OMRON

AC Servo System 1S-series

Startup Guide for Multi-axis Setup and Tuning

R88M-1A[]/R88D-1SAN[]-ECT (AC Servo System)
R88M-1[]/R88D-1SN[]-ECT (AC Servo System)
SYSMAC-SE20[][] (Automation Software)

Startup Guide

SYSMAC always in control

I827-E1-02

NOTE

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Introduction

The Servo System 1S-Series Startup Guide for Multi-axis Setup and Tuning (hereinafter, may be referred to as "this Guide") describes the procedures for installation and setup of 1S Servo Drives, where an NJ/NX-series CPU Unit is used in combination with1S-series AC Servomotors/Servo Drives and NX-series Safety Unit, by using the Sysmac Studio. A simple installation model is used for the discussion. You can perform the procedures that are presented in this Guide to quickly gain a basic understanding of a 1S-series AC Servomotors/Servo Drives.

This Guide does not contain safety information and other details that are required for actual use. Thoroughly read and understand the manuals for all of the devices that are used in this Guide to ensure that the system is used safely. Review the entire contents of these materials, including all safety precautions, precautions for safe use, and precautions for correct use.

Intended Audience

This Guide is intended for the following personnel.

- Personnel in charge of introducing FA systems
- Personnel in charge of designing FA systems

The personnel must also have the following knowledge.

- Knowledge of electrical systems (an electrical engineer or the equivalent)
- Knowledge of NJ/NX-series CPU Units
- Knowledge of Servomotors/Drives
- Knowledge of operation procedure of Sysmac Studio

Applicable Products

This Guide covers the following products.

- CPU Units of NJ/NX-series Machine Automation Controllers
- Automation Software Sysmac Studio
- 1S-series Servomotors/Servo Drives or 1S-series Servomotors/Servo Drives with Safety Functionality
- NX-series EtherCAT Coupler Unit

Special Information

The icons that are used in this Guide are described below.

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.

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Additional information to read as required.

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- When building a system, check the specifications for all devices and equipment that will make up the system and make sure that the OMRON products are used well within their rated specifications and performances. Safety measures, such as safety circuits, must be implemented in order to minimize the risks in the event of a malfunction.
- Thoroughly read and understand the manuals for all devices and equipment that will make up the system to ensure that the system is used safely. Review the entire contents of these manuals, including all safety precautions, precautions for safe use, and precautions for correct use.
- Confirm all regulations, standards, and restrictions that the system must adhere to.
- Check the user program for proper execution before you use it for actual operation.

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The NJ-series CPU Units and Sysmac Studio incorporate 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/.

Related Manuals

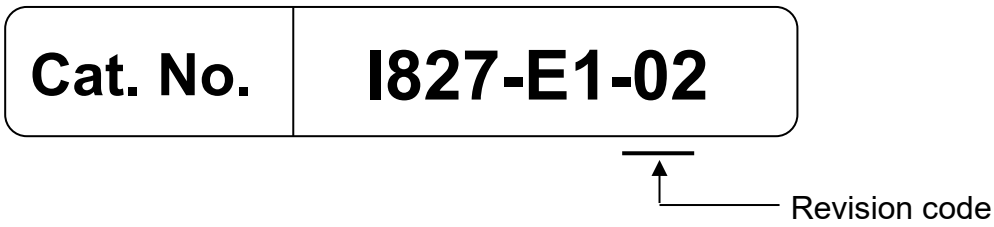
The following manuals are related. Use these manuals for reference.

Manual name	Cat. No.	Model	Application	Description
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.
Sysmac Studio Drive Functions Operation Manual	I589-E1	SYSMAC-SE2□□□	Learning about the operating procedures and functions of the Sysmac Studio for Drives	Describes the operating procedures of the Sysmac Studio to setup Drives
NJ-series CPU Unit Hardware User´s Manual	W500	NJ501-□□□□ NJ301-□□□□	Learning the basic specifications of the NJ-series CPU Units, including introductory information, designing, installation, and maintenance. Mainly hardware information is provided.	Provides an introduction to the entire NJ-series system along with the following information on the CPU Unit. • Features and system configuration • Overview • Part names and functions • General specifications • Installation and wiring • Maintenance and inspection Use this manual together with the *NJ/NX-series CPU Unit Software User's Manual* (Cat. No. W501).
NJ/NX-series CPU Unit Software User's Manual	W501	NJ501-□□□□ NJ301-□□□□	Learning how to program and set up an NJ/NX-series CPU Unit. Mainly software information is provided.	Provides the following information on a Controller built with an NJ/NX-series CPU Unit. • CPU Unit operation • CPU Unit features • Initial settings • Language specifications and programming based on IEC 61131-3 Use this manual together with the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500).
NJ/NX-series CPU Unit Motion Control User's Manual	W507	NJ501-□□□□ NJ301-□□□□ NJ101-□□□□	Learning about motion control settings and programming concepts.	Describes the settings and operation of the CPU Unit and programming concepts for motion control. When programming, use this manual together with the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500) and *NJ/NX-series CPU Unit Software User's Manual* (Cat. No. W501).
NJ/NX-series Instructions Reference Manual	W502	NJ501-□□□□ NJ301-□□□□	Learning detailed specifications on the basic instructions of an NJ/NX-series CPU Unit.	Describes the instructions in the instruction set (IEC 61131-3 specifications). When programming, use this manual together with the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500) and *NJ/NX-series CPU Unit Software User's Manual* (Cat. No. W501).

Manual name	Cat. No.	Model	Application	Description
NJ/NX-series Motion Control Instructions Reference Manual	W508	NJ501-□□□□ NJ301-□□□□	Learning about the specifications of the motion control instructions that are provided by OMRON.	Describes the motion control instructions. When programming, use this manual together with the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500), *NJ/NX-series CPU Unit Software User's Manual* (Cat. No. W501), and *NJ/NX-series CPU Unit Motion Control User's Manual* (Cat. No. W507).
NJ/NX-series Troubleshooting Manual	W503	NJ501-□□□□ NJ301-□□□□	Learning about the errors that may be detected in an NJ/NX-series Controller.	Describes concepts on managing errors that may be detected in an NJ/NX-series Controller and information on individual errors. Use this manual together with the *NJ-series CPU Unit Hardware User's Manual* (Cat. No. W500) and *NJ/NX-series CPU Unit Software User's Manual* (Cat. No. W501).
1S-series AC Servomotors/Servo Drives with Built-in EtherCAT Communications User's Manual	I586	R88D-1S□-ECT R88M-1□	Learning detailed specifications of a 1S-series Servo Drive.	Describes the hardware, setup methods, and functions of the 1S-series with Built-in EtherCAT Communications.
1S-series AC Servomotors/Servo Drives with Built-in EtherCAT Communications and Safety Functionality User's Manual	I621	R88D-1SAN□-ECT R88M-1AL□/1AM□	Learning about the 1S-series with Built-in EtherCAT Communications and Safety Functionality.	Describes the hardware, setup methods, and functions of the 1S-series with Built-in EtherCAT Communications and Safety Functionality.

Revision History

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



Revision code	Date	Revised content
01	April 2017	Original production
02	April 2023	• Added new functionality to Easy Tuning (Multiple Drives). • Corrected mistakes.

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1. Servo System Configuration and Peripheral Products

1.1. Outline

The 1S-series AC Servo Drives with Built-in EtherCAT communications support 100-Mbps EtherCAT. When you use the 1S-series Servo Drive with a Machine Automation Controller NJ/NX-series CPU Unit, you can construct a high-speed and sophisticated positioning control system.
Also, you need only one communications cable to connect the Servo Drive and the Controller. Therefore, you can realize a position control system easily with reduced wiring effort.
With auto tuning, adaptive filter, notch filter, and damping control, you can set up a system that provides stable operation by suppressing vibration in low-rigidity machines.
For machine composed with multiple 1S-series AC Servo Drives, Sysmac Studio provides a set of functions to set-up and tune parameters with less effort.

Additional Information

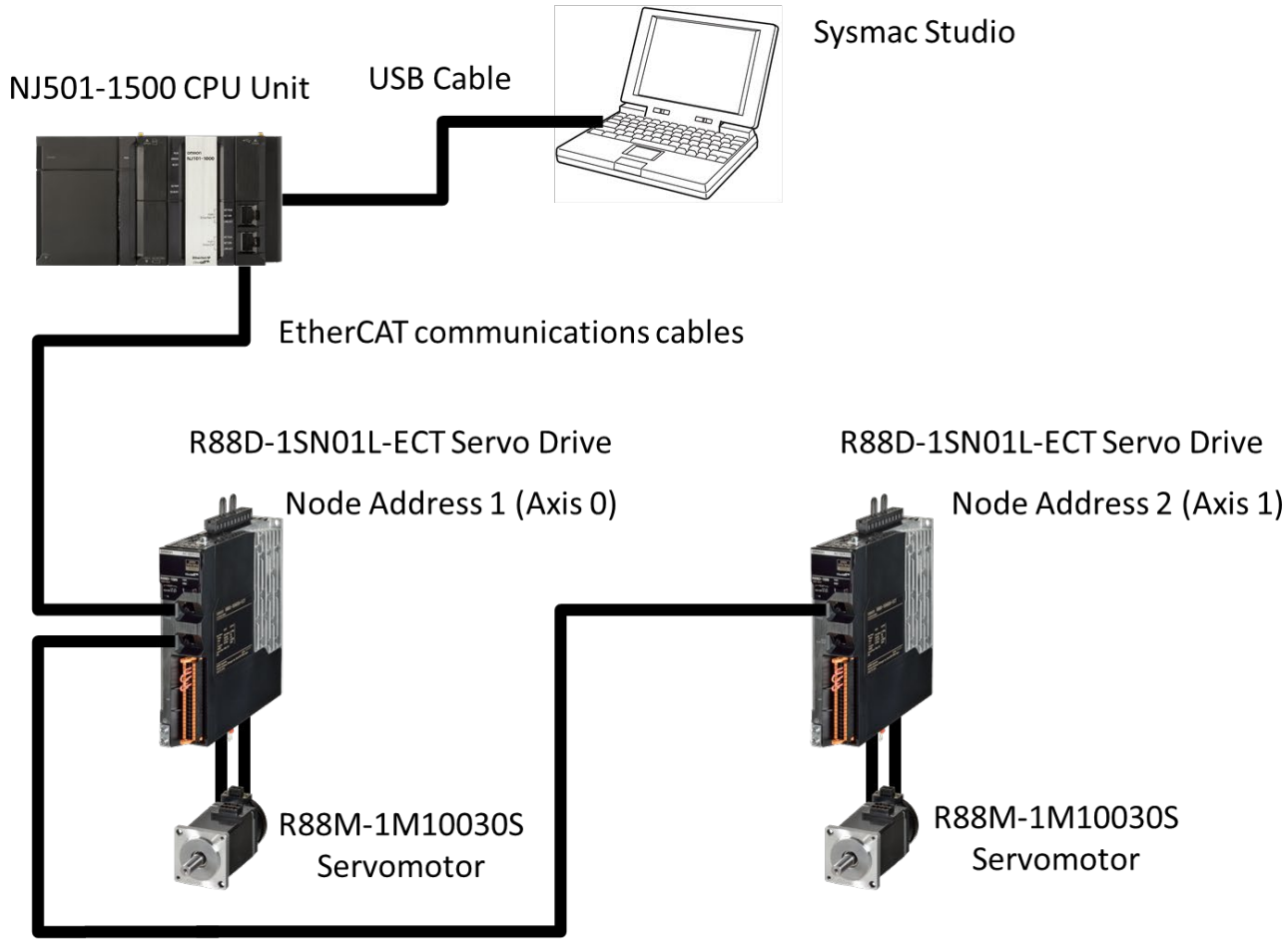
For additional information about 1S servo drive, please refer to 1S-series AC Servomotors and Servo Drives User's Manual (with Built-in EtherCAT Communications) (Cat. No. I586)

1.2. Servo System constructed in this guide

This 1S-series Startup Guide for multi-axis setup and tuning (hereafter referred to as “this Guide”) contains instructions to set up and tune systems composed of two 1S-series AC Servo Drives in multi-axis configurations, using an XY stage system with independent axes and a gantry system with mechanically linked axes as examples. Refer to Section 3 for the setup of an XY stage system and Section 4 for the setup of a gantry system.

The following figure shows the system configuration and devices that are used in this Guide.

The system configuration is shown in the following figure.



• Configuration devices

The models of the devices that are described in this Guide are given in the following table. When selecting devices for an actual application, refer to the device manuals.

Device name	Model	Manual name
NJ-series CPU Unit	NJ501-1500	NJ-series CPU Unit Hardware User's Manual (Cat. No. W500)
NJ-series Power Supply Unit	NJ-PA3001	
EtherCAT communications cables	XS5W-T421-CMD-K	
AC Servo Drives	R88D-1SN01L-ECT	1S-series AC Servomotors and Servo Drives User's Manual (with Built-in EtherCAT Communications) (Cat. No. I586)
AC Servo Motors	R88M-1M10030S	
Power cables	R88A-CA1A003S	
Encoder Cables	R88A-CR1A003C	

• Automation software

Product	Number of license	Model
Sysmac Studio Standard Edition Version 1.54 or higher	None (DVD only)	SYSMAC-SE200D
	1 license	SYSMAC-SE201L

2. Before You Begin

2.1. Installing the Sysmac Studio

The Sysmac Studio is the 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.
Install the Sysmac Studio on your computer.
Refer to the *NJ-series Startup Guide for CPU Units* (Cat. No. W513) for the procedure to install the Sysmac Studio.

2.2. Assembling the Hardware

This section describes how to assemble the hardware used in the system.
This section gives an overview of the assembly procedures. Refer to the manuals for the devices that are used in the system for detailed assembly procedures and safety precautions.

Precautions for Safe Use

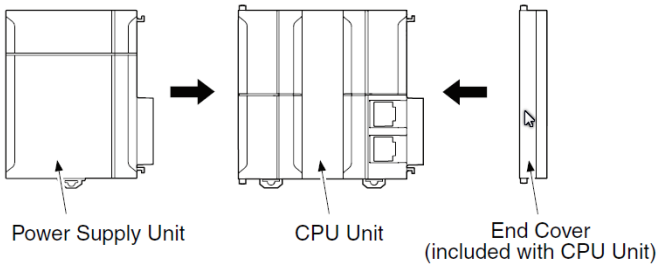
Always turn OFF the power supply to the Controller and to the Servo Drives before you attempt any of the following.

- Mounting or removing the CPU Unit and Other Units
- Assembling Racks
- Setting DIP switches or rotary switches.
- Connecting cables or wiring the system
- Connecting or disconnecting the connectors

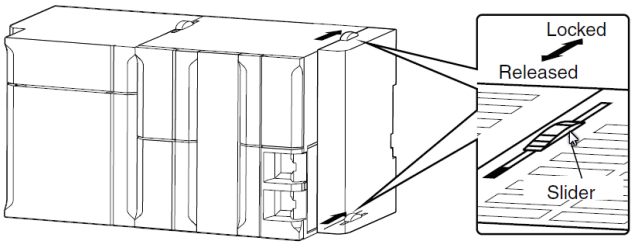
The Power Supply Unit continues to supply power to the Controller for up to several seconds after the power supply is turned OFF. The PWR indicator remains lit as long as power is supplied. Make sure that the PWR indicator is not lit before you perform any of the above operations.

Mounting the Units

Connect the Power Supply Unit, CPU Unit, and End Cover.



After joining the connectors between the Units, use the sliders at the top and bottom of each Unit to lock the Units together. Lock the sliders firmly into place.

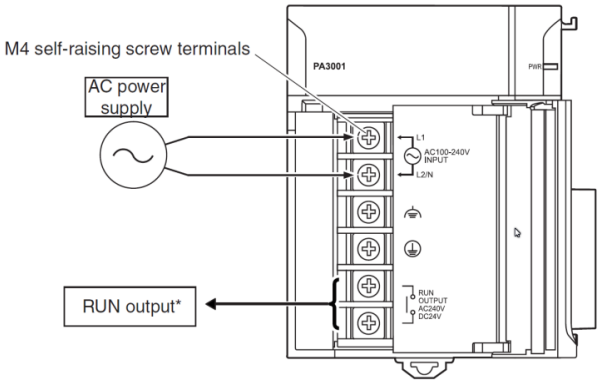


2.3. Wiring the Devices

This section describes how to wire the hardware devices.
This section gives an overview of the wiring procedures. Refer to the manuals for the devices that are used in the system for detailed wiring procedures and safety precautions.

Wiring the Rack Power Supply Unit

Wire the Power Supply Unit to the power supply.



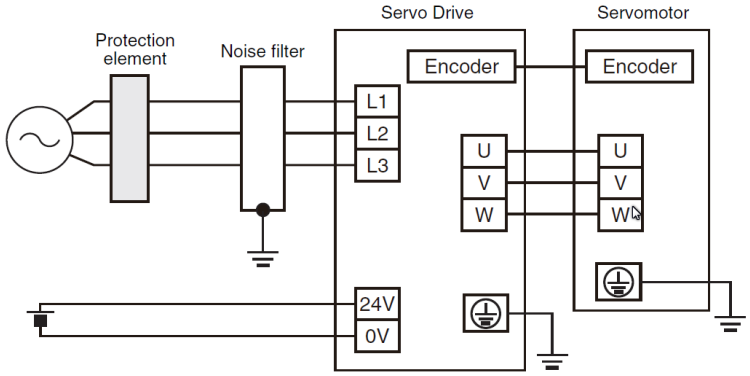
*The RUN output is ON when the CPU Unit is in RUN mode. It is OFF when the CPU Unit is in PROGRAM mode or when a major fault level Controller error occurs.

Additional Information

This Guide uses an NJ-PA3001 AC Power Supply Unit. An NJ-PD3001 DC Power Supply Unit can also be used.

Wiring the Servo Drive Power Supply

Wire the Servo Drives to the power supply as shown in the following figure.

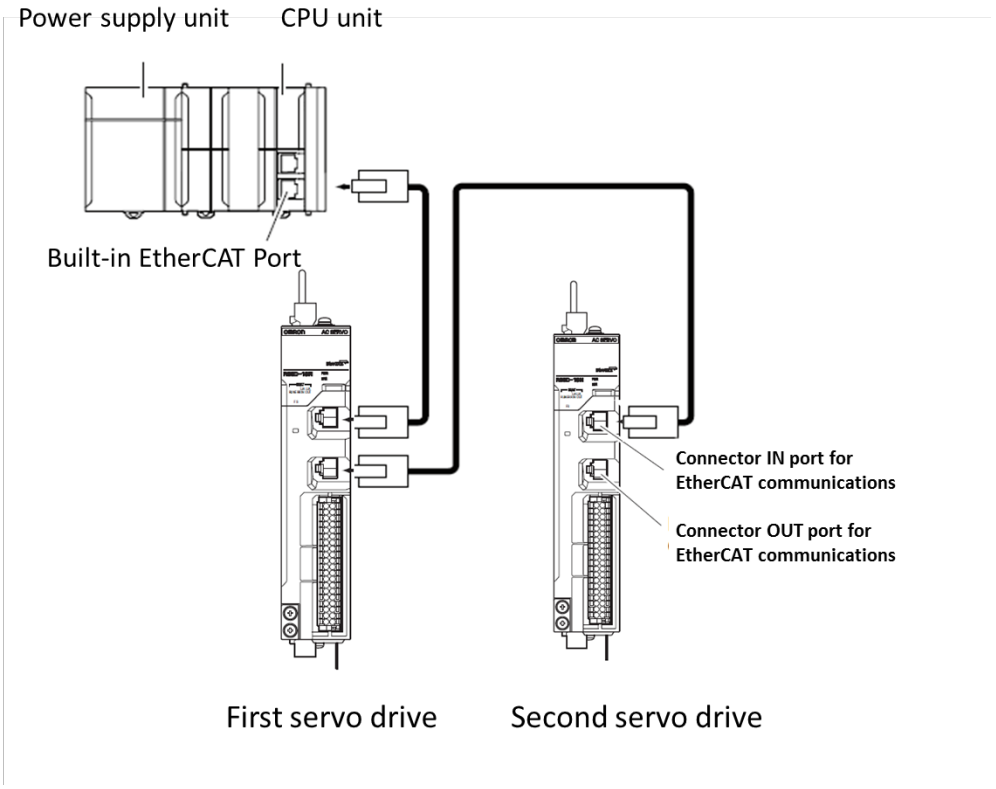


Additional Information

For further details about wiring method, please refer to 1S-series AC Servomotors and Servo Drives User's Manual (with Built-in EtherCAT Communications) (Cat. No. I586)

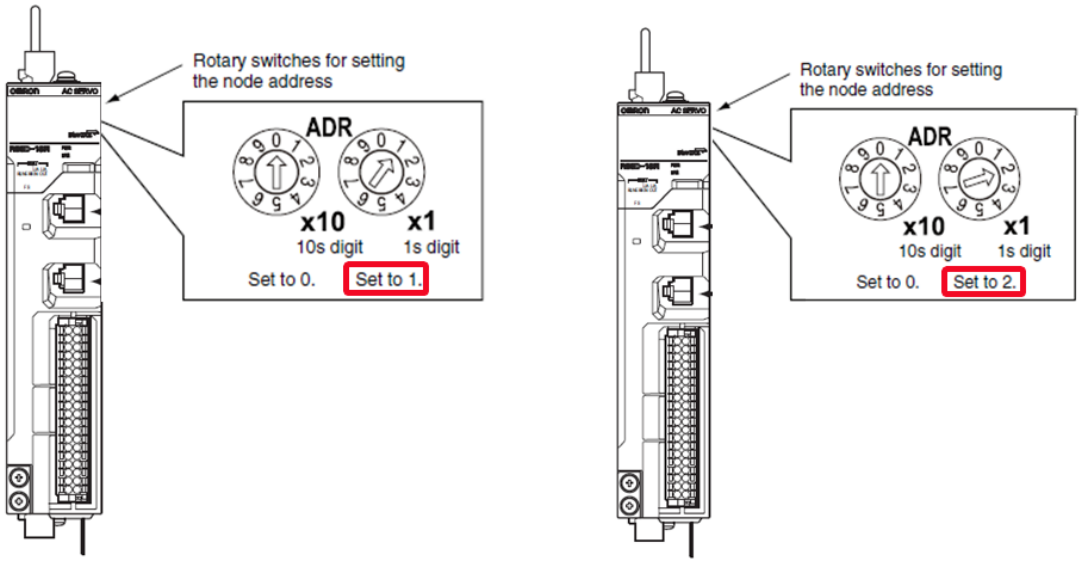
Laying EtherCAT Communications Cables

Connect the EtherCAT slave communications cables between the built-in EtherCAT port on the CPU Unit and the EtherCAT slaves as shown in the following figure.
Connect the communications cable from the built-in EtherCAT port to the input port on the first slave, and then connect the communications cable to the next slave to the output port on the first slave.
Do not connect anything to the output port of the slave at the end of the network.



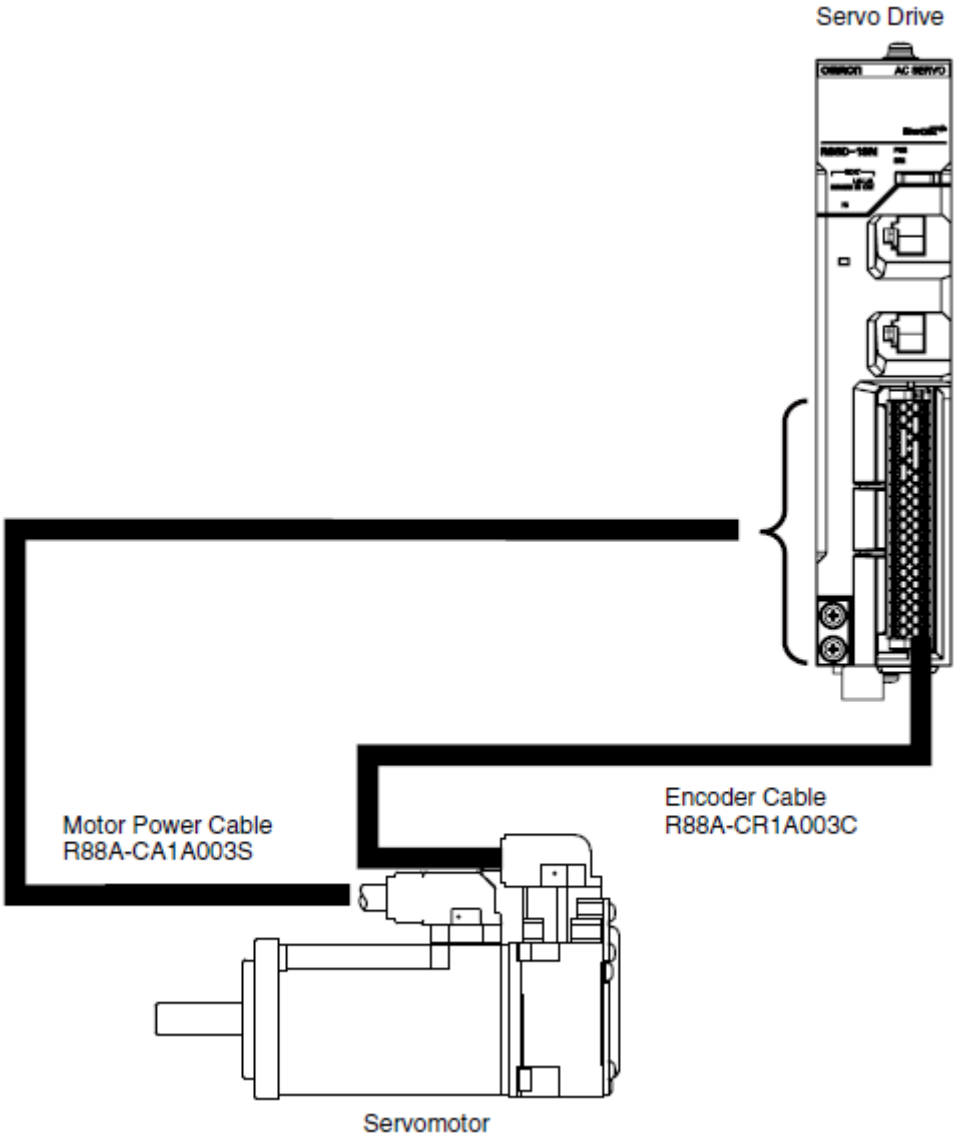
Setting the Node Addresses of the Servo Drives

Set the node addresses of the Servo Drives as shown below.



Wiring the Servo Drives and the Servomotors

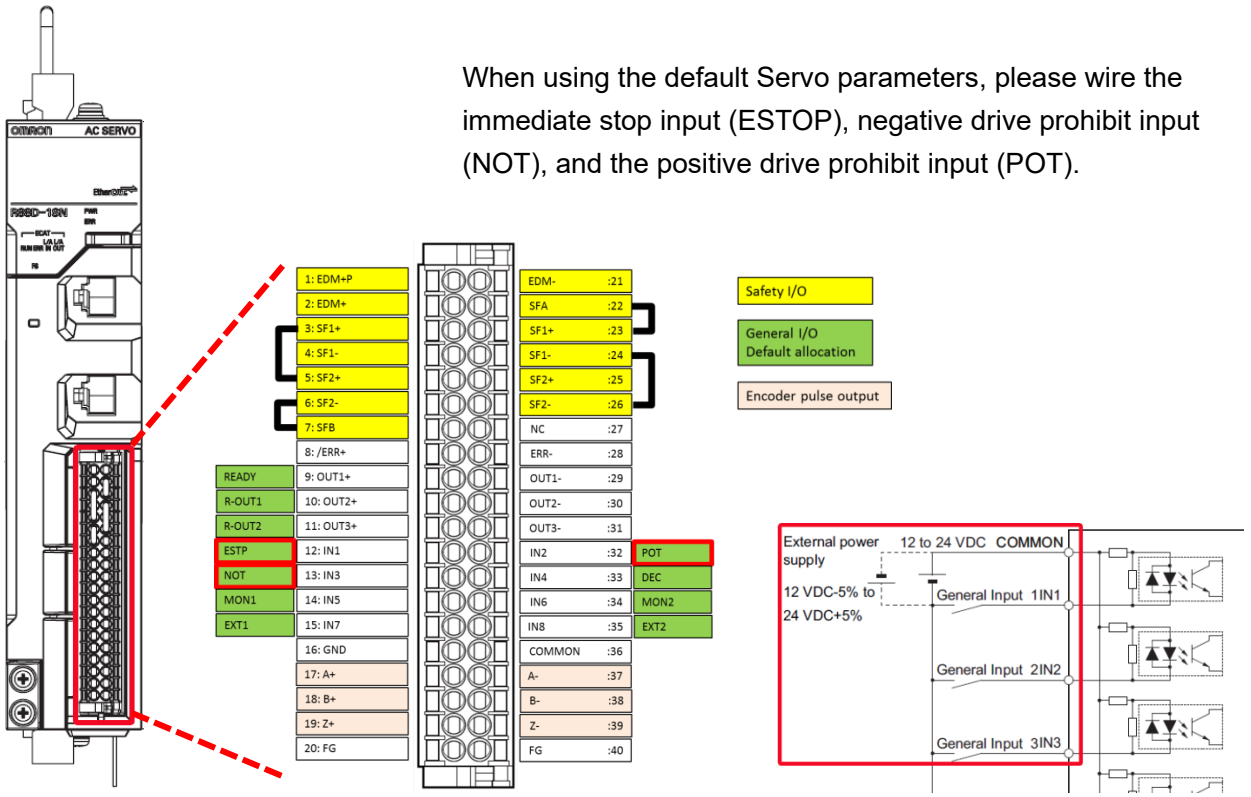
Wire the Servo Drives and the Servomotors as shown in the following figure.



Wiring the Control Input Signals for the Servo Drives

Wire the control input signals for the Servo Drive using the R88A-CN101C Control I/O connector (CN1).

For details on wiring, refer to the AC Servomotors/Servo Drives 1S-series with Built-in EtherCAT Communications User's Manual (Cat. No. I586).



*Control I/O Connector (CN1):

Used for command input signals, I/O signals, and as the safety device connector. The short-circuit wire is installed on the safety signals before shipment.

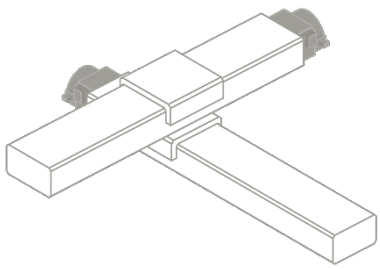
Additional Information

- If you use the default Servo parameters, you must wire the immediate stop input, negative drive prohibit input, and the positive drive prohibit input.
  If these inputs are not wired, the CPU Unit will remain in the drive prohibit signal and emergency stop signal detected state, and a minor fault level Controller error will occur. The minor fault level Controller errors that will occur are an Immediate Stop Input Error and a Drive Prohibition Input Error. (The event codes are 68220000 and 64E30000.)
- If the above signals are temporarily not wired while commissioning the system, you can temporarily change the Servo parameters to prevent these errors from occurring in the CPU Unit.
  Refer to A-1 Settings When Control Input Signals Are Not Wired for details on the settings that you must change in this case.

3. Performing Setup

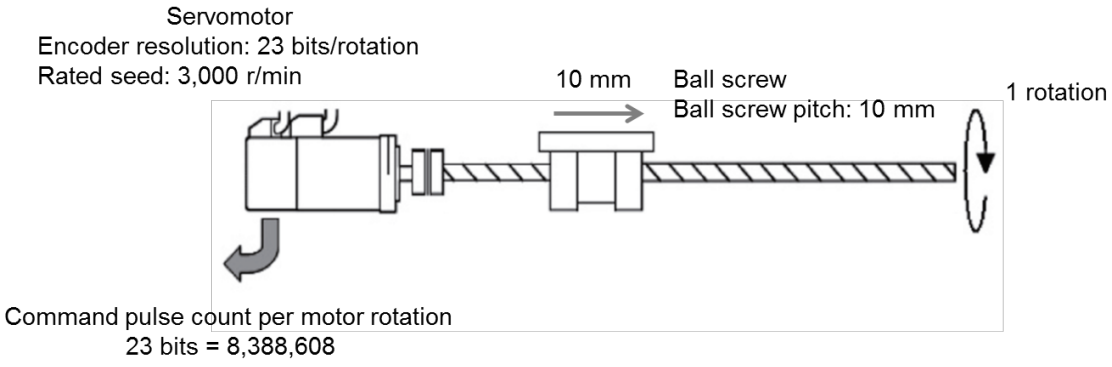
3.1. Two-axis Servo System Operation (XY Stage System)

This section describes how to set up an XY stage system as a two-axis servo system.
In this system, axis 0 and axis 1 are set up for an XY stage.

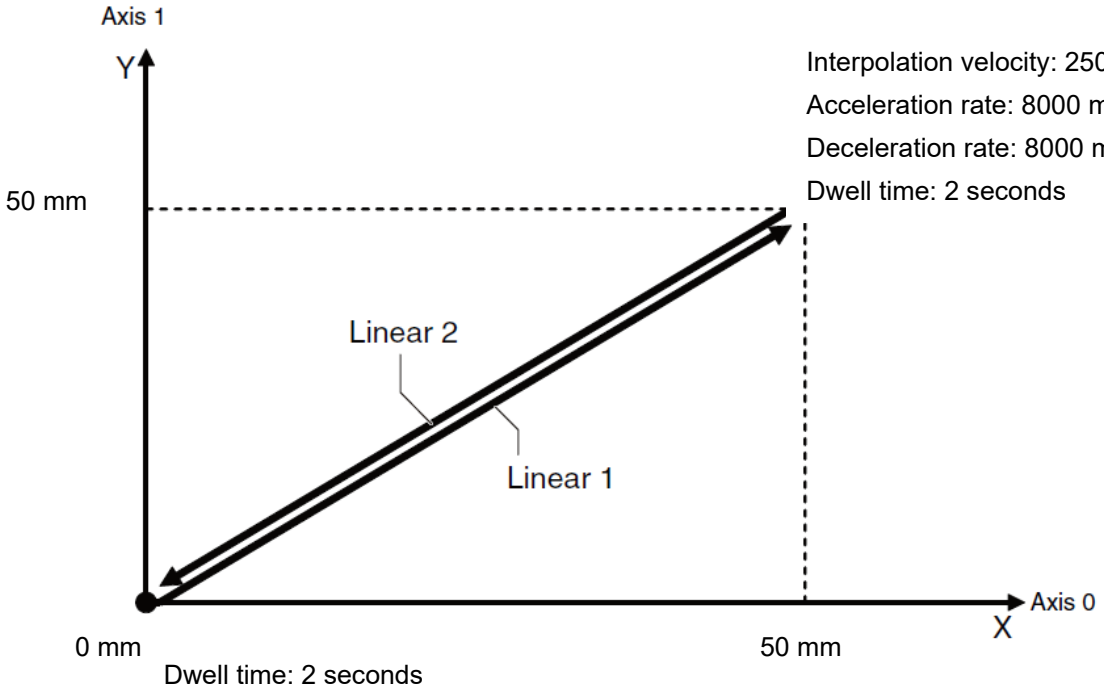


The mechanical configuration of axis 0 and axis 1 are as shown in the following table.

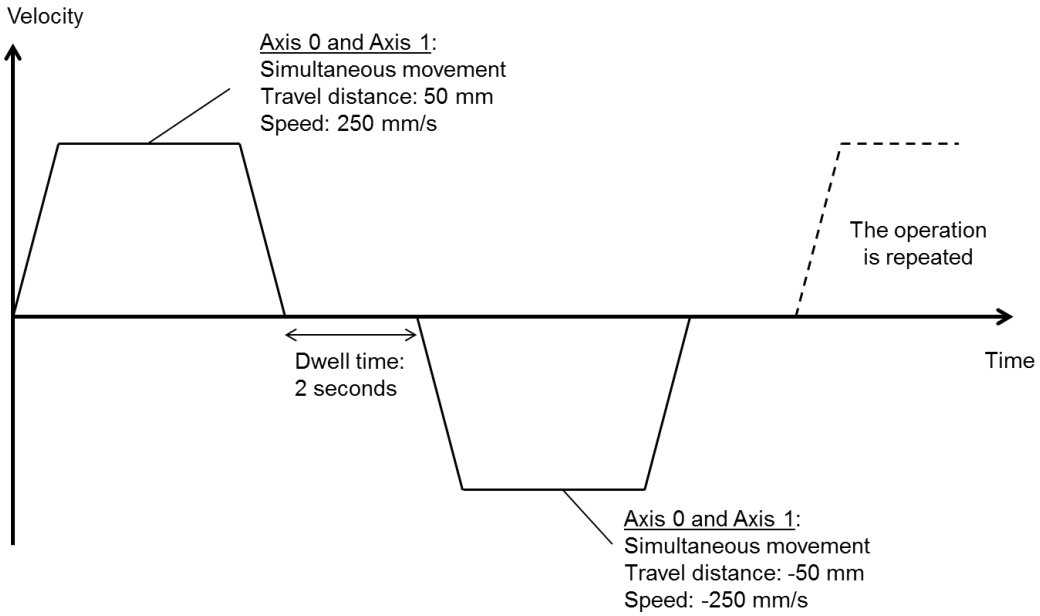
Item	Axis 0 / Axis 1 mechanical configuration
Motor rated speed	3000 r/min
Ball screw pitch	10 mm
Encoder resolution	23 bits/rotation



The XY stage moves back and forth between two points using linear interpolation. It dwells for two seconds after each movement.



The speed waveforms for axis 0 and axis 1 are shown below



3.2. System setup procedures

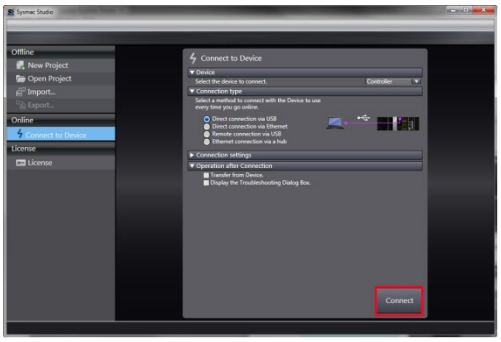
1	Create a project with Auto connection
▼	
2	Create the EtherCAT Network configuration
▼	
3	Create motion axes
▼	
4	Program making and transfer to the CPU Unit
▼	
5	Drives and motors parameters setup
▼	
6	Easily Tuning Multiple Drives (Gain Adjustment)

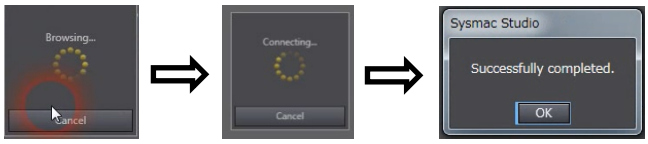
3.3. Creating project with Auto connection

Start the Sysmac Studio:

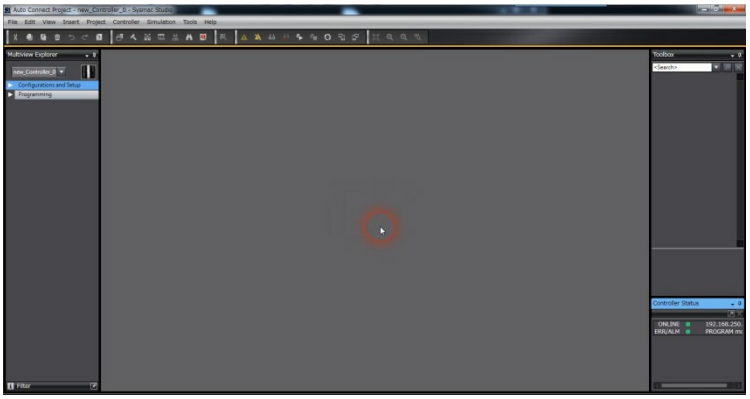
Select **All Programs − OMRON − Sysmac Studio − Sysmac Studio** from the Windows Start Menu.

Create a project in the Sysmac Studio

1.	Click the Button in the Project window
2.	In the **Connect to Device** Dialog Box, Click the button  Sysmac Studio will browse and connect to the controller



This concludes the procedure to create a project file with auto connection

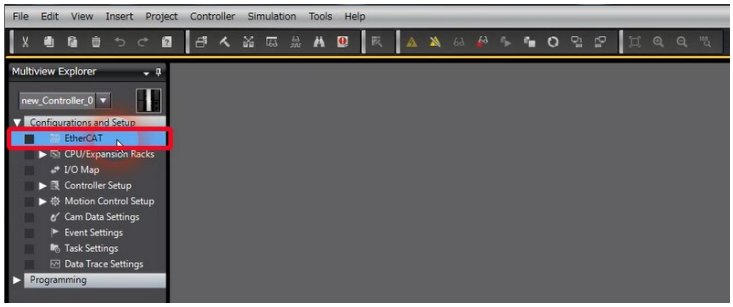
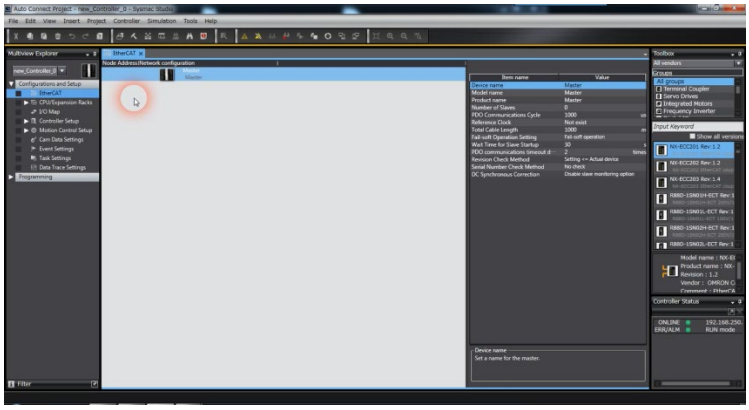
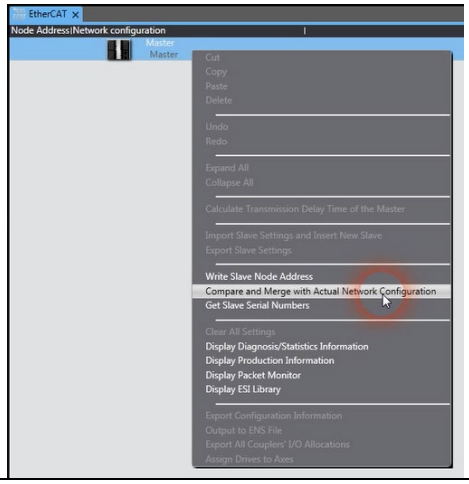


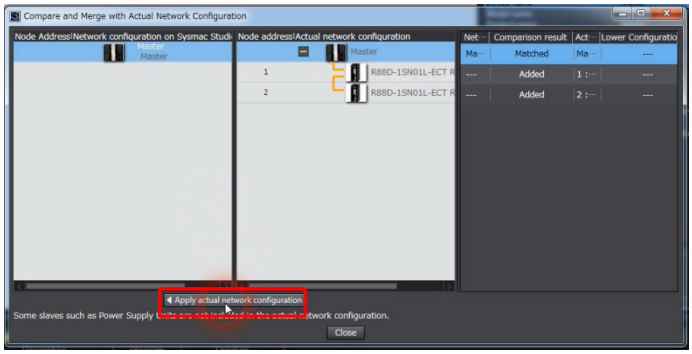
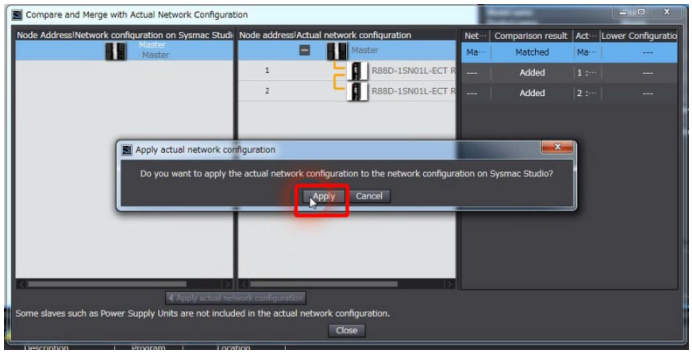
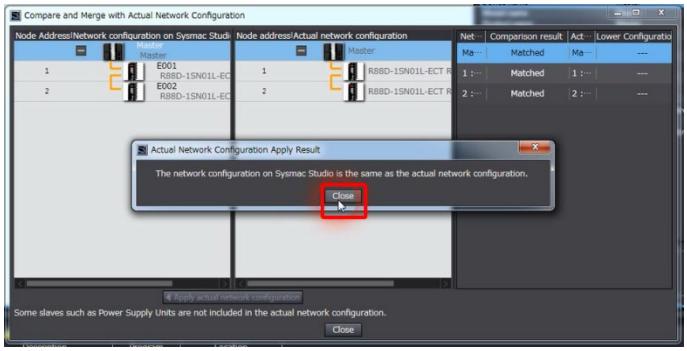
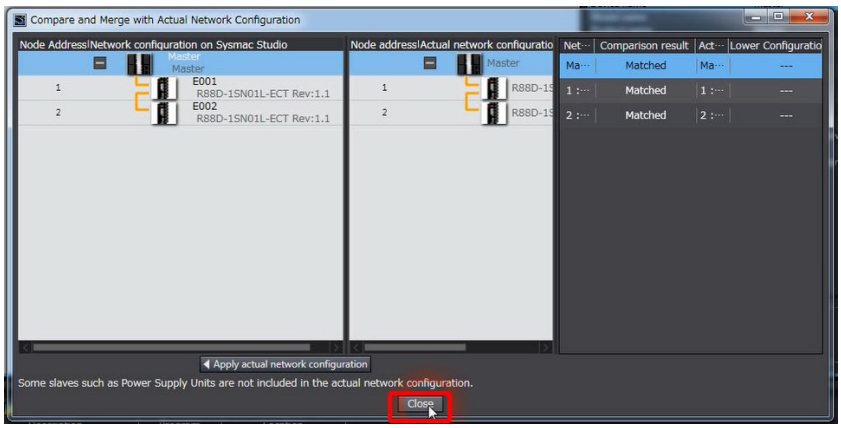
Additional Information

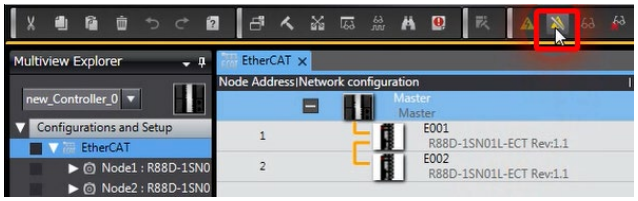
For creating a project offline or specific procedures please refer to the Sysmac Studio Version 1 Operation Manual (Cat. No. W504).

3.4. Creating the EtherCAT Network Configuration

Two R88D-1SN01L-ECT Servo Drives are registered in the EtherCAT network configuration

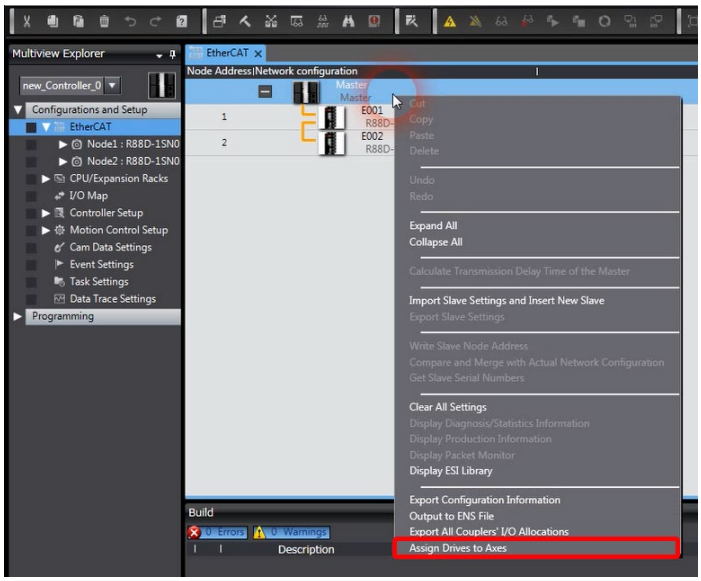
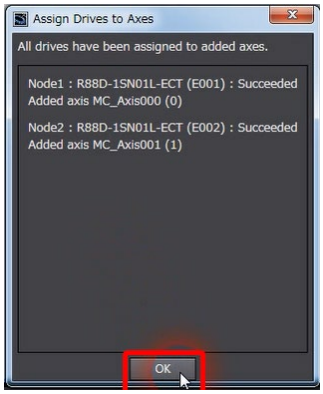
1.	Double-click **EtherCAT** under **Configurations and Setups** in the Multiview Explorer.  The EtherCAT page is displayed in the Edit Pane. 
2.	Right click on the **Master** and select **Compare and Merge with Actual Network Configuration** 

3.	The Compare and Merge with Actual Network Configuration window is displayed Click on **Apply actual network configuration** to apply the actual network configuration.  Click **Apply** to confirm:  A pop-up message confirmed the network configuration. Click the **Close** Button  Confirm the detected configuration and close the window 

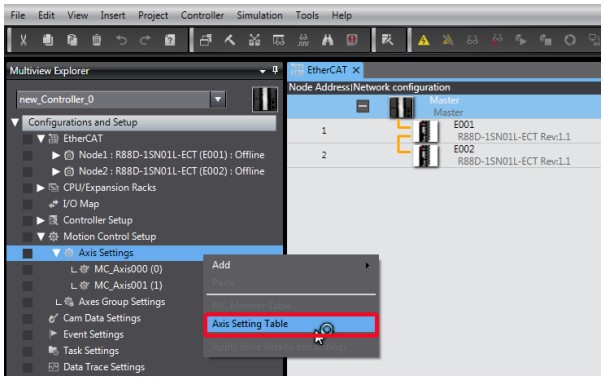
	Disconnect from the controller 

3.5. Creating motion axes

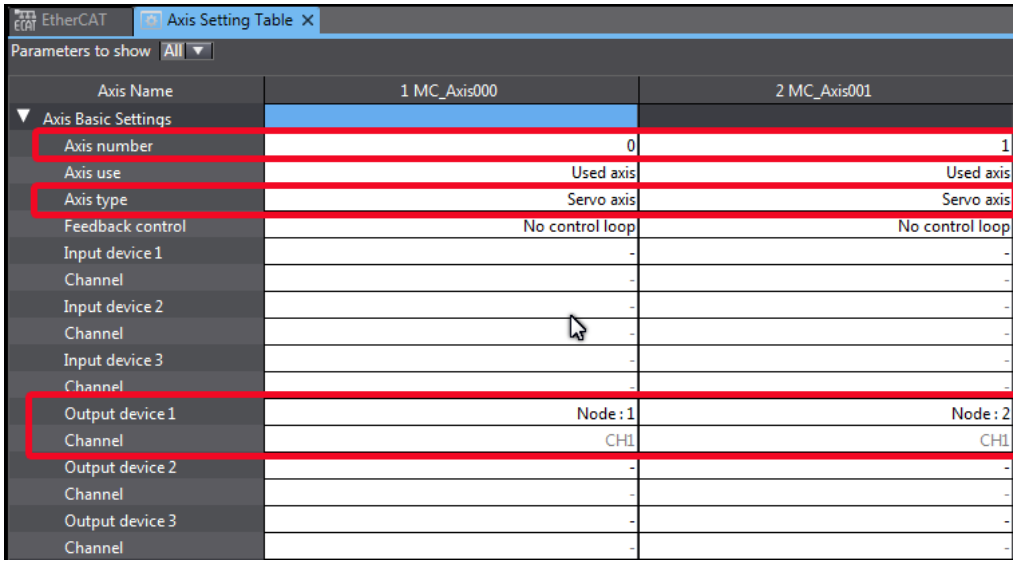
This section describes how to add axes used to control Servo Drives. Axes will be created based on detected Servo Drives.

1.	Right click on the **Master** and select **Assign Drives to Axes**  Confirm axes allocation by clicking the **Yes** Button Confirm the list of Axes added and Click the **Ok** Button 

Right-click **Axis Settings** in the Multiview Explorer and select **Axis setting table.**



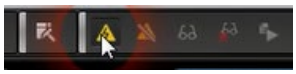
Axis number has been set to 0 and 1**, Axis type** to Servo axis and **Output device 1** to Node: 1 and Node: 2 on CH1 (Channel 1).



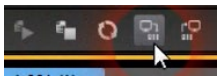
Axis Name	1 MC_Axis000	2 MC_Axis001
Axis Basic Settings		
Axis number	0	1
Axis use	Used axis	Used axis
Axis type	Servo axis	Servo axis
Feedback control	No control loop	No control loop
Input device 1	-	-
Channel	-	-
Input device 2	-	-
Channel	-	-
Input device 3	-	-
Channel	-	-
Output device 1	Node : 1	Node : 2
Channel	CH1	CH1
Output device 2	-	-
Channel	-	-
Output device 3	-	-
Channel	-	-

Project transfer to synchronize Sysmac Studio project and the CPU unit

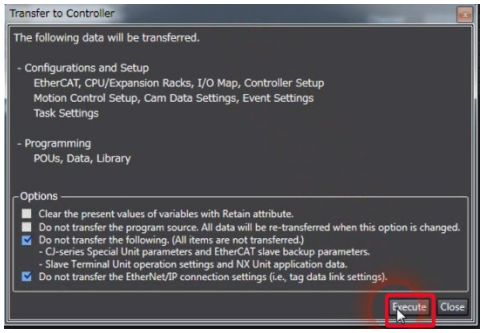
2. Click the **Connect Button** on the Toolbar



Click the **Transfer to Controller** Button on the Toolbar



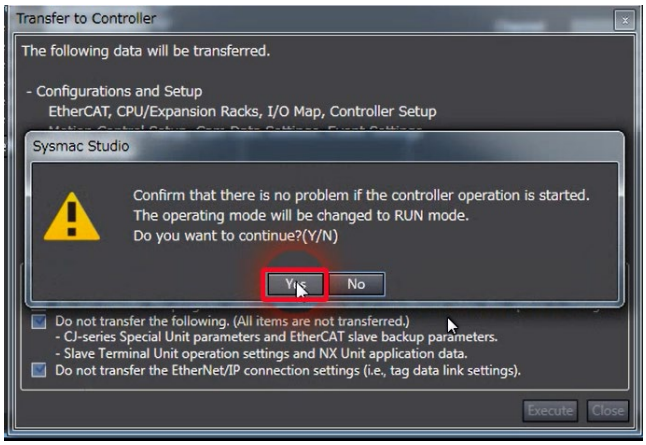
Click the **Execute** Button to transfer the project from the computer to the CPU unit



Click the **Yes** Button

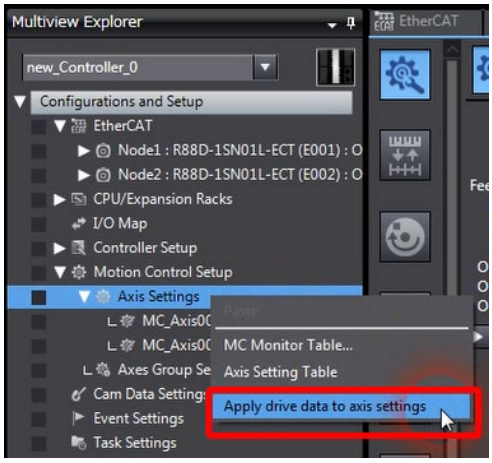
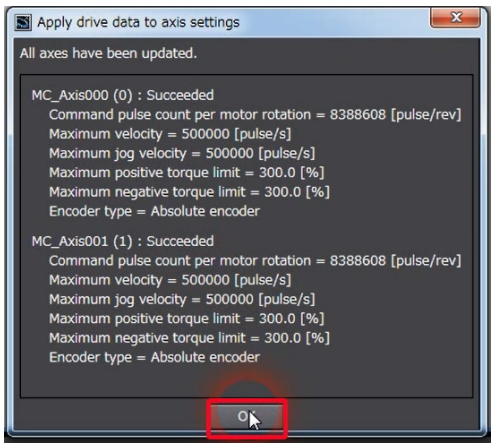
The operating mode changes to PROGRAM mode, and the Sysmac Studio starts transferring the project to the CPU Unit. During the transfer, a progress bar appears in the Synchronize Pane.

After download completion, Click The Yes Button to switch to RUN mode.

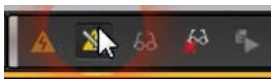
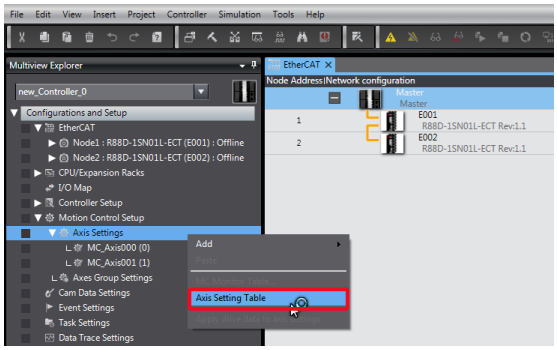
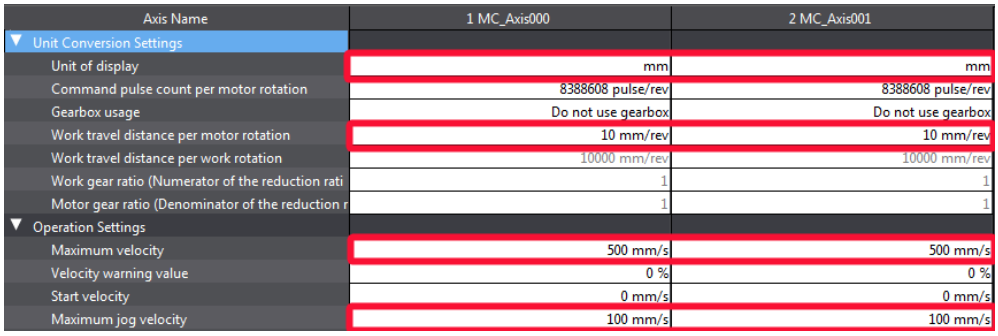


The transfer is completed, Click the Ok Button

Apply Drive/Motor data to axis via network reading

3.	Right-click **Axis Settings** in the Multiview Explorer and select **Apply drive data to axis settings**.  Click the **Yes** Button to acquire data from the servo drive via EtherCAT Network Applied axis settings are based on drive and motor data: **Command pulse count per motor rotation** is set to 8,388,608 following the 23 bits resolution of the motor. **Maximum velocity** and **Maximum jog velocity** are set based on rated speed of the motor. **Maximum positive torque limit** and **Maximum negative torque limit** are set based on drive/motor maximum torque limit. **Encoder type** is set to Absolute encoder.  After confirmation, Click the **Ok** Button.

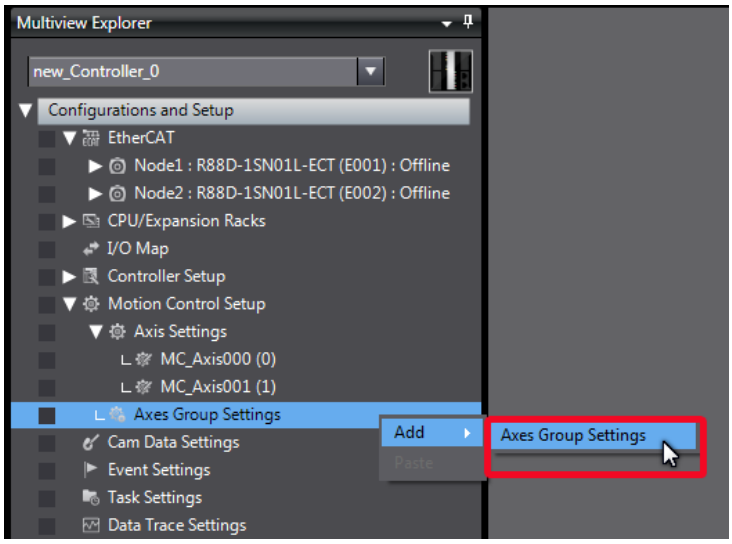
Modification of axis settings to match the XY stage System

3.	Disconnect from the Controller  Right-click **Axis Settings** in the Multiview Explorer and select **Axis setting table.**  **Edit axis settings according to the XY stage ball screw system** 

Axis Name	1 MC_Axis000	2 MC_Axis001
Unit Conversion Settings		
Unit of display	mm	mm
Command pulse count per motor rotation	8388608 pulse/rev	8388608 pulse/rev
Gearbox usage	Do not use gearbox	Do not use gearbox
Work travel distance per motor rotation	10 mm/rev	10 mm/rev
Work travel distance per work rotation	10000 mm/rev	10000 mm/rev
Work gear ratio (Numerator of the reduction rati	1	1
Motor gear ratio (Denominator of the reduction r	1	1
Operation Settings		
Maximum velocity	500 mm/s	500 mm/s
Velocity warning value	0 %	0 %
Start velocity	0 mm/s	0 mm/s
Maximum jog velocity	100 mm/s	100 mm/s

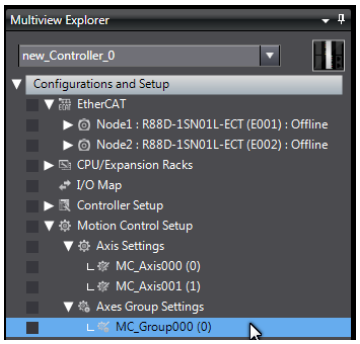
Note: Alternatively, Unit conversion settings can also be modified before transferring the project; in that case operation settings will be scaled based on mm units and drive data.

Adding Axes Group Settings

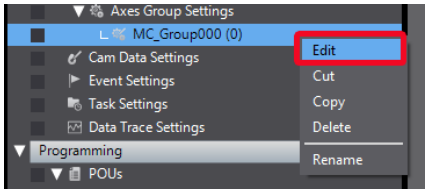
4.	Right-click **Axes Group Settings** under **Configurations and Setup - Motion Control Setup** in the **Multiview Explorer** and select **Add - Axes Group Settings** from the menu. 

An axes group is added to the Multiview Explorer.

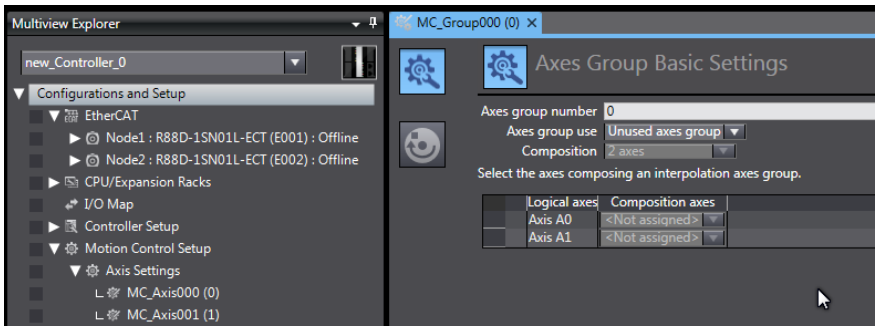
The new axes group is displayed as **MC_Group000**.



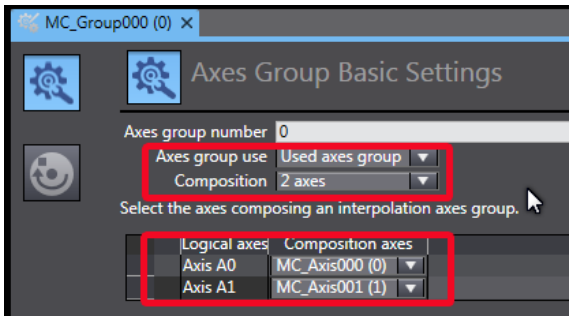
Right-click the group that you added in the Multiview Explorer and select **Edit** from the menu.



The axes group settings are displayed on the Axes Group Basic Settings Display in the Edit Pane.



Set the Axes Group Basic Settings for axes group 0 as shown in the following figure.



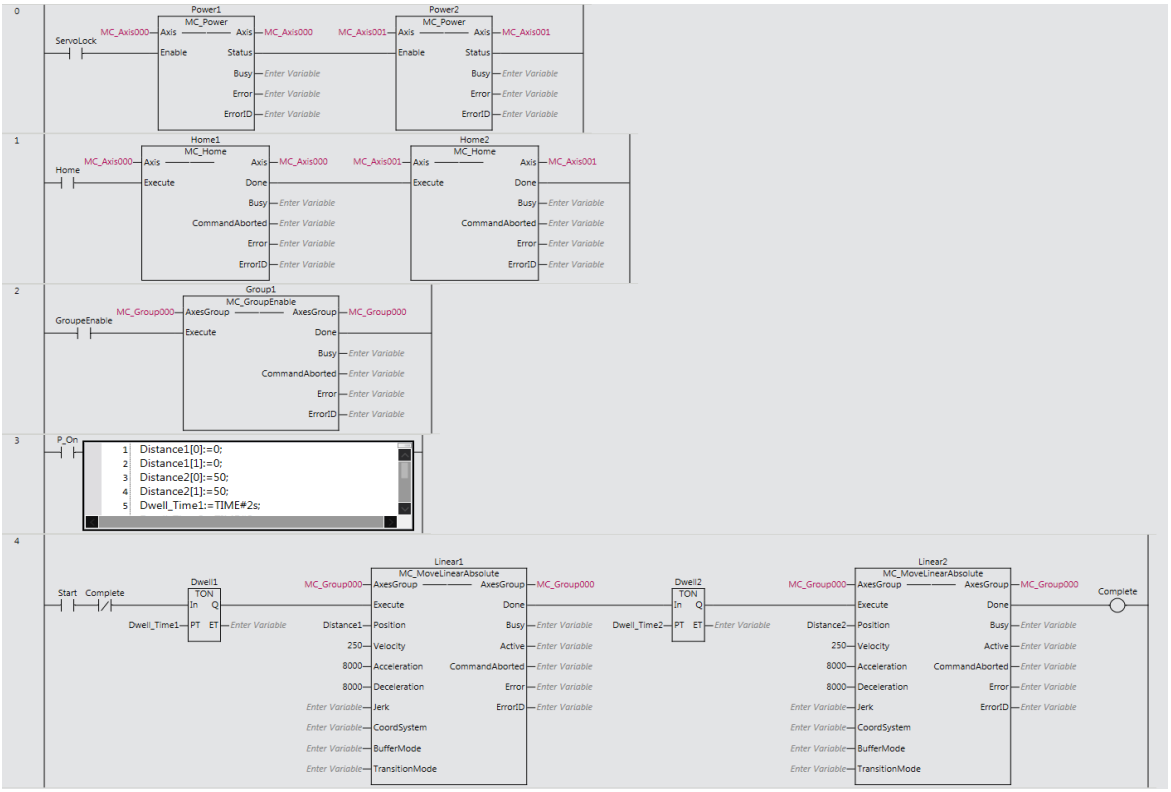
This concludes the axes group settings.

3.6. Program making and transfer to the CPU Unit

Create the instructions to perform linear interpolation of two axes.

The following instructions are created. To do so, we will use axis variables, an axes group, and motion control instructions.

Rung 0: Axes Servo ON
Rung 1: Axes homing to zero position preset
Rung 2: Axis group enable
Rung 3: Absolute position assigned to input variables
Rung 4: Movement cycle (Repeats Move 50 mm > Dwell for 2 s > Move -50 mm > Dwell for 2 s)



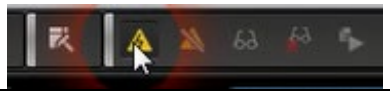
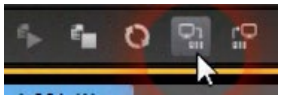
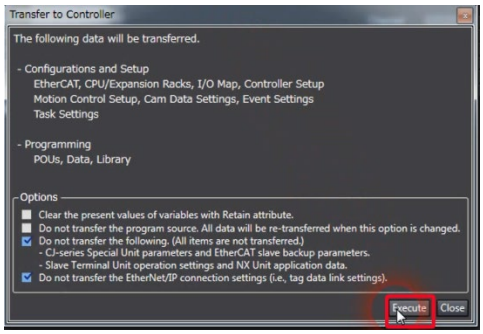
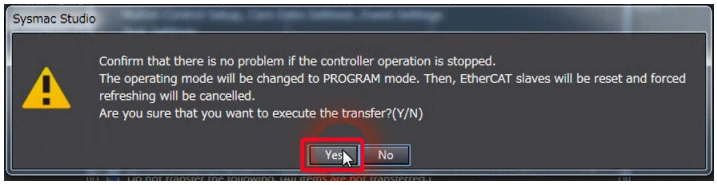
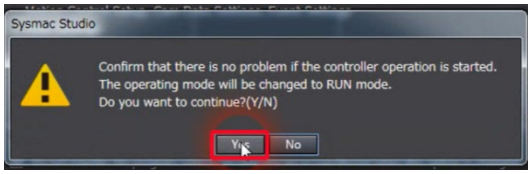
Please refer to A-2 Appendix for the equivalent Structured Text program example

Refer to the *NJ/NX-series Startup Guide for CPU Units* (Cat. No. W513) for details on how to create ladder diagrams.

Precautions for Correct Use

The sample programming that is provided in this Guide includes only the programming that is required to operate the Servomotors. When programming actual applications, also program EtherCAT communications, device interlocks, I/O with other devices, and other control procedures.

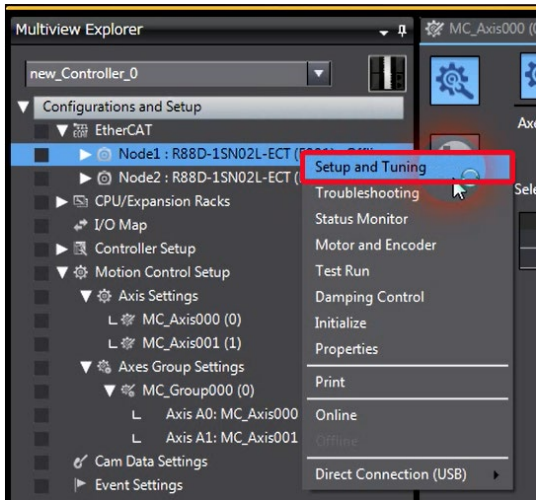
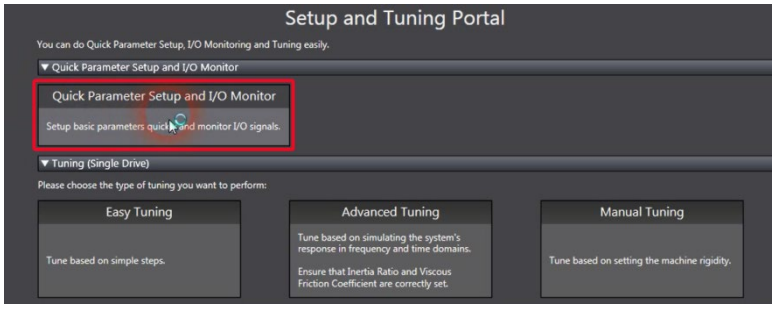
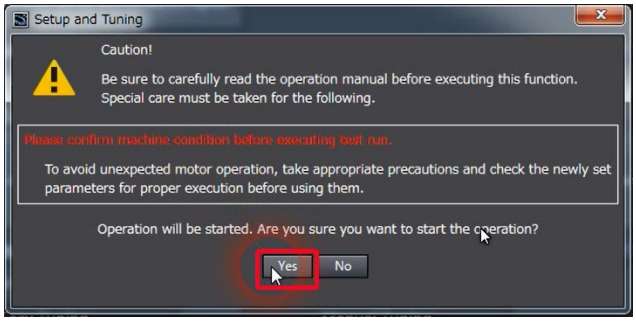
Transfer to the CPU Unit

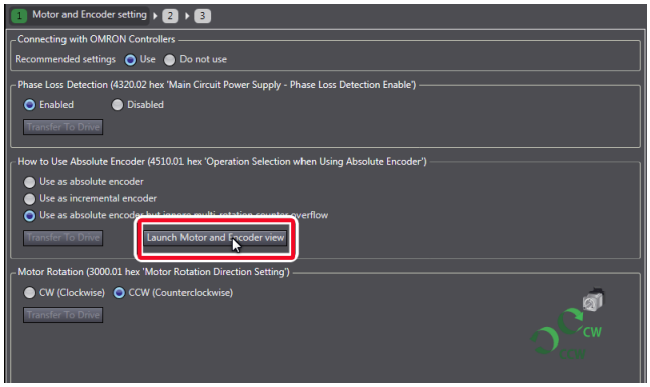
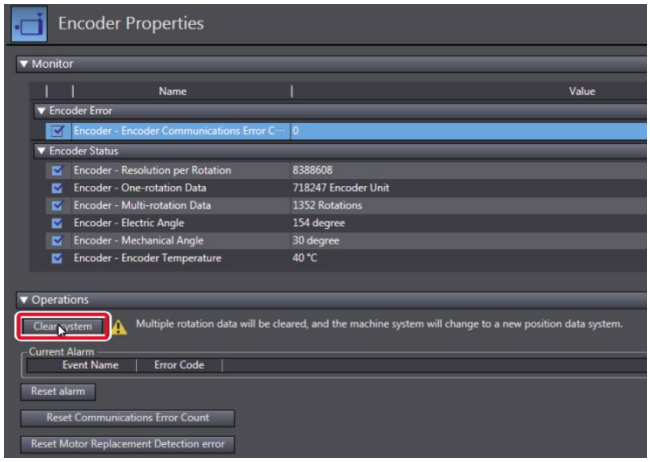
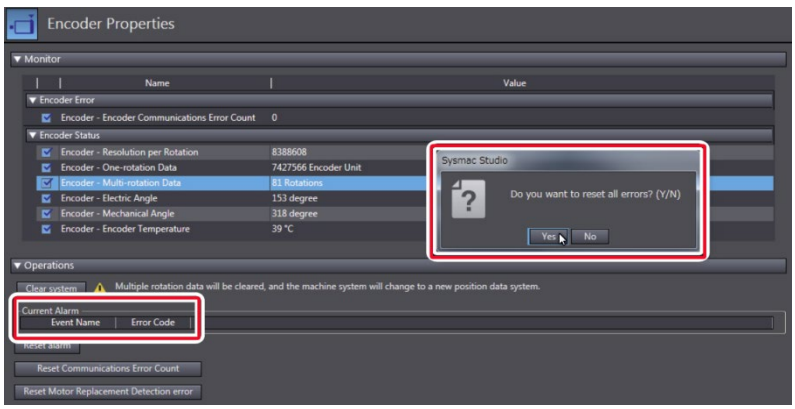
1.	Click the **Connect Button** on the Toolbar 
2.	Click the **Transfer to Controller** Button on the Toolbar 
3.	Click the **Execute** Button to transfer the project from the computer to the CPU Unit.  Click the **Yes** Button  The operating mode changes to PROGRAM mode, and the Sysmac Studio starts transferring the project to the CPU Unit. During the transfer, a progress bar appears in the Synchronize Pane. After download completion, Click The **Yes** Button to switch to RUN mode.  The transfer is completed, Click the **Ok** Button

3.7. Drives and motors parameters setup

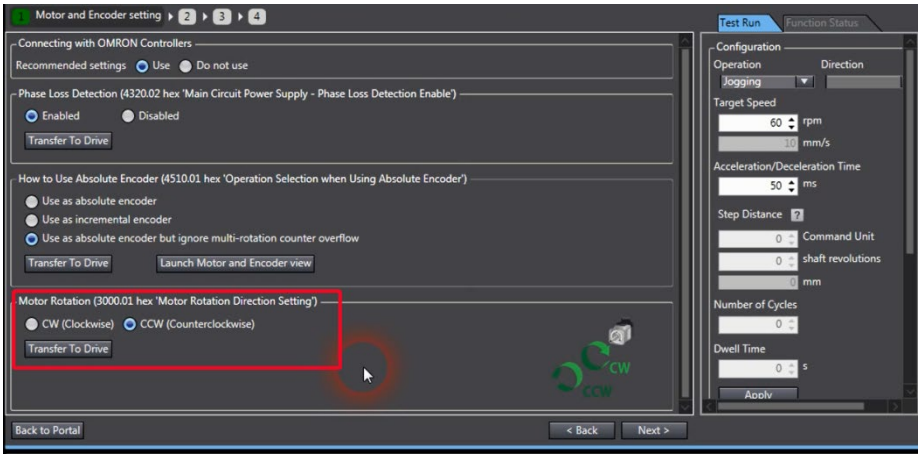
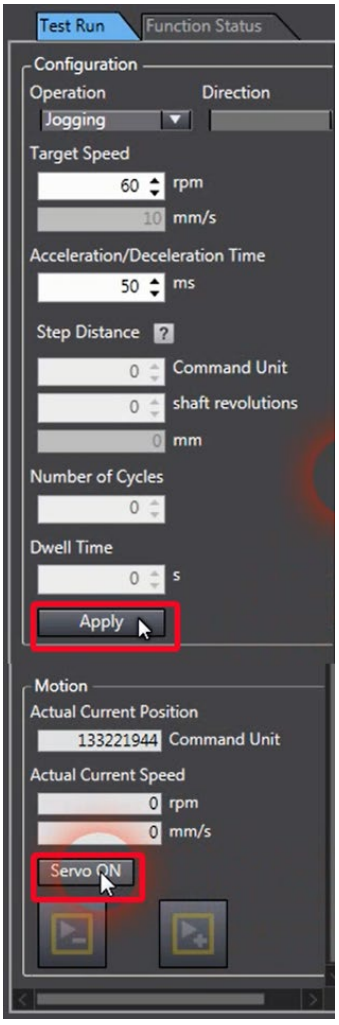
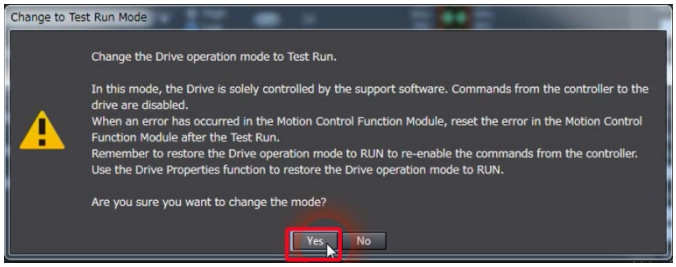
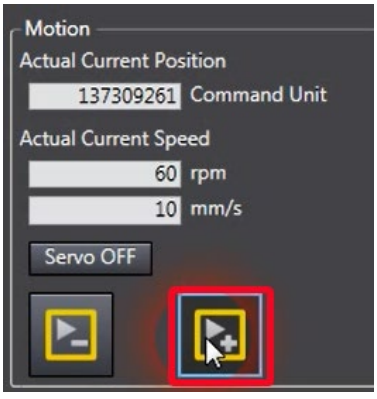
This section explains the procedure to setup parameters of drives and motors.

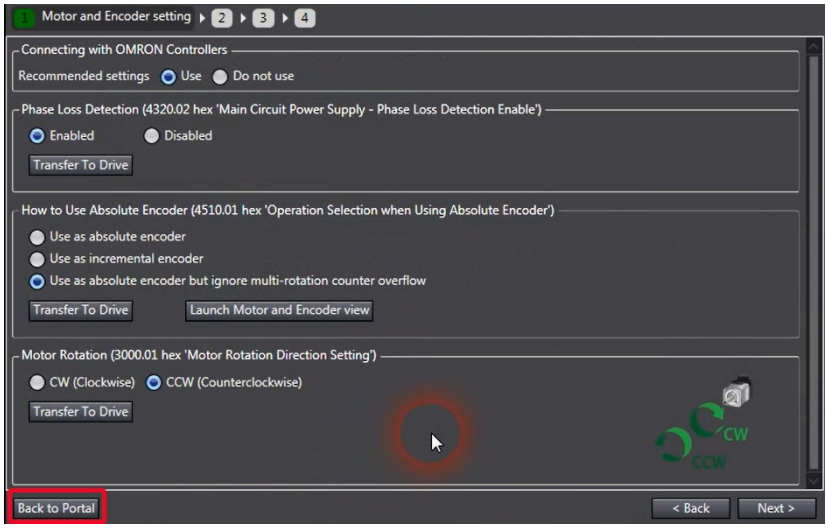
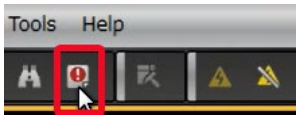
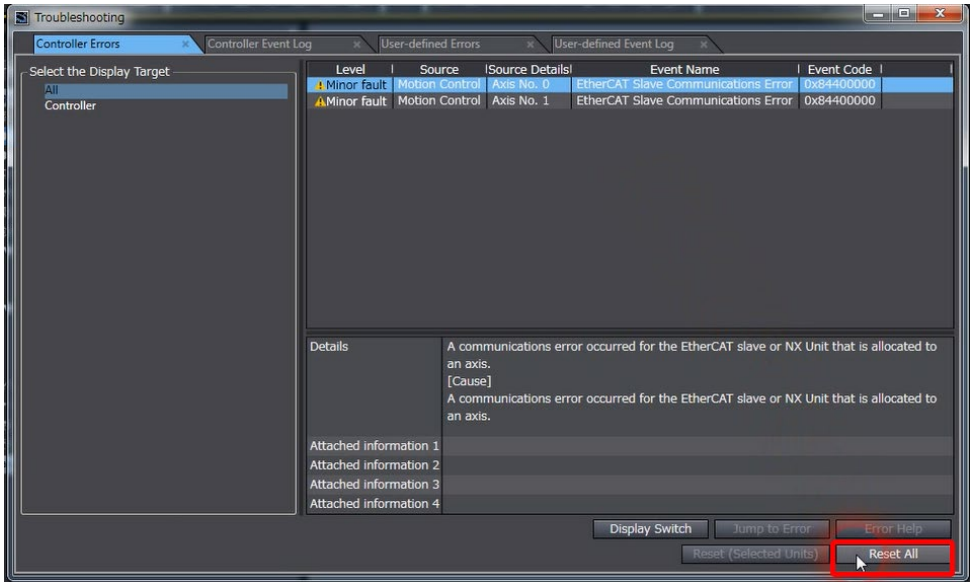
The absolute encoder must be set up the first time it is used, and when the rotation data is initialized to 0.

1.	Right-click the Servo Drive and select **Setup and Tuning** from the menu.  The Setup and Tuning Portal appears.
2.	Click the **Quick Parameter Setup and I/O Monitor** Button.  The following dialog box appears. Click the **Yes** Button.  The Motor and Encoder setting Page appears.

3.	Click the **Launch Motor and Encoder view** Button.  The Encoder Properties Tab Page appears.
4.	Click the **Clear system** Button.  An Absolute Value Clear Error (error display number: 2701) will occur, and a dialog box indicating "Restart the drive to complete the operation."
5.	Click the **Yes** Button.  The multiple rotation data of the absolute encoder is cleared. Return to the Wizard window.

Check the motor rotation direction and modify settings if required

6.	Adjust the motor rotation direction and transfer to the drive 
7.	**Validate the motor operation** Apply the test run configuration, activate the Servo ON and initiate the movement    Note: In case of Error 87.00 ESTP input, please check your wiring connection or disable the error stop input (IN1) as explained in A-1 Settings When Control Input Signals Are Not Wired for details on the settings that you must change in this case.

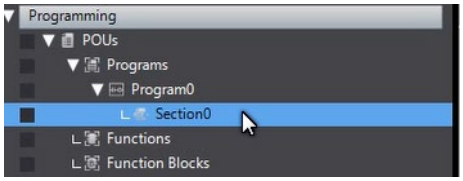
8.	Click the **Back to Portal** Button 
9.	Please repeat the same operation for the node 2.
10.	Following above procedure, drives have been restarted to apply Input settings. Please Reset the EtherCAT Slave Communication Error in the CPU Unit with Troubleshooting window.  Click on **Reset All** button 

3.8. Easily Tuning Multiple Drives (Gain Adjustment) — When There Is No Axis Interference

In this section we will explain how to perform Easy tuning for multiple Drives simultaneously.
The Motion Controller will perform the motion profile.
Before running the program, be sure to place the XY system in the homing position required.

Confirm operating mode of the CPU Unit is in RUN mode and then use control
BOOL variables (set/reset) to control the motion control instructions.

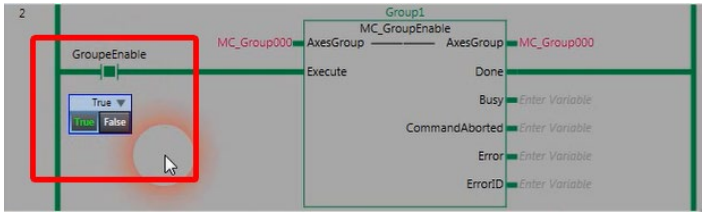
Double-click **Section0** under **Programming − POUs − Programs − Program0** in the Multiview Explorer.



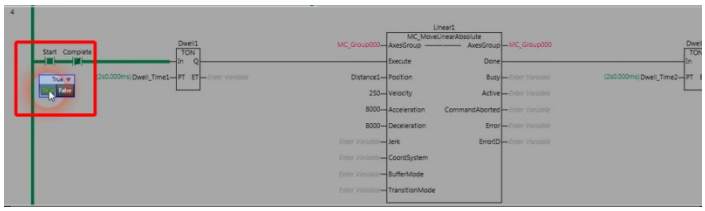
The ladder program is displayed in the Edit Pane.
Change the BOOL variables in the following order :
Change *ServoLock* to TRUE to execute Power1 and Power2.

Change *Home* to TRUE to execute Home1 and Home2. This sets the axes to preset zero positions for the axes. (Homing sets the axes to preset zero positions.)

Change *GroupeEnable* to TRUE to execute Group1.

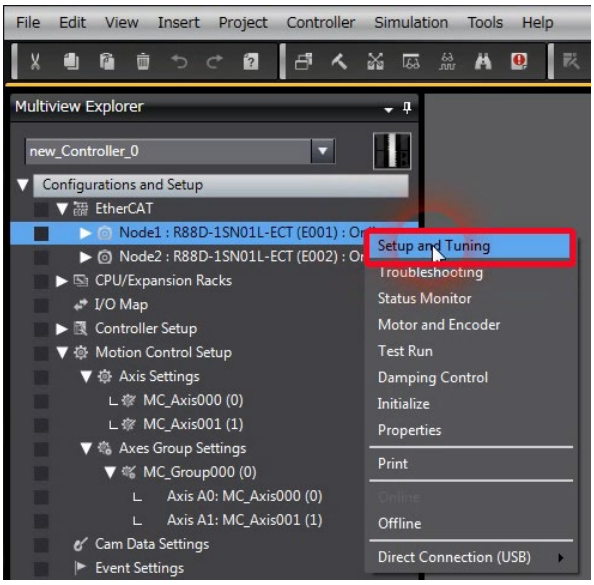
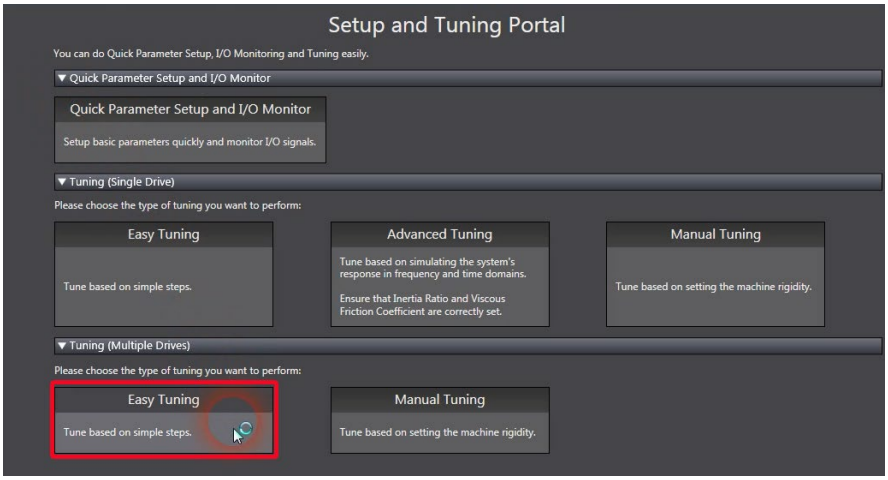
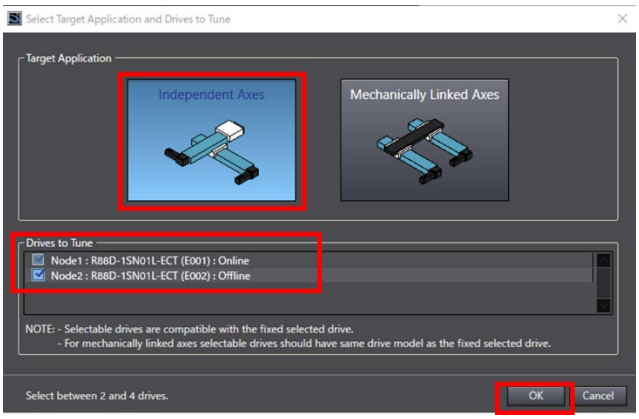


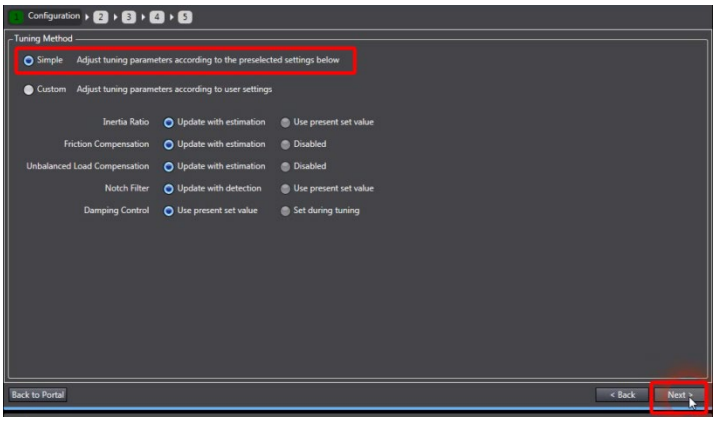
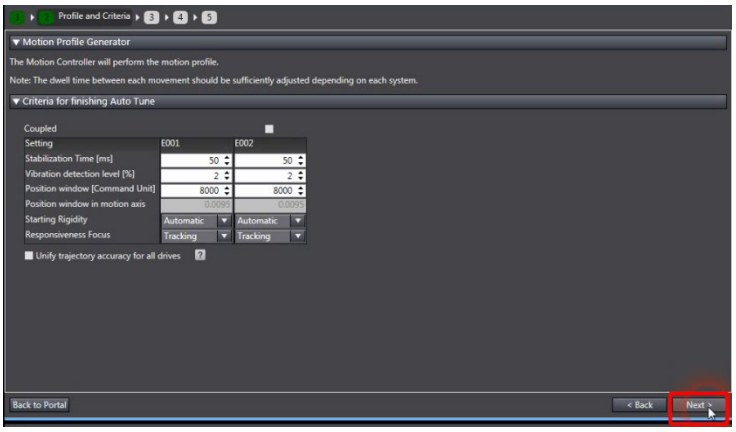
Change *Start* to TRUE.



Linear1 is executed to position both of the axes. When the positioning is completed, the axes dwell, and then Linear2 is executed to position the axes. This sequence is repeated with a dwell time of 2 seconds between each movement.

Perform the easy tuning (Multiple drives)

1.	Right-click **Node1: R88D-1SN01L-ECT** under **Configurations and Setup -EtherCAT** in the Multiview Explorer, and select **Setup and Tuning** from the menu.  The Setup and Tuning Portal appears in Edit Pane
2.	Click the **Easy Tuning** Button under **Tuning (Multiple Drives)**  Select **Independent Axes** as the target application, select the drives to tune, and click the **OK** Button. The XY stage system has an axis configuration with independent axes. 

3.	**Tuning configuration** Select **Simple** mode and click **Next** 
4.	**Profile and criteria** The motion profile generator is the Motion Controller. Adjust criteria to achieve tuning and click **Next** button  Operation setting using the **Unify trajectory accuracy for all drives** Check Box Selected: The target axes will be tuned with the same gain. Cleared: Each of the target axes will be individually tuned with a gain. The gain does not match between axes.

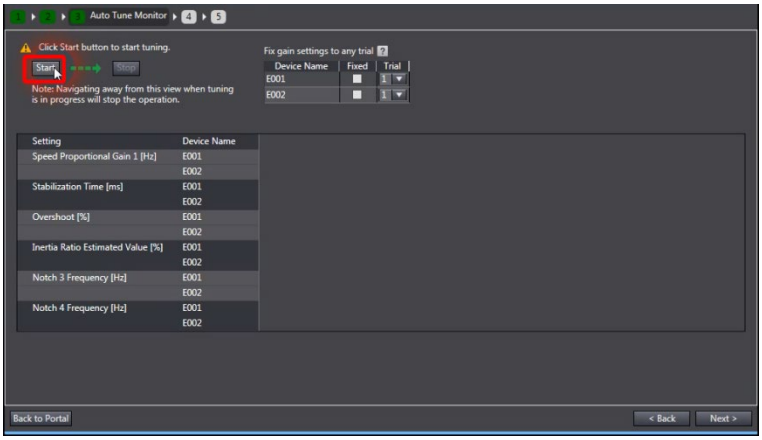
Precautions for Correct Use

The Load Characteristic Estimation function may not operate properly under the following conditions. In such cases, set the related objects manually.

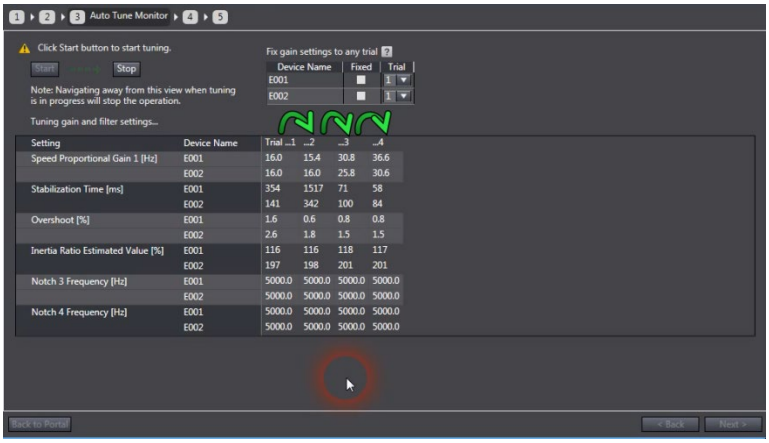
	Conditions that interfere with the Load Characteristic Estimation function
Load inertia	• If the load inertia is small, i.e. less than 3 times the rotor inertia or large, i.e. the applicable load inertia or more • If the load inertia changes easily
Load	• If the machine rigidity is extremely low • If there is a non-linear element (play), such as a backlash
Operation	• If the speed continues at lower than 100 r/min • If the acceleration/deceleration is 2,000 r/min/s or lower • If the acceleration/deceleration torque is small compared with the unbalanced load and the friction torque • If the speed or torque oscillates due to the high gain or small effect of each filter.

5. **Auto Tune Monitor**

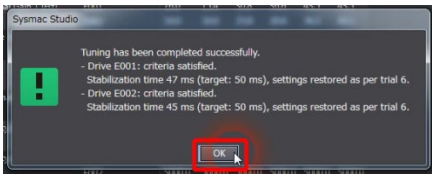
Click the **Start** Button



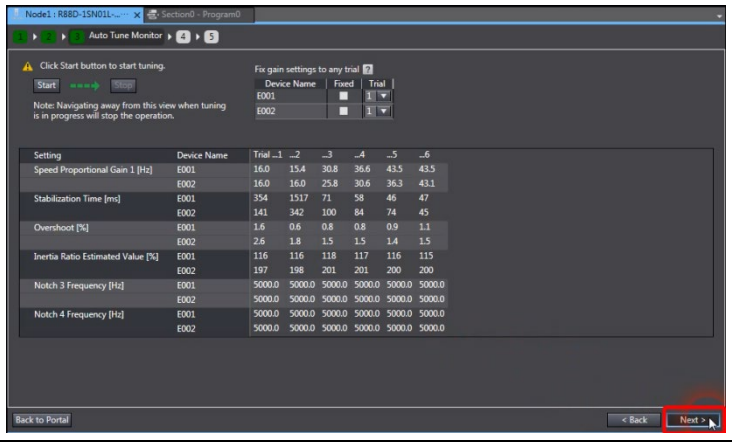
- The gain will be increased gradually until the stabilization time in the completion conditions is reached. The stabilization time is the time until the position deviation enters the positioning window after an instruction is issued. If a vibration above the vibration detection level is detected during tuning, an adjustment failure will occur.
- Even if tuning fails, the motor will not stop because it continues to receive the instruction from the CPU Unit.



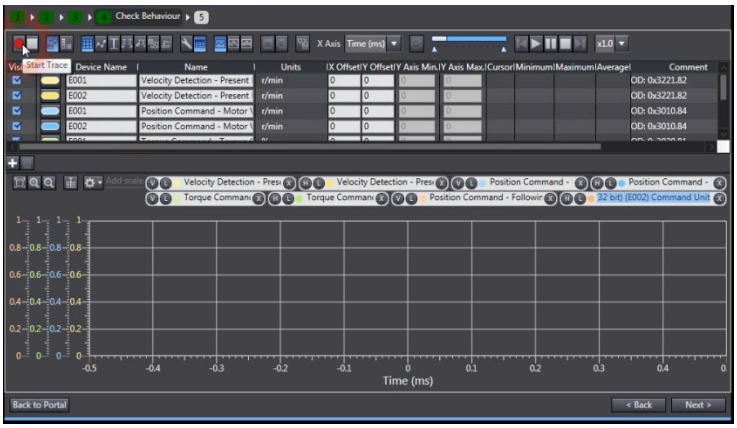
Criteria achieved, click the **Ok** Button



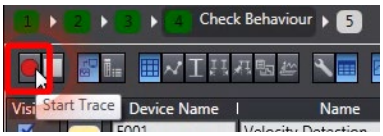
Click the **Next** Button



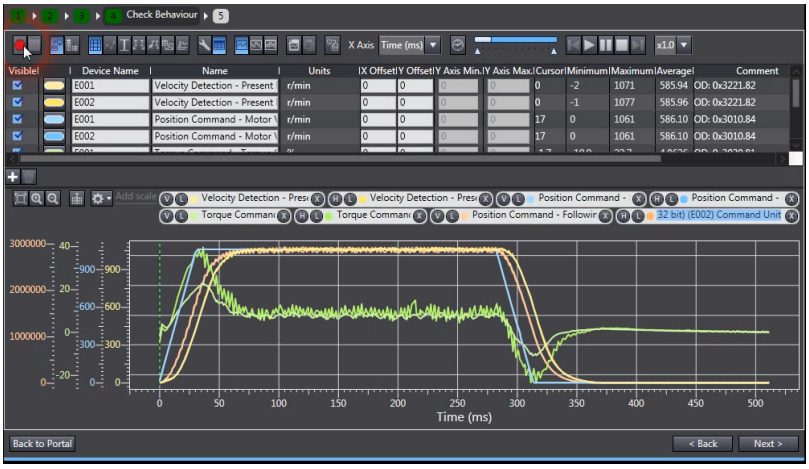
6. **Check Behavior**



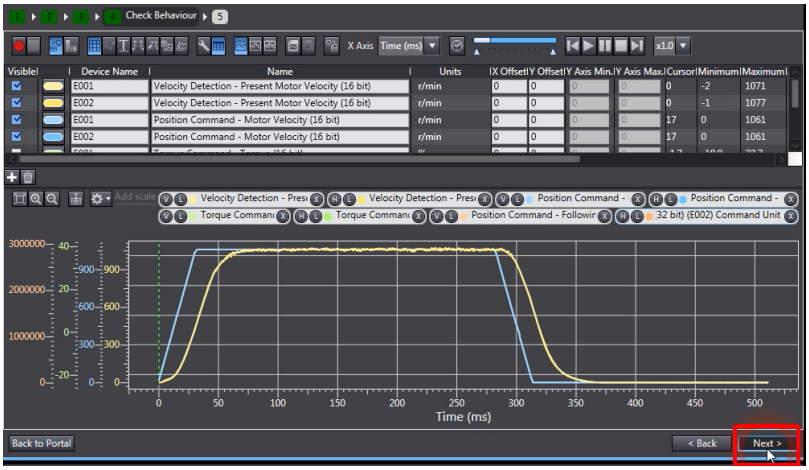
Click the **Record** Button



Monitor data will be traced and automatically scaled

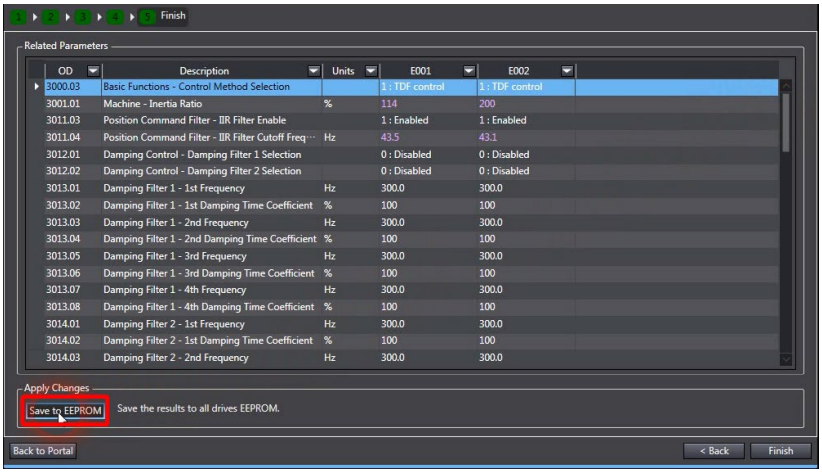


Confirm the behavior and click the **Next** Button



7. **Finish**

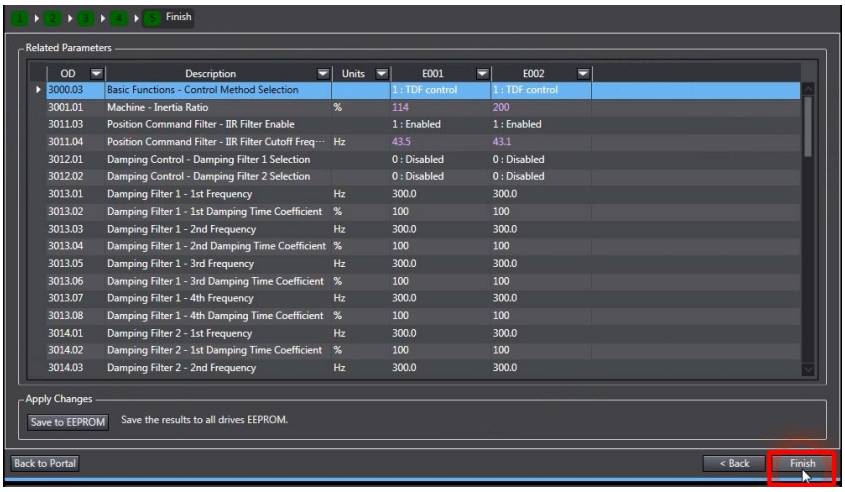
Confirm new gain parameters and save to EEPROM



Click the **Ok** Button

The easy tuning wizard for multiple drives is completed

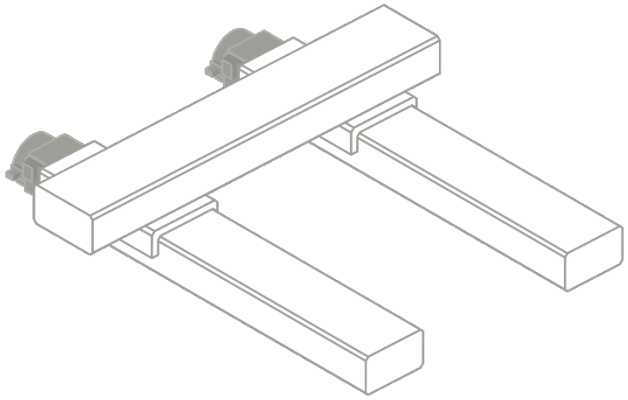
Click the **Finish** Button



4. Performing Setup

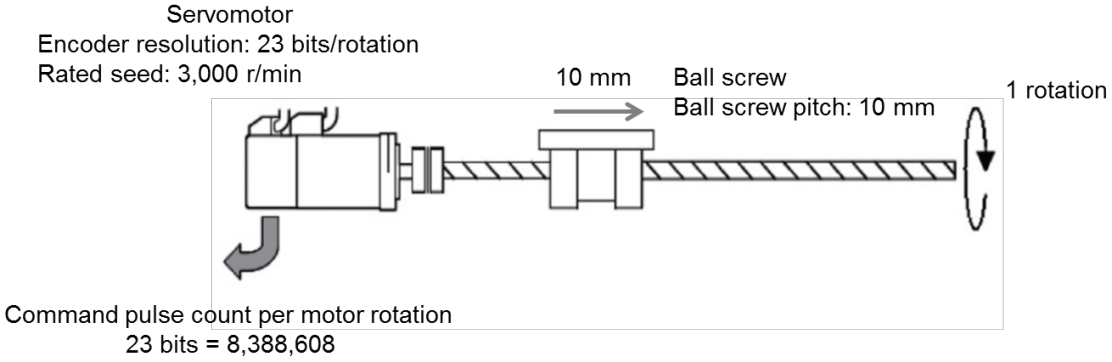
4.1. Two-axis Servo System Operation (Gantry System)

This section describes how to setup a gantry system as a two-axis servo system.
In this system, axis 0 and axis 1 are set up for the gantry.
To mechanically link the two axes, align their mechanical zero positions.

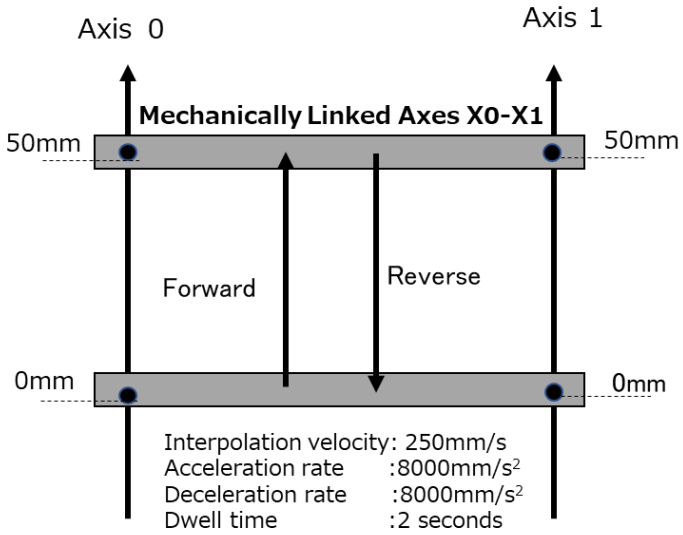


The mechanical configuration of axis 0 and axis 1 are as shown in the following table.

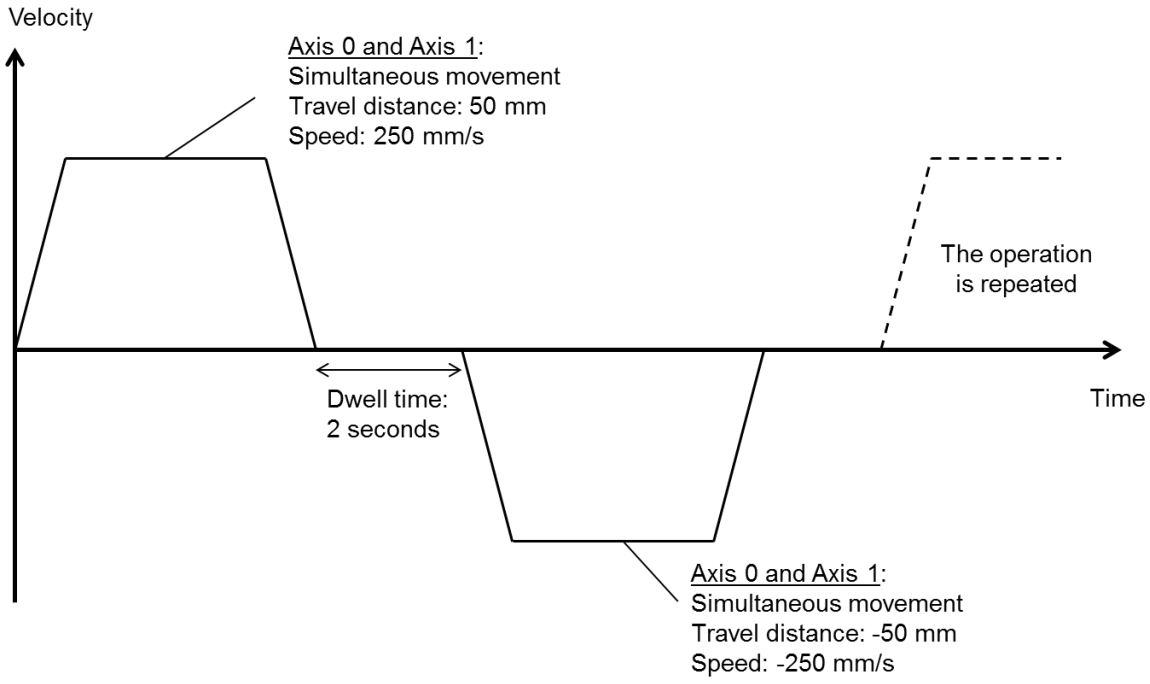
Item	Mechanical configuration of axis 0 and axis 1
Motor rated speed	3,000 r/min
Ball screw pitch	10 mm
Encoder resolution	23 bits/rotation



A gantry system is a mechanism in which axis 0 and axis 1 are linked together, and axis 0 and axis 1 move back and forth between two points in a synchronized manner. It dwells for two seconds after each movement.



The velocity waveforms for axis 0 and axis 1 are shown below.



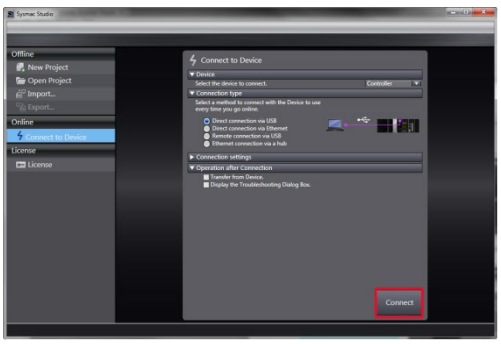
4.2. System Setup Procedures

The following is a basic flow of designing a servo system.
The setup procedures are described in the following order.

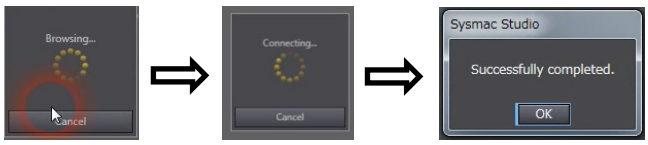
1	Creating a Project with Auto Connection
▼	
2	Creating an EtherCAT Network Configuration
▼	
3	Setting Up the Axes
▼	
4	Transferring the Project to the CPU Unit
▼	
5	Setting Up the Drives and Motors
▼	
6	Easily Tuning Multiple Drives (Gain Adjustment)

4.3. Creating a Project with Auto Connection

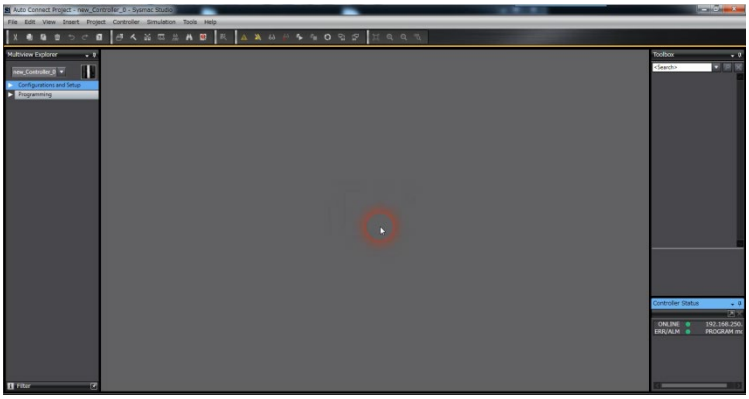
Start the Sysmac Studio:
Select **All Programs – OMRON – Sysmac Studio – Sysmac Studio** from the Windows **Start** Menu.

1.	Click the Button in the Project window.
2.	In the **Connect to Device** Dialog Box, click the Button. 

The Sysmac Studio browses through the network and connects to the controller.



This concludes the procedure to create a project with auto connection.

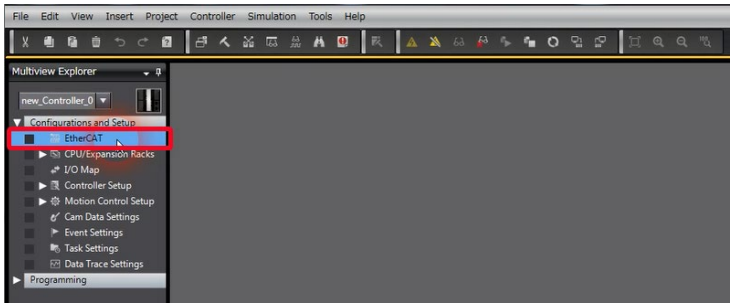
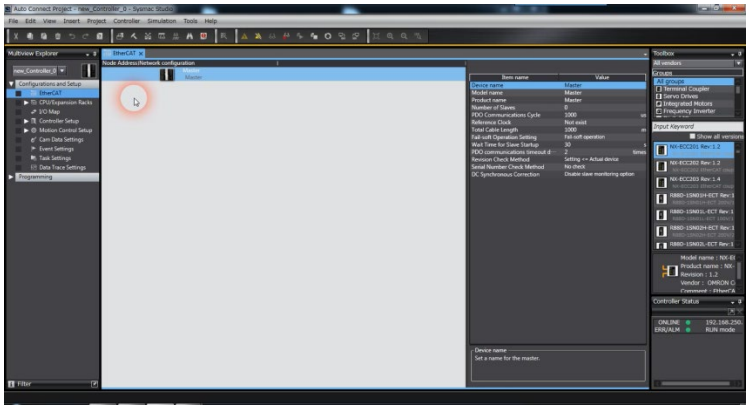
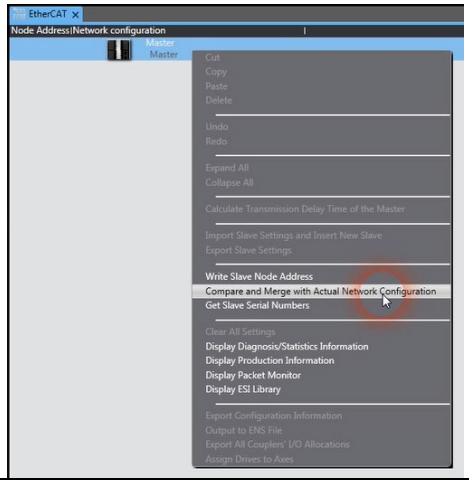


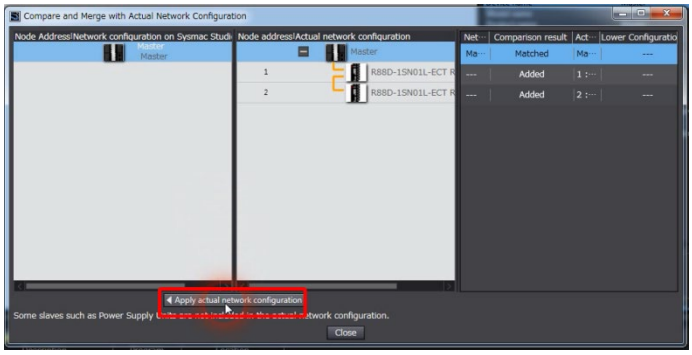
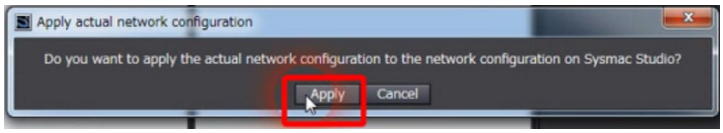
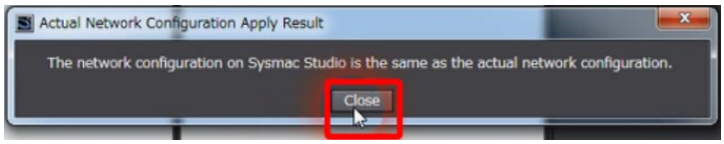
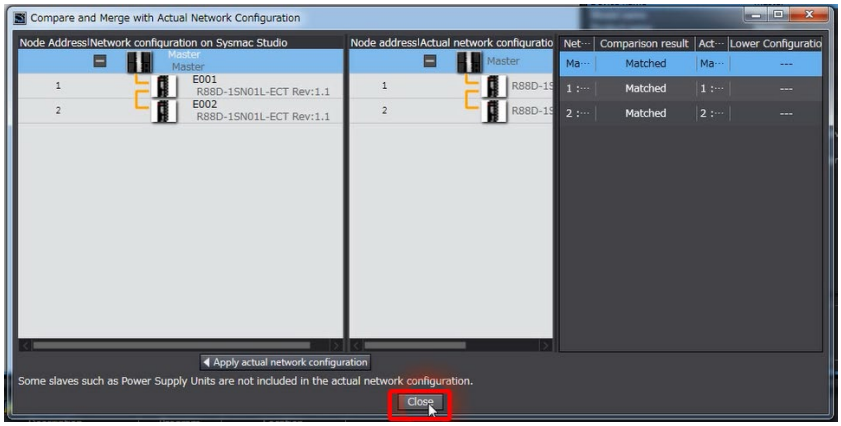
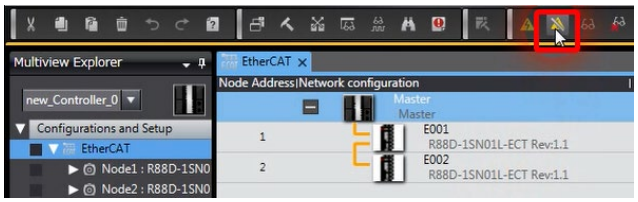
Additional Information

For creating a project offline or specific procedures, please refer to the *Sysmac Studio Version 1 Operation Manual* (Cat. No. W504).

4.4. Setting Up the Axes

Register a Servo Drive (R88D-1SN01L-ECT) in the EtherCAT network configuration.

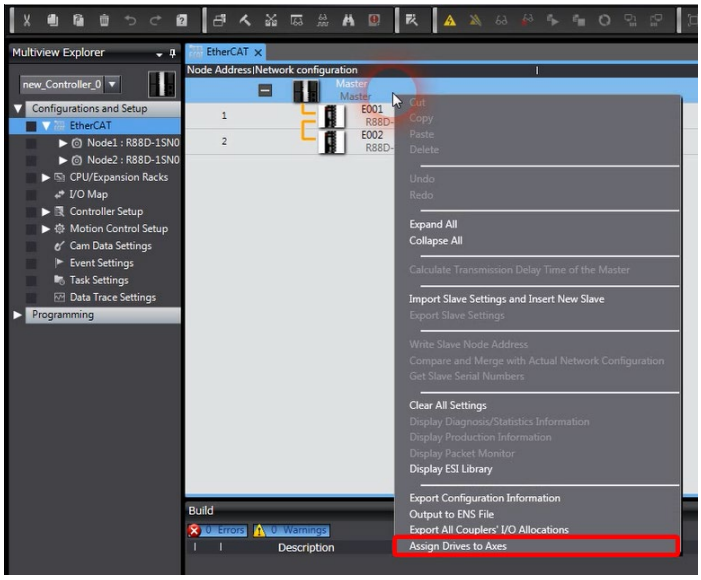
1.	Double-click **EtherCAT** under **Configurations and Setup** in the Multiview Explorer.  The EtherCAT Tab Page is displayed in the Edit Pane. 
2.	Right-click the **Master** and select **Compare and Merge with Actual Network Configuration**. 

3.	The **Compare and Merge with Actual Network Configuration** Dialog Box is displayed. Click the **Apply actual network configuration** Button to apply the actual network configuration.  Click the **Apply** Button.  The network configuration is matched. Click the **Close** Button.  Confirm the detected configuration and close the dialog box.  Disconnect the Sysmac Studio from the controller. 

4.5. Creating Motion Axes

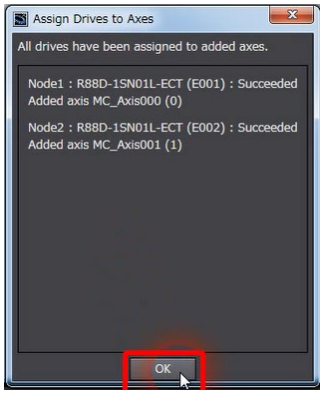
This section describes how to add axes to control Servo Drives and assign Servo Drives to them. Use the procedure below to add Servo Drive axes that are configured for EtherCAT.

1. Right-click the **Master** and select **Assign Drives to Axes**.

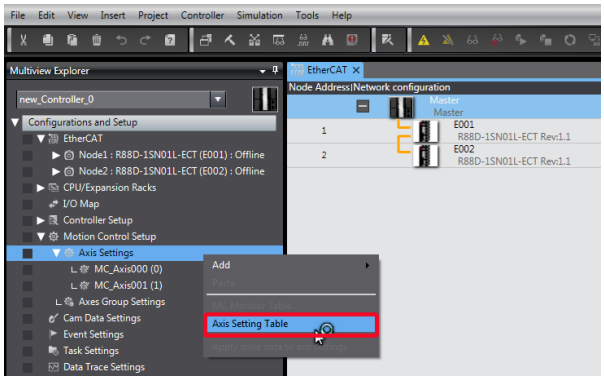


Confirm that you are assigning the drives to the axes to be added, and click the **Yes** Button.

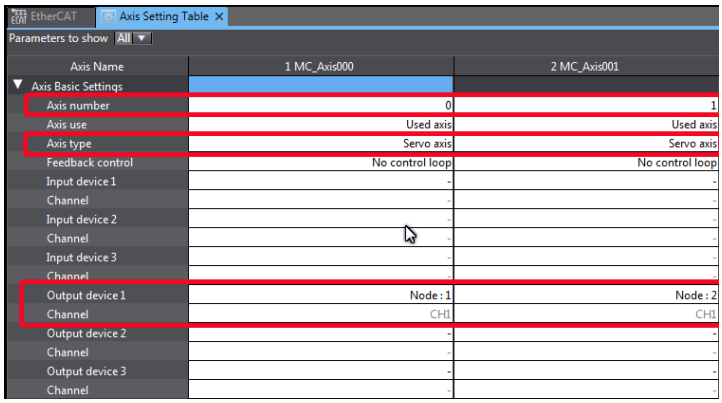
Confirm the list of axes added and click the **OK** Button.



Right-click **Axis Settings** in the Multiview Explorer and select **Axis Setting Table**.



For the added axes, set **Axis number** to 0 and 1, **Axis type** to Servo axis, and **Output device** to Node: 1 and Node: 2.

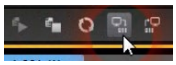


Transferring the project to the CPU Unit

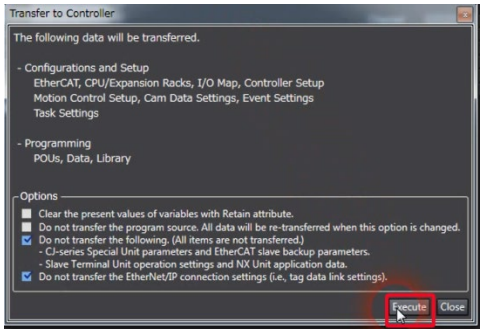
2.

Click the Button on the Toolbar.

Click the Button on the Toolbar.



Click the **Execute** Button to transfer the project from the computer to the CPU Unit.



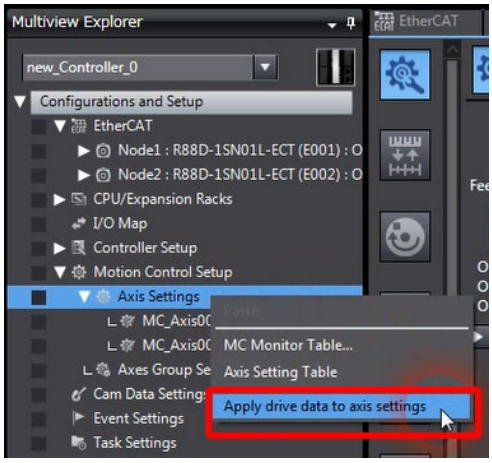
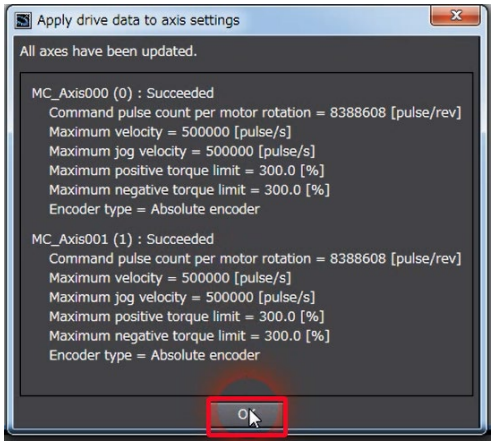
Click the **Yes** Button.

The operating mode changes to PROGRAM mode, and the Sysmac Studio starts transferring the project to the CPU Unit. During the transfer, the progress rate is displayed in the Synchronizing Pane.

When the transfer is completed, the following dialog box appears. Click the **Yes** Button. The operating mode is set to RUN mode.

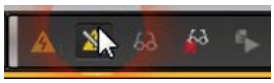
The transfer is completed. Click the OK Button.

Applying drive and motor data to the axes via the network

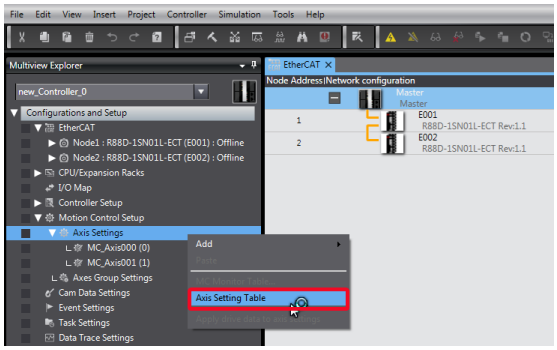
3.	Right-click **Axis Settings** and select **Apply drive data to axis settings** in the Multiview Explorer.  Click the **Yes** Button to acquire data from the Servo Drive via the EtherCAT network. The following axis setting items are updated. **Unit conversion setting**: Command pulse count per motor rotation (23 bits per resolution) **Operation settings**: Maximum velocity and Maximum jog velocity **Extended operation settings**: Maximum positive torque limit and Maximum negative torque limit **Position count setting**: Encoder type (Absolute encoder)  After confirming the above, click the **OK** Button.

Modifying the axis settings to match the configuration of the gantry system

3. Disconnect the Sysmac Studio from the controller.



Right-click **Axis Settings** in the Multiview Explorer and select **Axis Setting Table**.



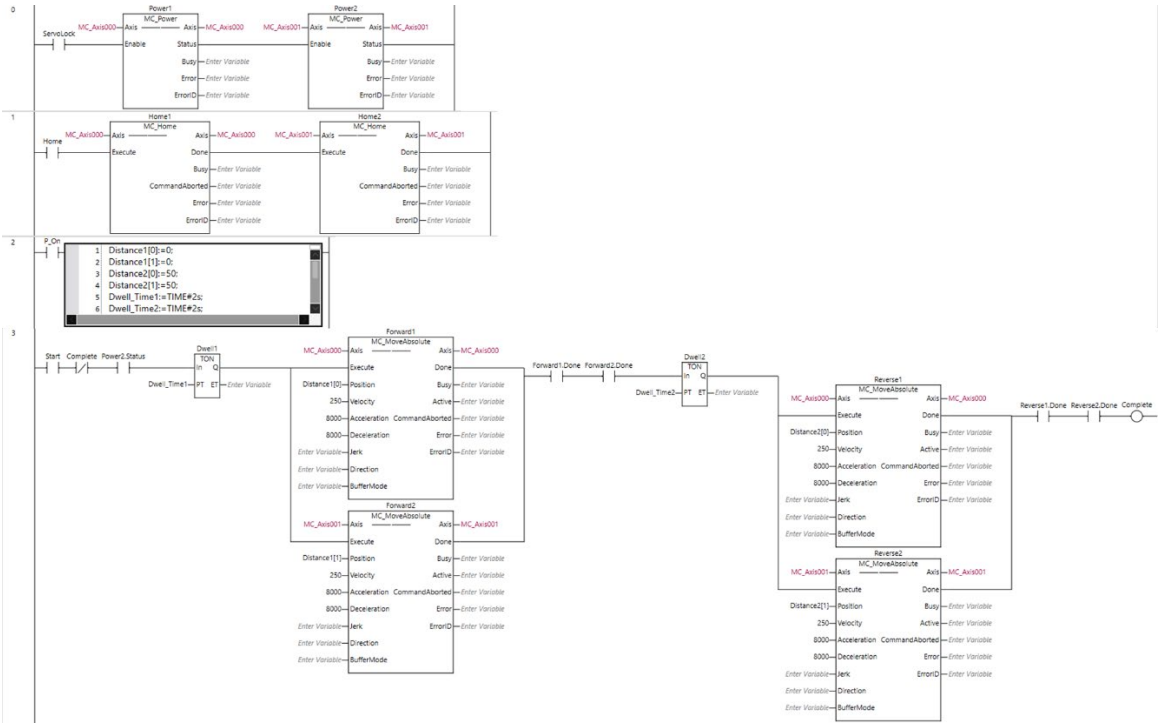
Edit the axis settings according to the ball screw specifications of the gantry system.

Axis Name	1 MC_Axis000	2 MC_Axis001
Unit Conversion Settings		
Unit of display	mm	mm
Command pulse count per motor rotation	8388608 pulse/rev	8388608 pulse/rev
Gearbox usage	Do not use gearbox	Do not use gearbox
Work travel distance per motor rotation	10 mm/rev	10 mm/rev
Work travel distance per work rotation	10000 mm/rev	10000 mm/rev
Work gear ratio (Numerator of the reduction rati	1	1
Motor gear ratio (Denominator of the reduction r	1	1
Operation Settings		
Maximum velocity	500 mm/s	500 mm/s
Velocity warning value	0 %	0 %
Start velocity	0 mm/s	0 mm/s
Maximum jog velocity	100 mm/s	100 mm/s

4.6. Transferring the Project to the CPU Unit

Create a program for synchronous operation of the two axes.

To do so, use axis variables, an axes group variable, and motion control instructions.
Rung 0: Axes Servo ON
Rung 1: Axes homing to preset zero positions
Rung 2: Absolute position coordinates assigned to input variables
Rung 3: Movement cycle (Repeats Move 50 mm > Dwell for 5 s > Move -50 mm > Dwell for 2 s)
* Instructions will not be updated if the servo system for one of the axes is turned OFF.

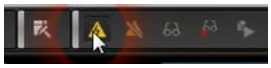
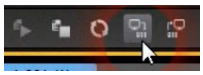
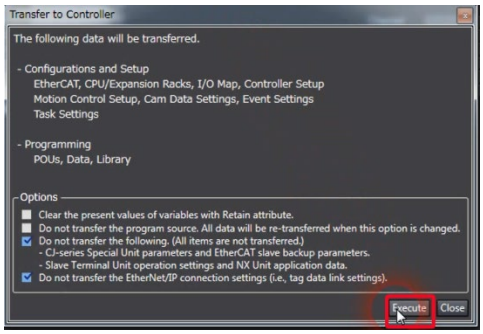
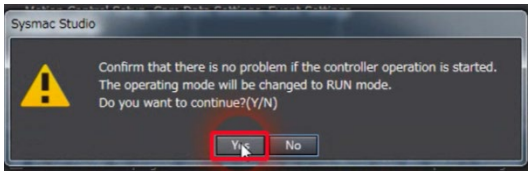


Please refer to ANNEX A-3 for an example of equivalent structured text programming.
Please refer to the *NJ/NX-series Startup Guide for CPU Units* (Cat. No. W513) for details on programming with ladder diagrams.

Precautions for Correct Use

This sample program includes only the parts that are required to operate the Servomotors. When programming actual applications, add interlocks for EtherCAT communications and operations of equipment, input to/output from other devices, control procedures, etc.

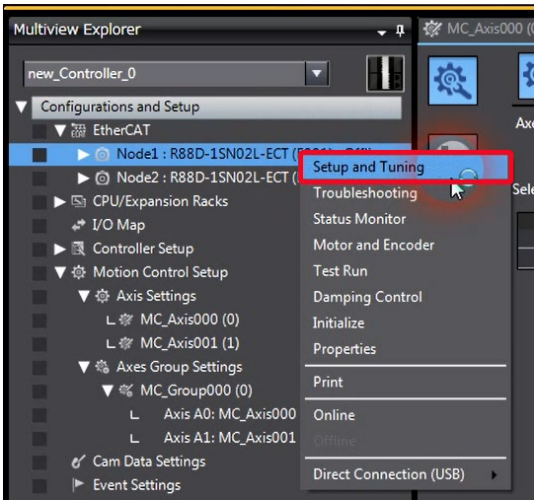
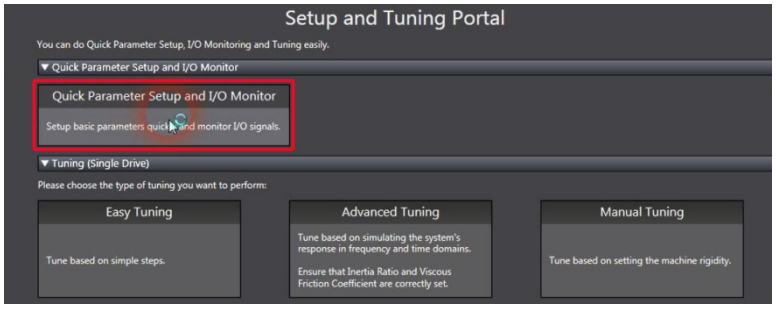
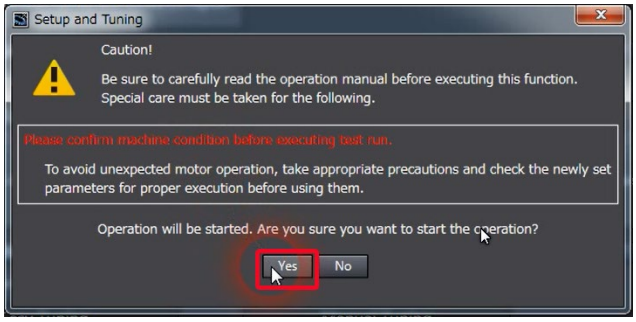
Transferring the project to the CPU Unit

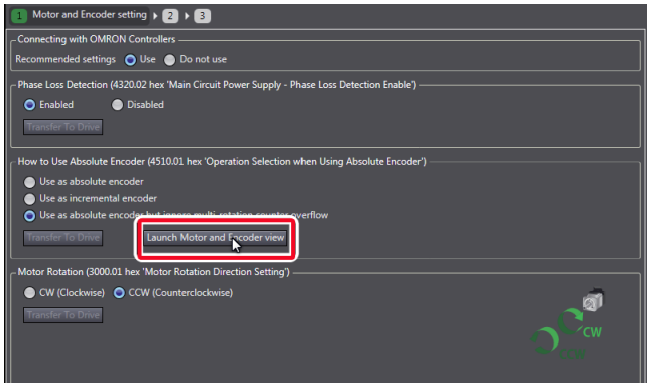
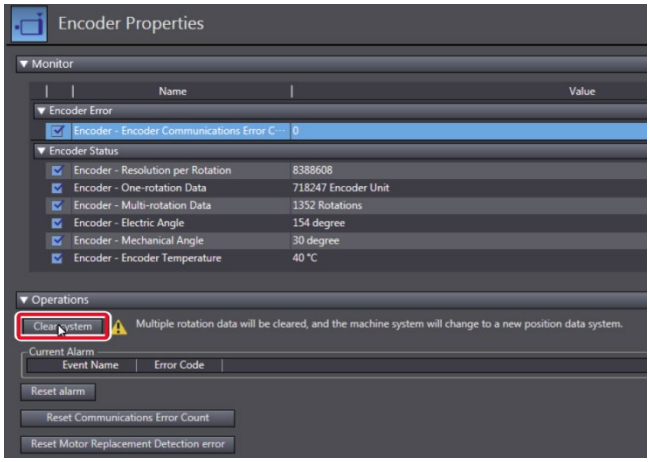
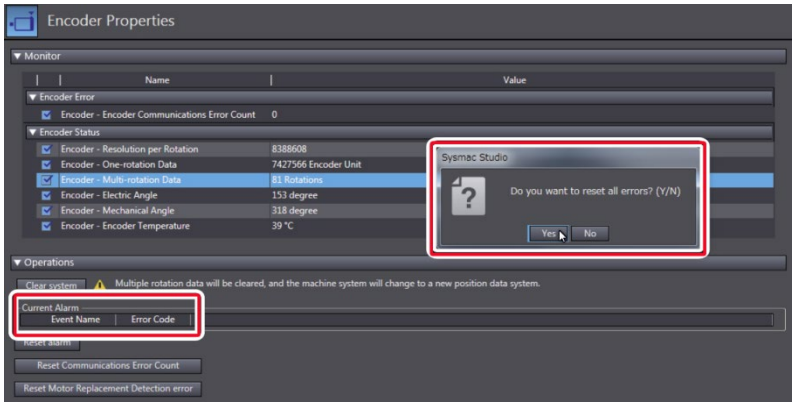
1.	Click the Button on the Toolbar. 
2.	Click the Button on the Toolbar. 
3.	Click the **Execute** Button to transfer the project from the computer to the CPU Unit.  Click the **Yes** Button. The operating mode changes to PROGRAM mode, and the Sysmac Studio starts transferring the project to the CPU Unit. During the transfer, the progress rate is displayed in the Synchronizing Pane. When the transfer is completed, the following dialog box appears. Click the **Yes** Button. The operating mode is set to RUN mode.  The transfer is completed. Click the **OK** Button.

4.7. Setting Up the Drives and Motors

This section explains the procedure to set up drive and motor parameters.

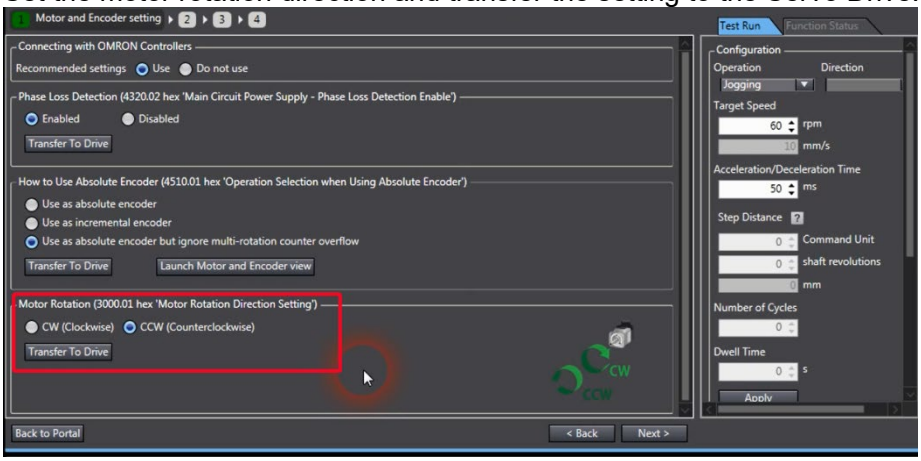
You need to set up the absolute encoder when using it for the first time or when initializing the rotation data to 0.

1.	Right-click the Servo Drive and select **Setup and Tuning** from the menu.  The **Setup and Tuning Portal** Wizard appears.
2.	Select **Quick Parameter Setup and I/O Monitor**.  The following dialog box appears. Click the **Yes** Button.  The **Motor and Encoder setting** Page appears.

3.	Click the **Launch Motor and Encoder view** Button.  The **Encoder Properties** Page appears.
4.	Click the **Clear system** Button.  An Absolute Value Clear Error (error display number: 2701) occurs, and a dialog box showing *Do you want to reset all errors?* appears.
5.	 Click the **Yes** Button. The multi-rotation data of the absolute encoder is cleared.

Checking the motor rotation direction and modifying the settings if required

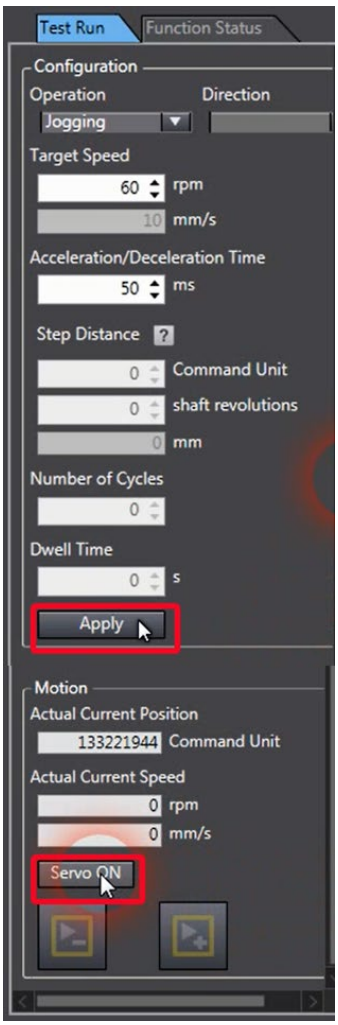
6. Set the motor rotation direction and transfer the setting to the Servo Drive.

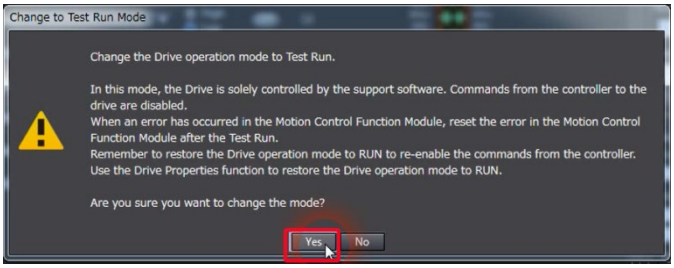


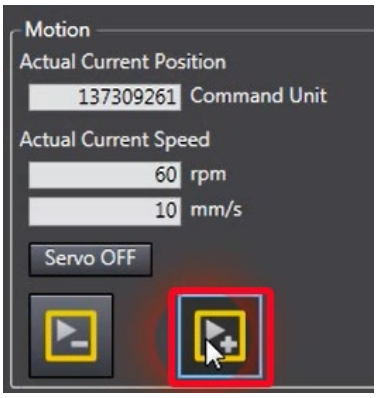
7. **Check the motor operation.**

- Be sure to check each axis with fastening parts removed and return it to the original state after checking.
- Configure the operation settings on the Test Run Tab Page and click the **Apply** Button.

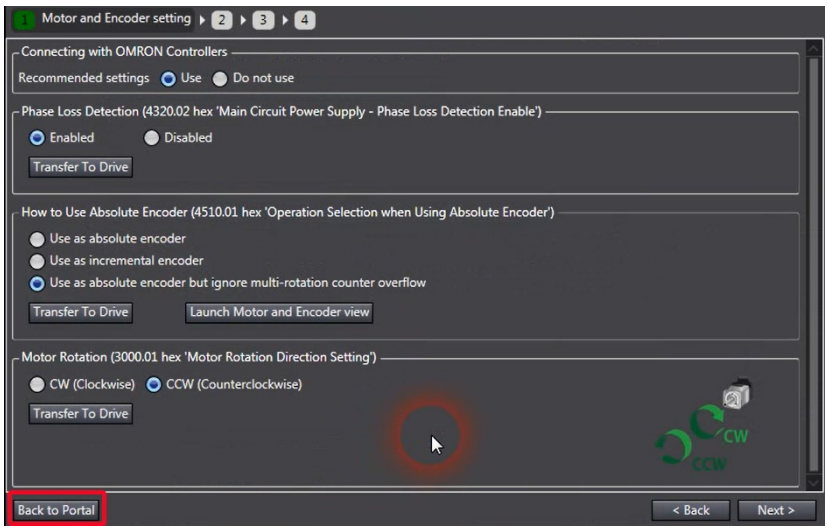
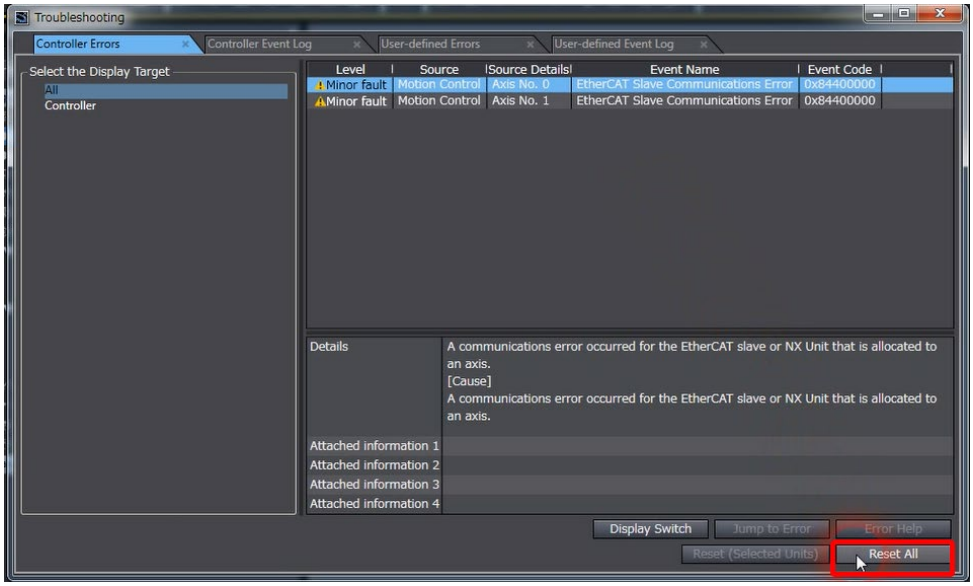
Next, click the **Servo ON** Button to start the test run.







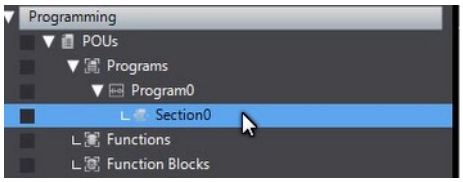
Note: If error 87.00 ESTP input occurs, check the wiring connections or disable the error stop input (IN1). For details on changing the settings, please refer to *A-1 Settings when control input signals are not wired*.

8.	Click the **Back to Portal** Button. 
9.	Repeat the same procedure for node 2.
10.	Following above procedure, restart the drive to apply input settings. Reset the EtherCAT Slave Communication Errors for the CPU Unit in the Troubleshooting Pane. To do so, click the **Reset All** Button. 

4.8. Easily Tuning Multiple Drives (Gain Adjustment) — When There Is Axis Interference

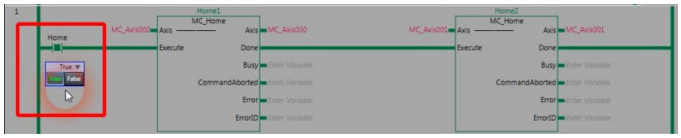
This section explains how to perform easy tuning of multiple axes (when there is axis interference).
Before running the program, place the gantry system in the homing position.
Check the operating mode of the CPU Unit in RUN mode and then use BOOL variables (True/False) to execute motion control instructions.
To check the operation of the created program, use the variable set/reset function.
Setting/resetting contacts allows motion control instructions to operate.

Double-click **Section0** under **Programming – POUs – Programs – Program0** in the Multiview Explorer.

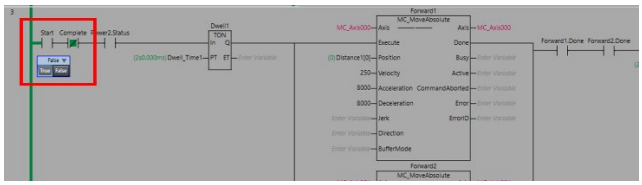


The ladder program is displayed in the Edit Pane.
Change the BOOL variables in the following order :
Change *ServoLock* to TRUE to execute Power1 and Power2.

Change *Home* to TRUE to execute Home1 and Home2. This sets the axes to preset zero positions for the axes. (Homing sets the axes to preset zero positions.)



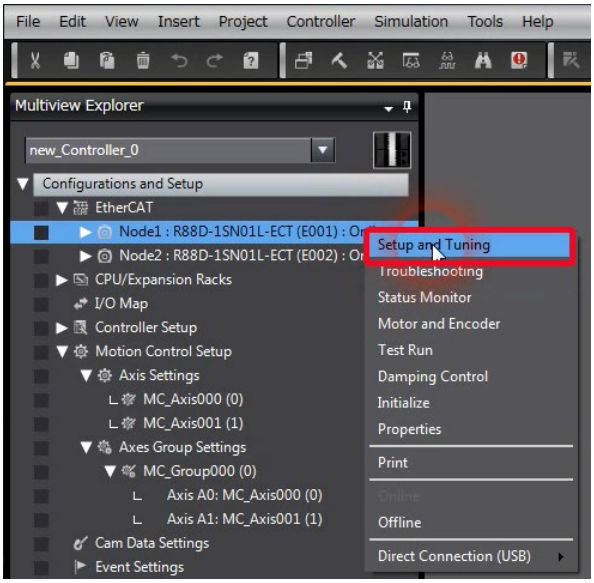
Change *Start* to TRUE.



Forward1/Forward2 is executed to position both of the axes. When the positioning is completed, the axes dwell, and then Reverse1/Reverse2 is executed to position the axes. This sequence is repeated with a dwell time of 2 seconds between each movement.

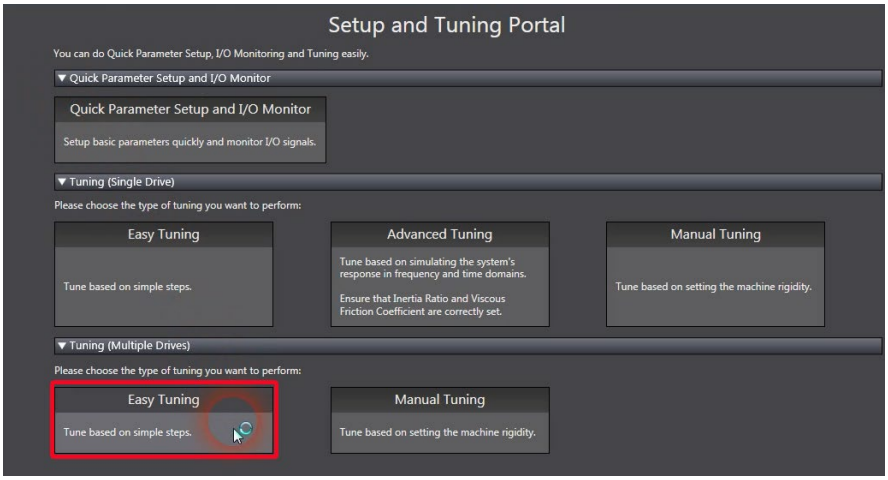
Easily tuning multiple drives

1. Right-click **Node1: R88D-1SN01L-ECT (E001): Offline** under **Configurations and Setup – EtherCAT** in the Multiview Explorer and select **Setup and Tuning** from the menu.

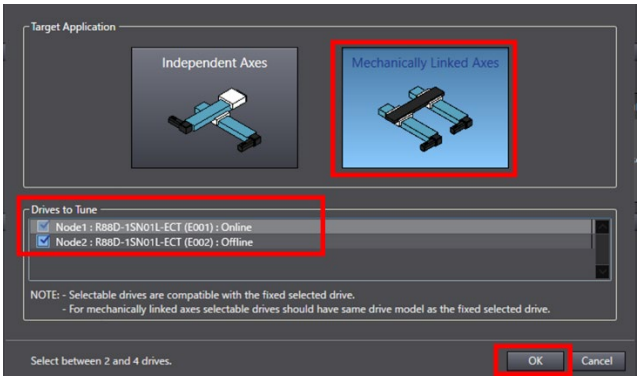


The **Setup and Tuning Portal** Wizard appears.

2. Click the **Easy Tuning** Button under **Tuning (Multiple Drives)**.



Select **Mechanically Linked Axes** as the target application, select the drives to tune, and click the **OK** Button. The gantry system has an axis configuration with mechanically linked axes.

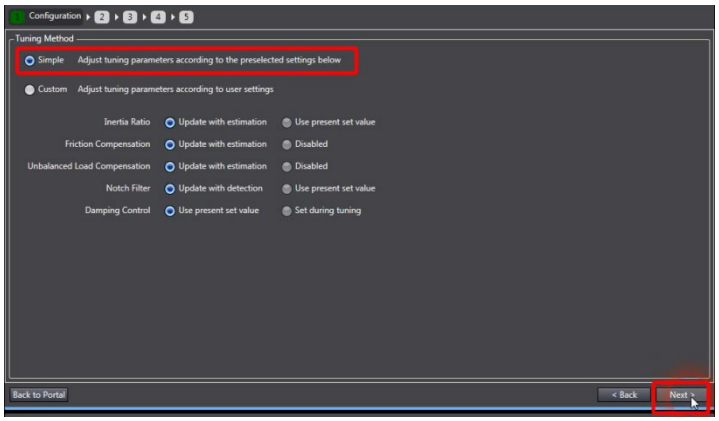
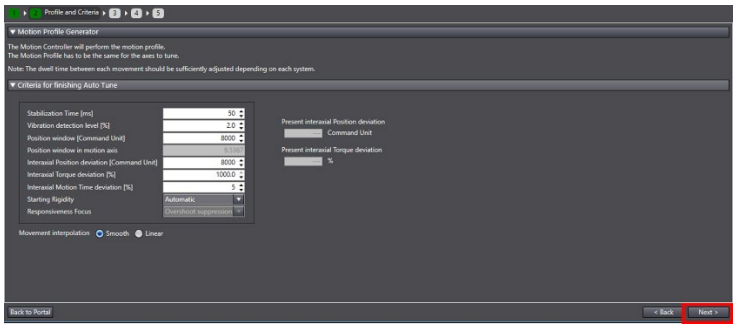


Operating conditions:

Drive and motor: Same model

Control method: ODF control

Unit version: Version 1.4 or later for 1S

3.	**Tuning Method** As the tuning method, select **Simple** and click the **Next** Button. 
4.	**Profile and Criteria** The Motion Controller will perform the motion profile. Set the criteria for achieving the tuning and click the **Next** Button. 

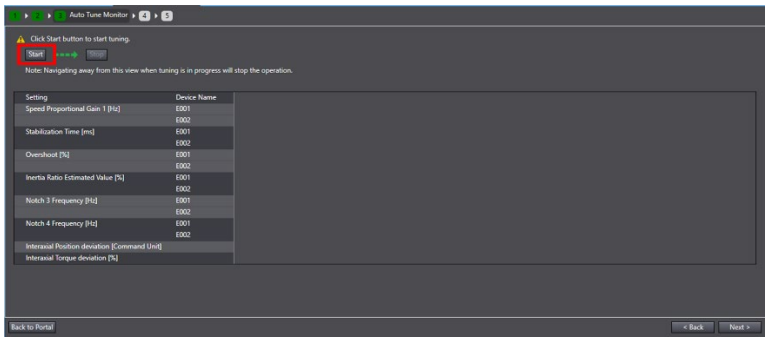
Precautions for Correct Use

The Load Characteristic Estimation function may not operate properly under the following conditions. In such cases, set the related objects manually.

	Conditions that interfere with the Load Characteristic Estimation function
Load Inertia	• If the load inertia is small (less than 3 times the rotor inertia) or large (the applicable load inertia or more) • If the load inertia changes suddenly
Load	• If the machine rigidity is extremely low • If there is a non-linear element (play), such as a backlash
Operation	• If the speed continues to be lower than 100 r/min • If the acceleration/deceleration is 2,000 r/min or lower for 1 s • If the acceleration/deceleration torque is small compared with the unbalanced load and the friction torque • If the speed or torque oscillates due to the high gain or small effect of each filter

5. **Auto Tune Monitor**

Click **Start** Button.

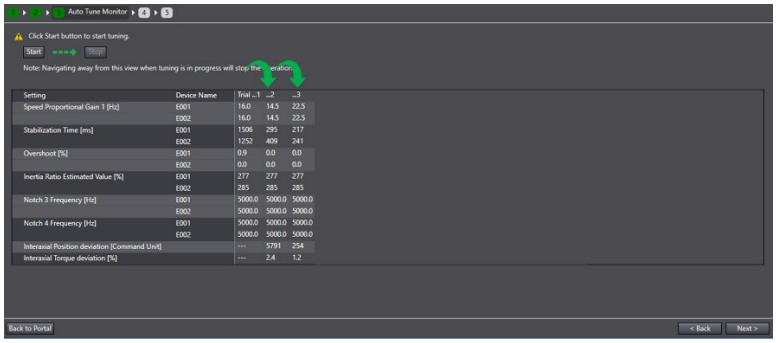


- The gain will be increased gradually until the stabilization time in the completion conditions is reached. The stabilization time is the time until the position deviation enters the positioning window after an instruction is issued.

If any of the following occurs during tuning, it is considered as an adjustment failure.

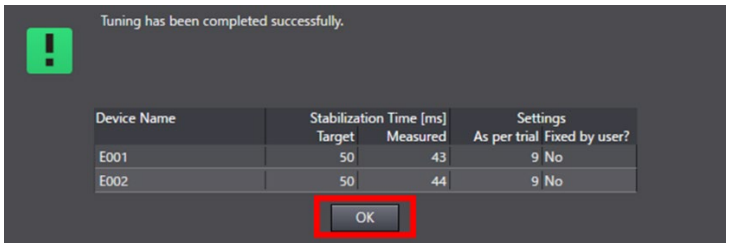
- Position deviation between the axes exceeded the detection level.
- Torque between the axes exceeded the detection level.
- Command time deviation exceeded the detection level.
- Vibration exceeded the detection level.

* Even if tuning fails, the motor will not stop because it continues to receive the instruction from the CPU Unit.

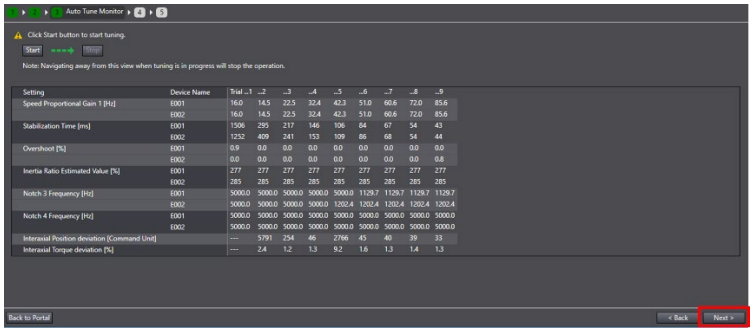


Easy tuning is completed.

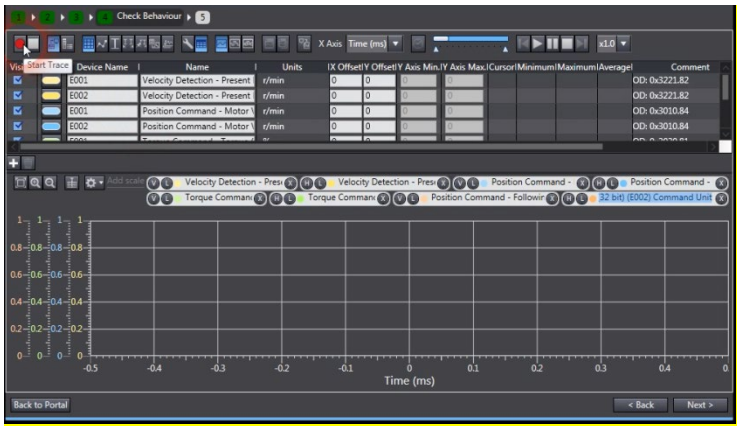
Click the **OK** Button.



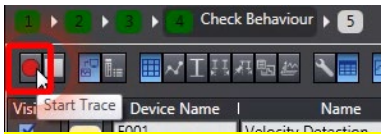
Click the **Next** Button.



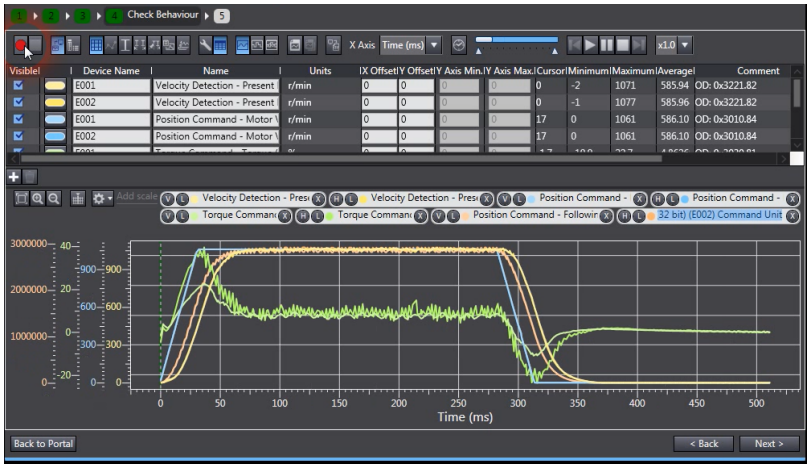
6. **Check Behavior**



Click **Start Trace** Button.

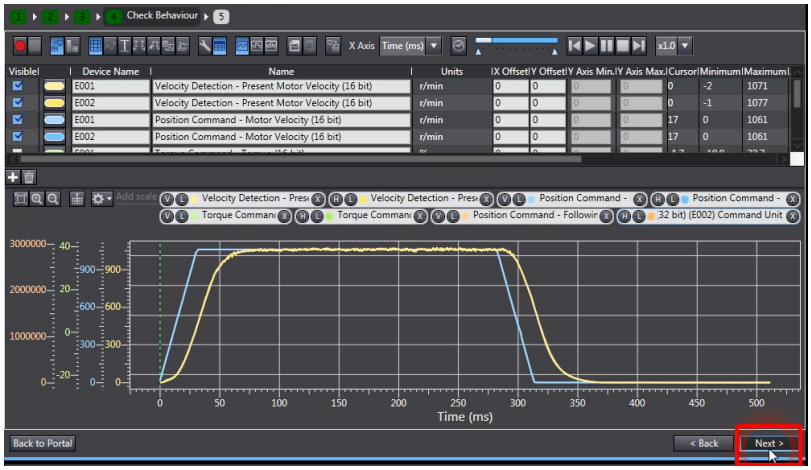


A graph showing the results of the data trace is displayed.



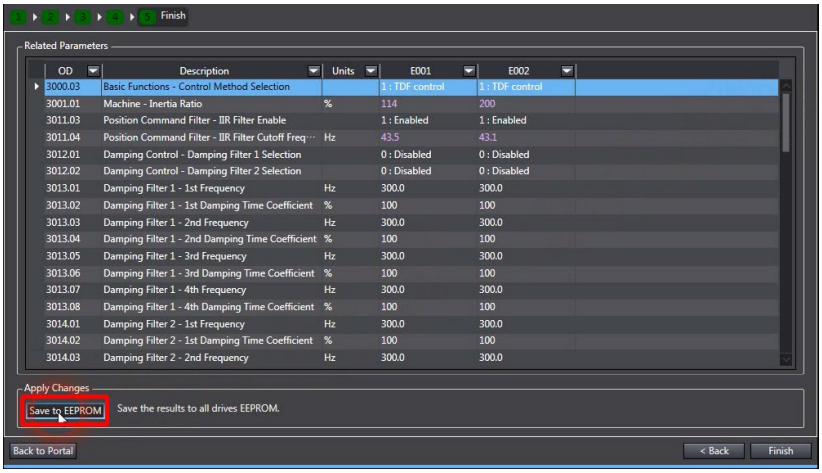
Check the displayed behavior and click the **Next** Button.

Click the **Next** Button.



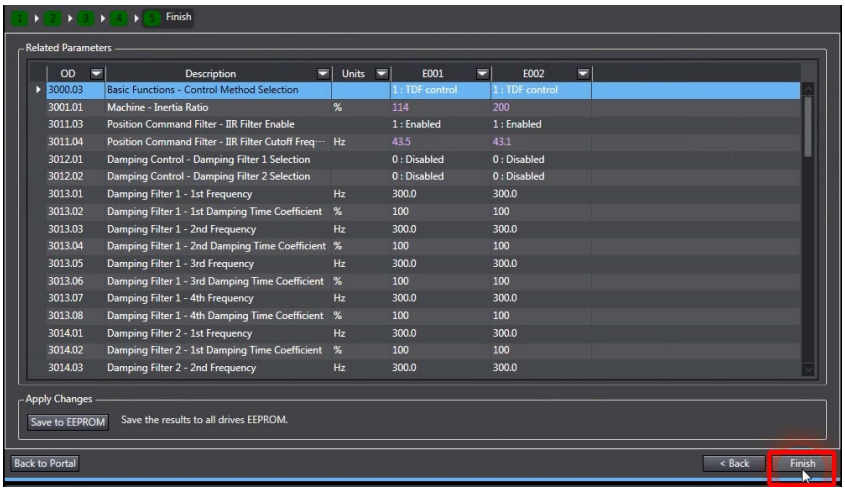
7. **Finish**

Confirm the new gain parameters and click the **Save to EEPROM** Button.



Click the **OK** Button.

The Easy Tuning (Multiple Drives) Wizard is completed. Click the **Finish** Button.



ANNEX

A-1 Settings when control input signals are not wired

An error will occur in the CPU Unit if the Servo parameters for the Servo Drive are left at their default values when the Servo Drive control input signals are not wired. This is because the CPU Unit stops operation when a drive prohibit or immediate stop signal is detected. The minor fault level Controller errors that occur are as follows:

- Error Stop Input (Event code: 68220000)
- Drive Prohibition Input Error (Event code: 64E30000)

This section describes how to temporarily change the Servo parameters to prevent these errors from occurring in the CPU Unit.

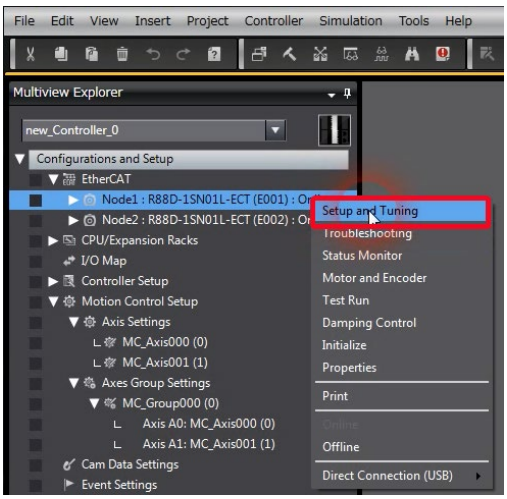
The procedure described here assume that a project with a Servo Drive registered to the EtherCAT network configuration has been transferred to the CPU Unit and that the CPU Unit is currently online.

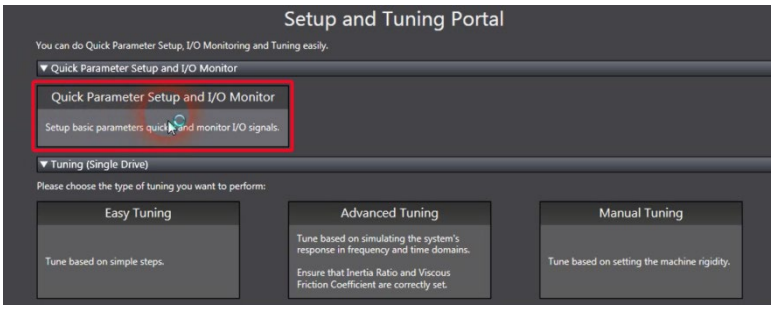
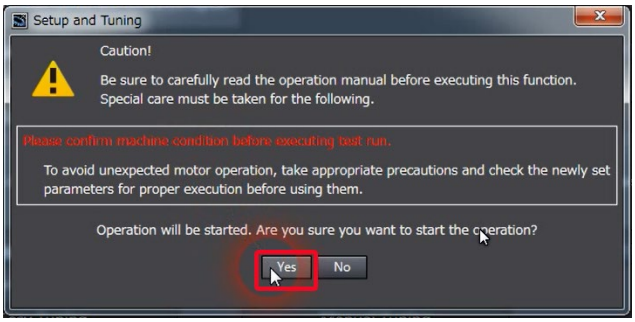
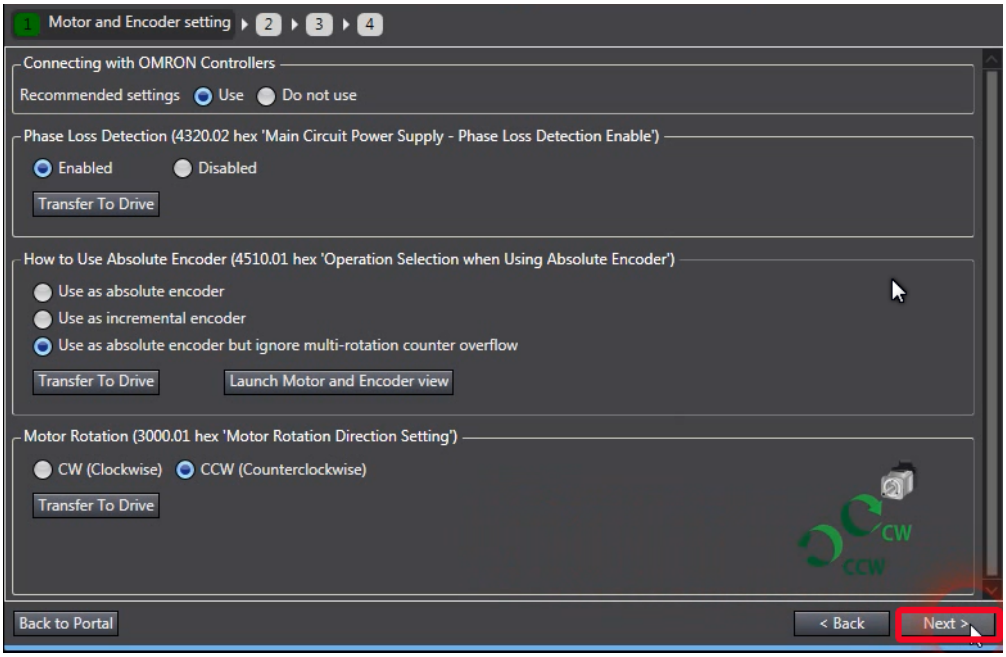
Precautions for Correct Use

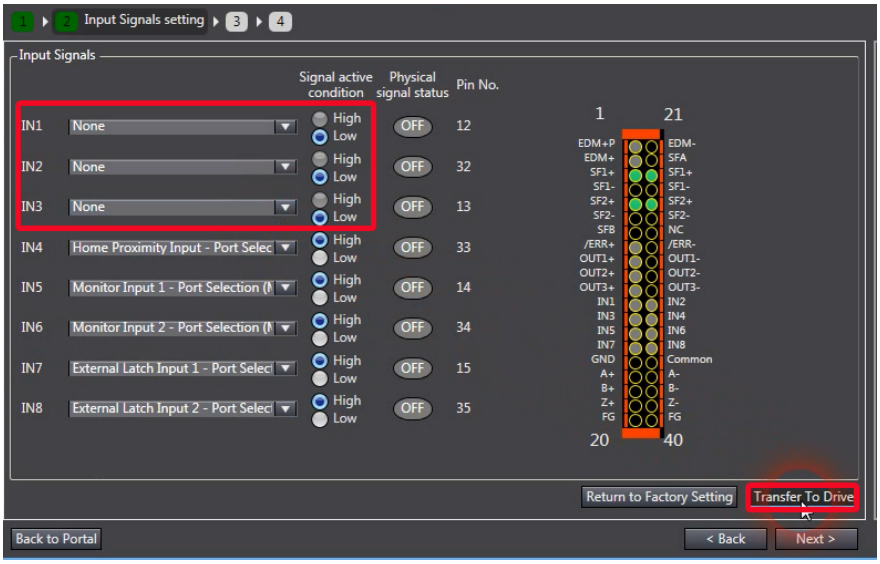
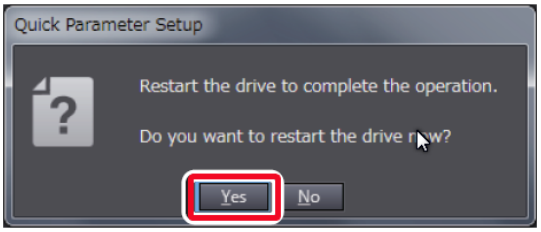
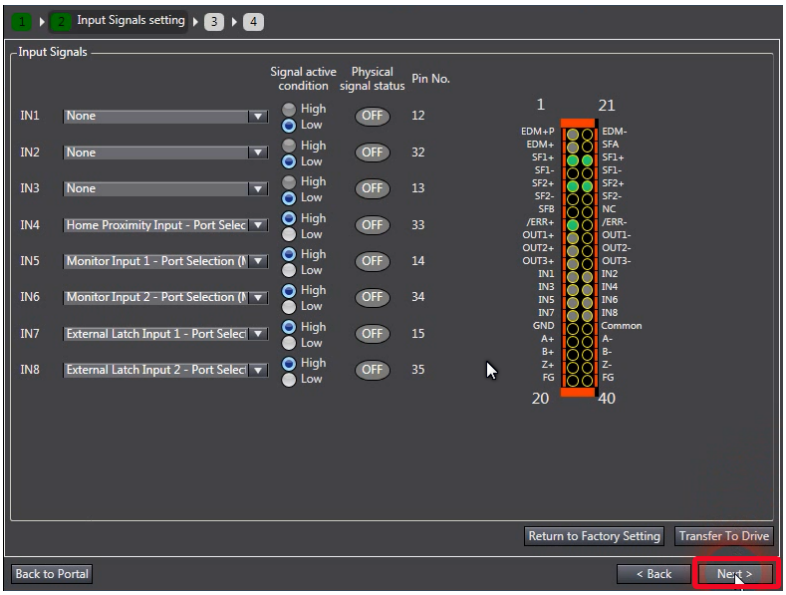
If the control input signals are not wired, it will not be possible to stop operation for limit inputs or immediate stop inputs in the event that unexpected motor operation occurs. Remove the coupling from the motor shaft or take other suitable measures to prevent a hazardous condition from occurring.

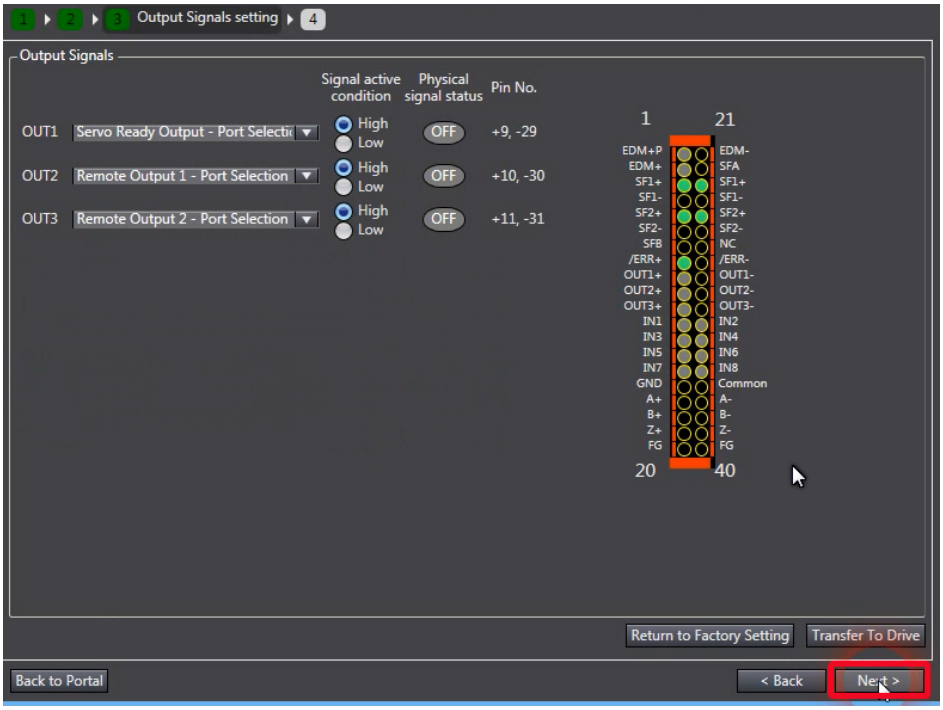
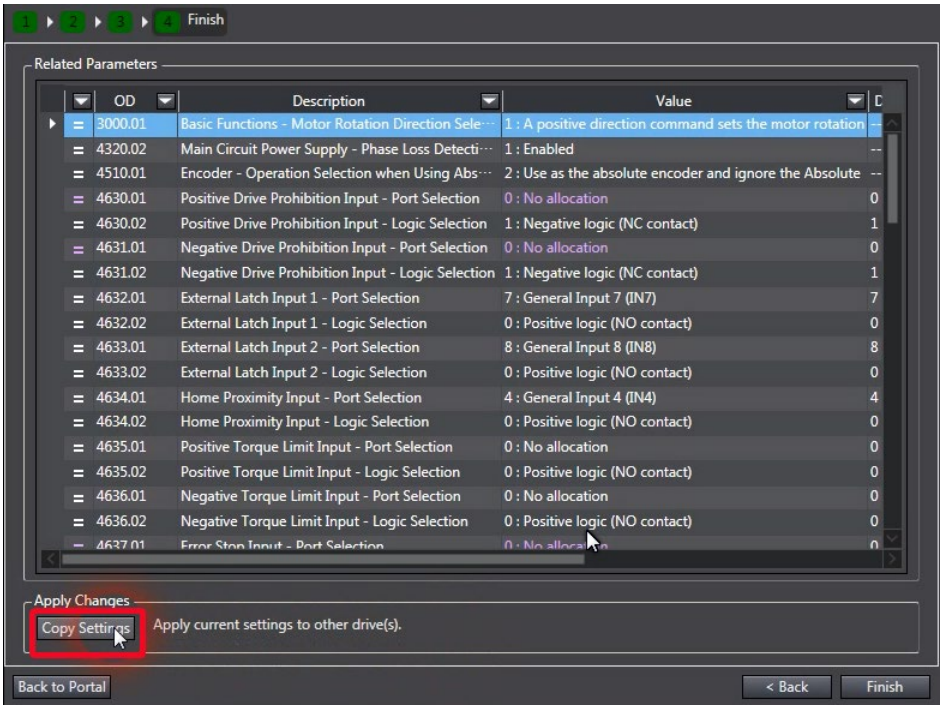
Perform the following before you perform the procedures that are given in this section.

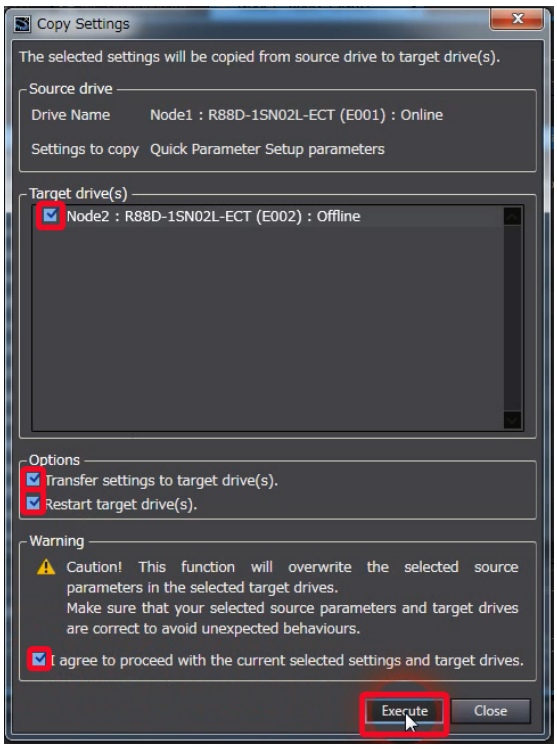
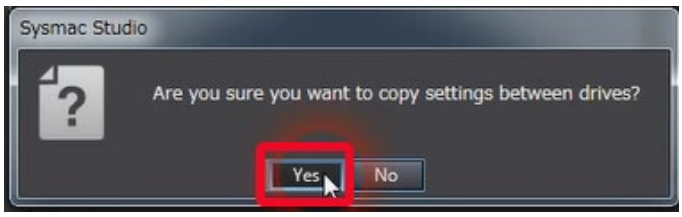
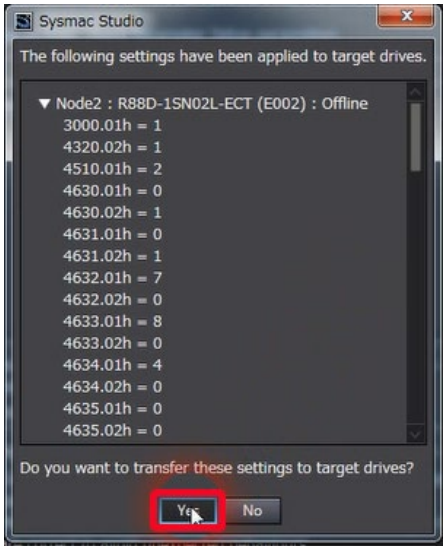
- Place the Sysmac Studio online with the CPU Unit.
- Transfer to the CPU Unit the project that contains the EtherCAT network configuration in which the Servo Drives are registered.

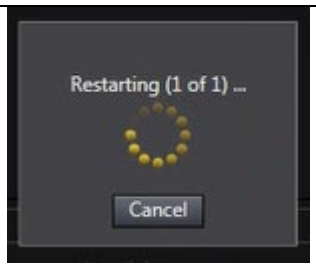
1.	Right-click the Servo Drive and select **Setup and Tuning** from the menu.  The Setup and Tuning Portal appears.

2.	Click the **Quick Parameter Setup and I/O Monitor** Button.  The following dialog box appears. Click the **Yes** Button.  The Motor and Encoder setting Page appears.
3.	Click the **Next** Button  The Input Signals setting Page appears.

5.	Change the signal allocation of the below listed input signal, and then click the **Transfer to Drive** Button. • Error Stop Input • Positive Drive Prohibit Input • Negative Drive Prohibit Input  The following dialog box appears. Click the **Yes** Button  The drive restarts and you return to the Input Signals setting Page.
6.	Click the **Next** Button The Output Signals setting Page appears 

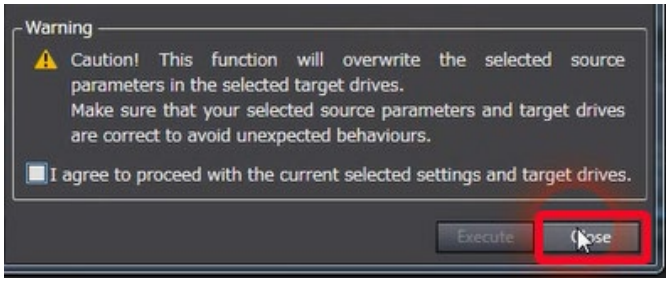
7.	Click the **Next** Button 
8.	Please Set Node2: R88D-1SN01L-ECT(E002) in the same way as Node1. Please click to the **Copy Settings** Button  The Copy Settings window appears.

9.	Check boxes and click the **Execute button** to start the procedure  Click the **Yes** Button to confirm the copy settings  Click the **Yes** Button to transfer settings to target drive  The target drive is restarting

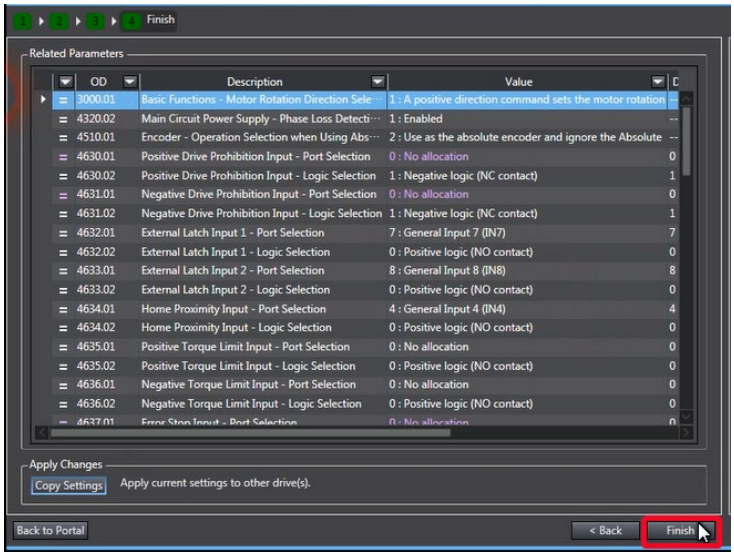


Settings are now effective in the target drive, click the **Ok** Button

Click the **Close** Button

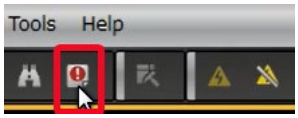


Click the **Finish** Button

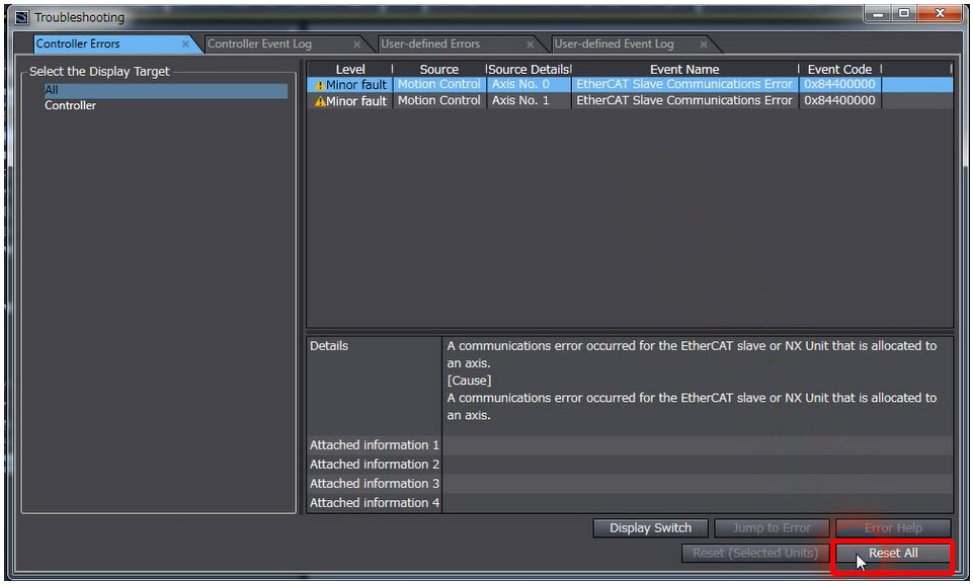


This concludes the procedure to change Input settings of Node 1 and Node 2.

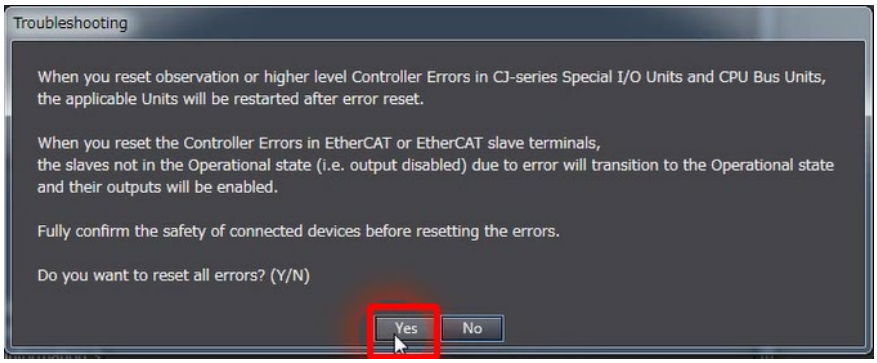
10. Following above procedure, drives have been restarted to apply Input settings. Please Reset the EtherCAT Slave Communication Error in the CPU Unit with Troubleshooting window.



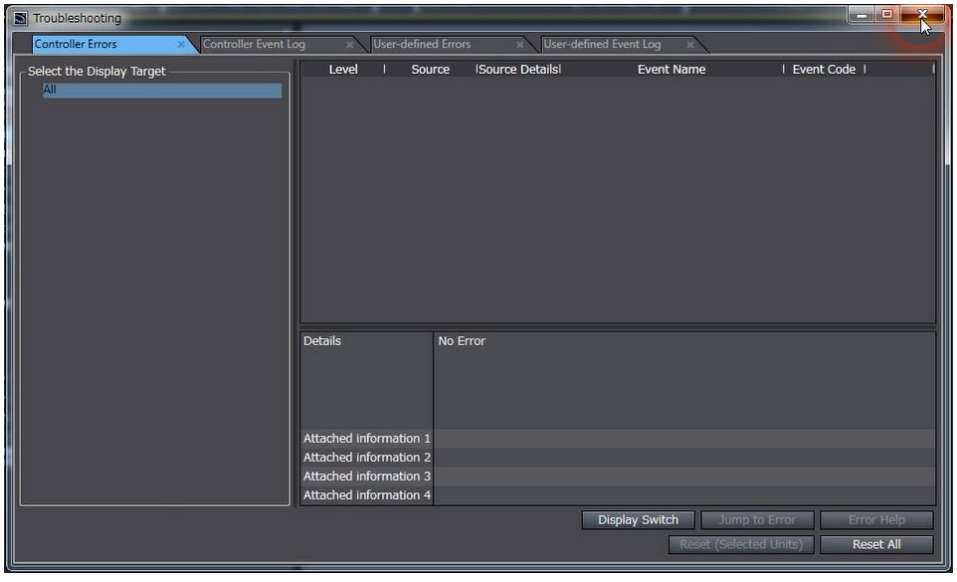
Click on **Reset All** button



Confirm the below message and lick on **Yes** button



Errors are now resetted



A-2 Program making with structured text

Below is an alternative program to move the XY stage with structured text.

```
Power1(Axis:=MC_Axis000, Enable:=ServoLock);
Power2(Axis:=MC_Axis001, Enable:=ServoLock);

Home1(Axis:=MC_Axis000, Execute:=Home);
Home2(Axis:=MC_Axis001, Execute:=Home);

Group1(AxesGroup:=MC_Group000, Execute:=GroupEnable);


Distance1[0]:=0;
Distance1[1]:=0;
Distance2[0]:=50;
Distance2[1]:=50;
Dwell_Time1:=TIME#2s;
Dwell_Time2:=TIME#2s;

Dwell1(In:=Start AND NOT Complete, PT:=Dwell_Time1, Q=>Go_Linear1);
Dwell2(In:=Start AND NOT Complete AND MoveLinear1.Done, PT:=Dwell_Time2,
Q=>Go_Linear2);

MoveLinear1(AxesGroup:=MC_Group000, Execute:=Go_Linear1, Position:=Distance1,
Velocity:=250, Acceleration:=8000, Deceleration:=8000);
MoveLinear2(AxesGroup:=MC_Group000, Execute:=Go_Linear2, Position:=Distance2,
Velocity:=250, Acceleration:=8000, Deceleration:=8000,    Done=>Complete);
```

A-3 Program making with structured text

Below is a sample program with structured text to move the gantry system.

```
Start

Power1(Axis:=MC_Axis000, Enable:=ServoLock);
Power2(Axis:=MC_Axis001, Enable:=ServoLock);

Home1(Axis:=MC_Axis000, Execute:=Home);
Home2(Axis:=MC_Axis001, Execute:=Home);

Distance1[0]:=0;
Distance1[1]:=0;
Distance2[0]:=50;
Distance2[1]:=50;
Dwell_Time1:=TIME#2s;
Dwell_Time2:=TIME#2s;

Dwell1(In:=Start AND NOT Complete, PT:=Dwell_Time1, Q=>Go_Linear1);
Dwell2(In:=Start AND NOT Complete AND MoveLinear1.Done, PT:=Dwell_Time2, Q=>Go_Linear2);

MoveLinear1(AxesGroup:=MC_Group000, Execute:=Go_Linear1, Position:=Distance1,
Velocity:=250, Acceleration:=8000, Deceleration:=8000);
MoveLinear2(AxesGroup:=MC_Group000, Execute:=Go_Linear2, Position:=Distance2,
Velocity:=250, Acceleration:=8000, Deceleration:=8000,    Done=>Complete);

End
```

Note: Do not use this document to operate the Unit.

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