ARRAY [1..5] OF BOOL |
| D | ARRAY [0..18] OF BOOL |
| E | ARRAY [5..8] OF BOOL |



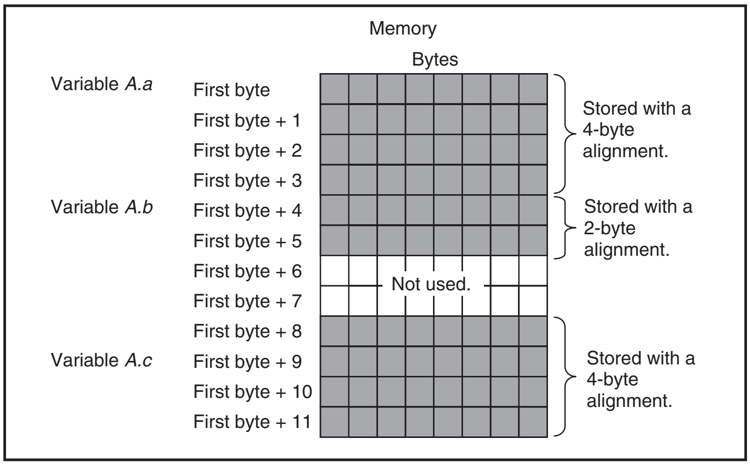

Variable Table

| Name | Data type |
|---|---|
| Variable *A* | ARRAY[0..4] OF INT |

## Structures

A continuous section of memory is allocated based on the alignment value of the data type of the structure variable to store structure data.

Example:




Data Type Definitions

| Name | Data type |
|---|---|
| Structure A | STRUCT |
| a | DINT |
| b | INT |
| c | DINT |

Variable Table

| Name | Data type |
|---|---|
| Variable *A* | Structure *A* |

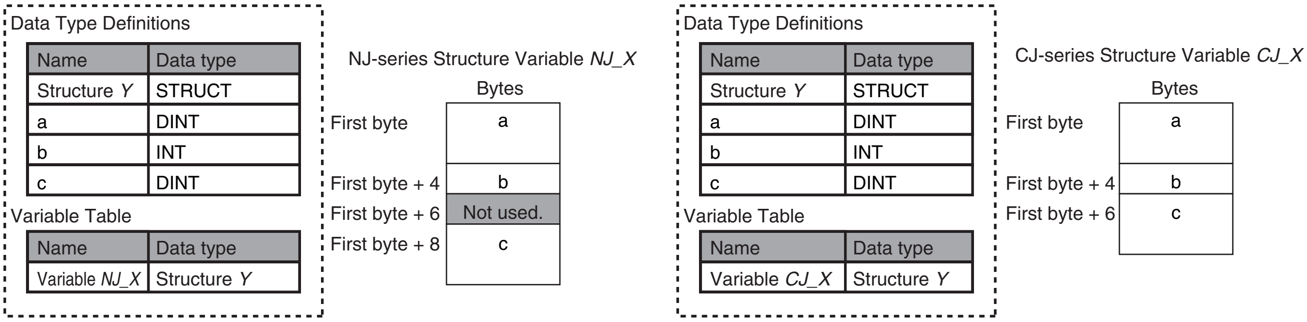
## A-7-2 Important Case Examples

When you exchange structure variable data between an NJ-series CPU Unit and another device, you must align the memory locations of the structure variable members with those of the other device. This is not necessary when you exchange data between NJ-series CPU Units.

You need to be aware of the locations in memory of structure variable members in the following cases.

### ● Reading and Writing Variables through CIP Messages or EtherNet/IP Tag Data Links between an NJ-series CPU Unit and Another CPU Unit

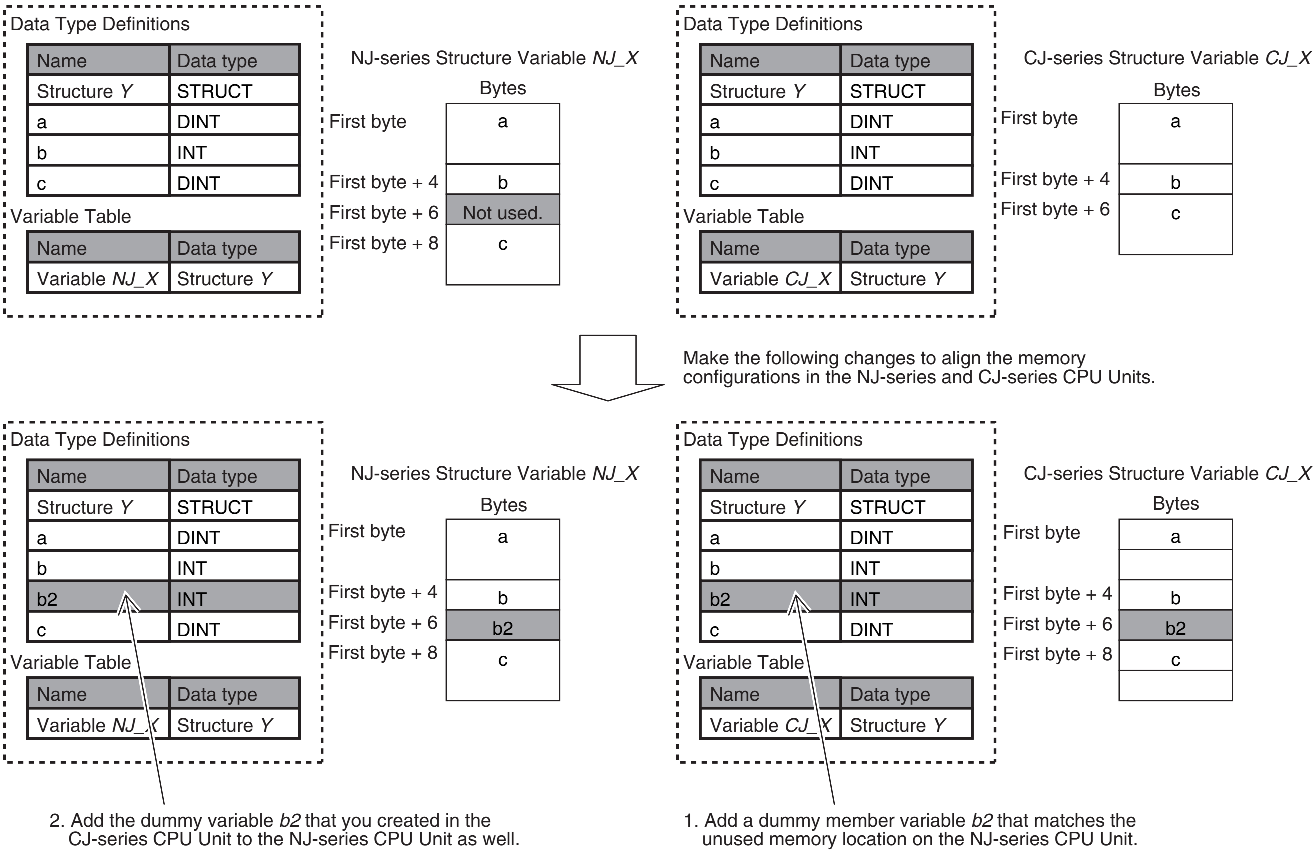
When the object for a tag data link includes a structure variable, make sure that the locations in memory of the structure variable members matches between the NJ-series CPU Unit and an other CPU Unit you need to exchange data with. For example, the differences in memory configuration for structure variables between an NJ-series CPU Unit and a CJ-series CPU are shown below.




In this case, align the CJ-series and NJ-series memory locations.

Solution: Insert members to adjust memory locations.

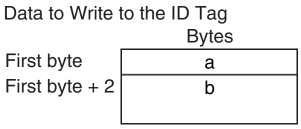
You must match both the memory locations and the data types. You need to create the alignment members for alignment in both the CJ-series and NJ-series CPU Units.



## ● Exchanging Structure Variable Data with ID Tags or Any Other Device Outside of the CPU Unit

When you create data to write to a device outside of the CPU Unit in an NJ-series CPU Unit structure variable, the data is arranged as shown below. Therefore, before you write the data to the ID Tag, you must arrange the data as shown below.

Example: Two-byte + four-byte data

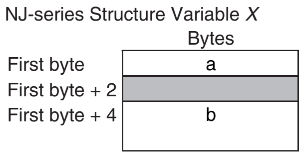



Data Type Definitions

| Name | Data type |
|---|---|
| Structure *Y* | STRUCT |
| a | INT |
| b | DINT |

Variable Table

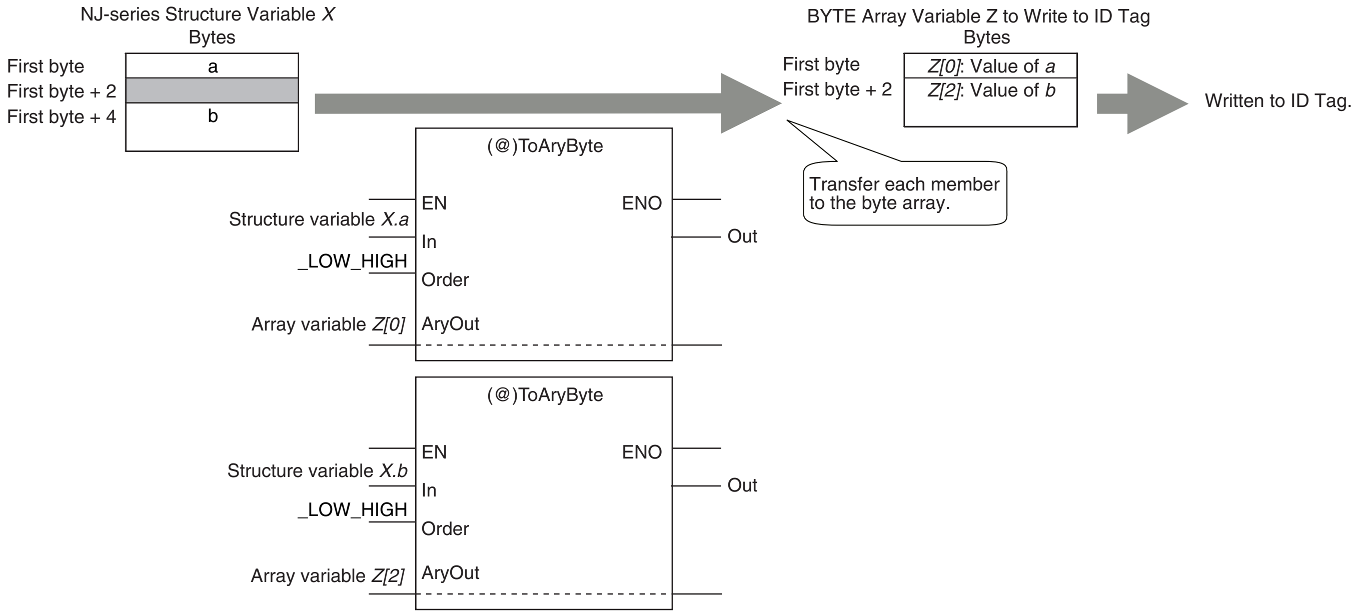
| Name | Data type |
|---|---|
| Variable *X* | Structure *Y* |



In this case, use one of the following solutions.

Solution 1: Change the data format of the ID tag.

Solution 2: Use instructions to convert the data on the NJ-series CPU Unit before you write it to the ID Tag.



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