AC Servo System 1S-series SS1/SLS Safety Sub-Functions

Startup Guide

R88M-1L[]/-1M[] (AC Servomotors)
R88D-1SN[]-ECT-51 (AC Servo Drives)
NJ/NX-series CPU Unit
NX-series Safety Unit
Sysmac Studio

always in control

I926-E1-01

NOTE

Introduction

The Servo System 1S-Series Servo Drive with Built-in EtherCAT Communications and SS1/SLS Safety Sub-Functions Startup Guide (hereinafter, may be referred to as “this Guide”) describes the procedures for installation and setup of a 1S-Series Servo Drive wtih Built-in EtherCAT Communications and SS1/SLS Safety Sub-Functions (hereinafter, may be referred to as 1S-Series Servo Drive with SS1/SLS Safety Sub-Functions), where an NJ/NX-series CPU Unit is used in combination with1S-series AC Servomotors/Servo Drives with SS1/SLS Safety Sub-Functions 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 with SS1/SLS Safety Sub-Functions.

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 NX-series Safety 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 with SS1/SLS Safety Sub-Functions
- NX-series EtherCAT Coupler unit
- NX-series Safety controller

Special Information

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

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.

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Information presented by Omron Companies has been checked and is believed to be accurate; however, no responsibility is assumed for clerical, typographical or proofreading errors or omissions.

Precautions

- 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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Software Licenses and Copyrights

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 https://www.fa.omron.co.jp/product/tool/454/nj/index_en.html.

Related Manuals

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

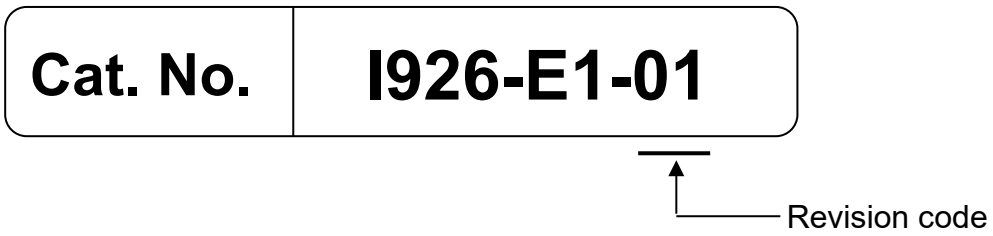
Manual name	Cat. No.	Model	Application	Description
1S-series AC Servomotors/Servo Drives with Built-in EtherCAT Communications and SS1/SLS Safety Sub-Functions User's Manual	I696	R88D-1S□-ECT-51 R88M-1□	Learning detailed specifications of a 1S-series Servo Drive with SS1/SLS Safety Sub-Functions.	Describes how to install and wire the Servo Drive, set parameters needed to operate the Servo Drive, and remedies to be taken and inspection methods to be used in case that problem occur.
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	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
NX-series CPU Unit Hardware User's Manual	W535	NX701-□□□□	Learning the basic specifications of the NX-series CPU Units, including introductory information, designing, installation, and maintenance. Mainly hardware information is provided.	An introduction to the entire NX-series system is provided along with the following information on the CPU Unit. • Features and system configuration • Introduction • Part names and functions • General specifications • Installation and wiring • Maintenance and inspection
NX-series NX102 CPU Unit Hardware User's Manual	W593	NX102-□□□□	Learning the basic specifications of the NX102 CPU Units, including introductory information, designing, installation, and maintenance. Mainly hardware information is provided.	An introduction to the entire NX102 system is provided along with the following information on the CPU Unit. • Features and system configuration • Introduction • Part names and functions • General specifications • Installation and wiring • Maintenance and inspection

Manual name	Cat. No.	Model	Application	Description
NX-series NX1P2 CPU Unit Hardware User's Manual	W578	NX1P2-□□□□	Learning the basic specifications of the NX1P2 CPU Units, including introductory information, designing, installation, and maintenance. Mainly hardware information is provided.	An introduction to the entire NX1P2 system is provided along with the following information on the CPU Unit. • Features and system configuration • Introduction • Part names and functions • General specifications • Installation and wiring • Maintenance and inspection
NX-series NX502 CPU Unit Hardware User's Manual		NX502-1□00	Learning the basic specifications of the NX502 CPU Units, including introductory information, designing, installation, and maintenance. Mainly hardware information is provided.	An introduction to the entire NX502 system is provided along with the following information on the CPU Unit. • Features and system configuration • Introduction • Part names and functions • General specifications • Installation and wiring • Maintenance and inspection
NJ-series CPU Unit Hardware User´s Manual	W500	NJ501-□□□□ NJ301-□□□□ NJ101-□□□□	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
NJ/NX-series Motion Control Instructions Reference Manual	W508	NX701-□□□□ NX502-1□00 NX102-□□□□ NX1P2-□□□□ NJ501-□□□□ NJ301-□□□□ NJ101-□□□□	Learning about the specifications of the motion control instructions that are provided by OMRON.	Describes the motion control instructions.
NJ/NX-series Troubleshooting Manual	W503	NX701-□□□□ NX502-1□00 NX102-□□□□ NX1P2-□□□□ NJ501-□□□□ NJ301-□□□□ NJ101-□□□□	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.

Manual name	Cat. No.	Model	Application	Description
NX-series Safety Control Units User's Manual	Z930	NX-SL□□□□ NX-SI□□□□ NX-SO□□□□	Learning how to use the NX-series Safety Control Units.	Describe the hardware, setup methods and functions of the NX-series Safety Control Units.
NJ/NX-series CPU Unit Software User's Manual	W501	NX701-□□□□ NX502-1□00 NX102-□□□□ NX1P2-□□□□ NJ501-□□□□ NJ301-□□□□ NJ101-□□□□	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
NJ/NX-series CPU Unit Motion Control User's Manual	W507	NX701-□□□□ NX502-1□00 NX102-□□□□ NX1P2-□□□□ 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.
NJ/NX-series Instructions Reference Manual	W502	NX701-□□□□ NX502-1□00 NX102-□□□□ NX1P2-□□□□ NJ501-□□□□ NJ301-□□□□ NJ101-□□□□	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).

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	July 2024	Original production

CONTENTS

1. Servo system configuration and peripheral products

1.1. Outline

The 1S-series AC Servo Drives with Built-in EtherCAT communications and SS1/SLS Safety Sub-Functions support 100-Mbps EtherCAT.
When you use the 1S-series Servo Drive with a Machine Automation Controller NJ/NX-series CPU Unit or CJ1W-NC□8□ EtherCAT-compatible Position Control 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.
The FSoE protocol, the technology for a safe communication layer supported by the 1S-series Servo Drives and SS1/SLS Safety Sub-Functions, allows you to build the safety system that uses the STO/SS1/SLS function from the safety controller on the EtherCAT network.

Additional Information

For additional information about 1S servo drive, please refer to *AC Servomotors/Servo Drives 1S-series with Built-in EtherCAT Communications and SS1/SLS Safety Sub-Functions User's Manual* (Cat. No. I696)

1.2. Servo System constructed in this guide

This Guide contains instructions from assembling the hardware that makes up a servo system to constructing a system for safety functions and performing debugging on the system. The servo system is built through the following steps:

■ **Performing Setup**

1	Installation and Wiring
▼	
2	System configuration with NJ and NX safety controller
▼	
3	Sysmac Studio project creation
▼	
4	Motor, ABS Encoder and I/O Setup
▼	
5	Gain tuning
▼	
6	Creating a Motor Control Program
▼	

■ **Adding a Safety Function**

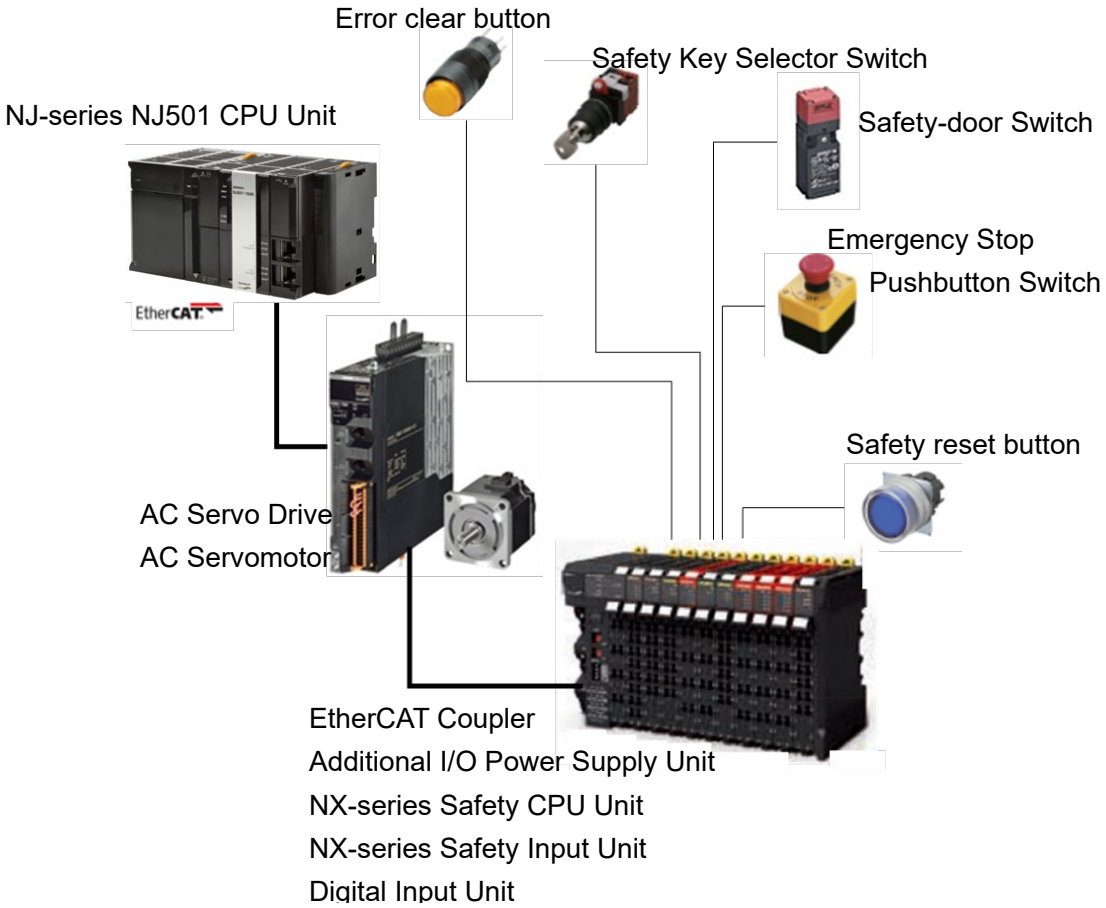
1	Select a safety function from below and add it. • Adding the Safe Stop 1 (SS1) Function • Adding the Safely-limited Speed (SLS) Function

Additional Information

For information on how to set up the motion controller, refer to the *Machine Automation Controller NJ/NX-Series Startup Guide for Motion Control* (Cat. No. W514).

1.3. System configuration

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 (Standard controller)	NJ501-[]	NJ-series CPU Unit Hardware User's Manual (Cat. No. W500)
NX-series EtherCAT Coupler	NX-ECC20[]	NX-series EtherCAT Coupler Unit User's Manual (Cat. No. W519)
Additional I/O Power Supply Unit	NX-PF0[]	NX-series System Units User's Manual (W523)
Digital Input Unit	NX-ID[]	NX-series Digital I/O Unit User's Manual (W521)
NX-series Safety CPU Unit (Safety controller)	NX-SL3500	NX-series Safety Control Unit User's Manual (Z930)
NX-series Safety Input Unit	NX-SID[]	
Ethernet/EtherCAT Communications Cable	XS5W-T[]	---

AC Servo Drive	R88D-1SN[]-51	AC Servomotors/Servo Drives 1S-series with Built-in EtherCAT Communications and SS1/SLS Safety Sub-Functions User's Manual (I696)
AC Servomotor	R88M-1[]	
Power cables	R88A-CA[]	
Encoder Cables	R88A-CR[]	
Error clear button	A3[]	---
Safety Key Selector Switch	A22TK[]	---
Safety-door Switch	D4NS[]	---
Emergency Stop Pushbutton Switch	A22[]	---

- **Automation Software**

Product	Number of licenses	Model
Sysmac Studio Standard Edition Version 1.59	None (DVD only)	SYSMAC-SE200D
	From 1 license to site license	SYSMAC-SE[]

2. Before You Begin

■ Unpack Drive/Motor

1.	Unpack motor package. The package includes only motor and instruction sheet. Cables are provided separately.  
2.	Unpack drive package. This product comes with the following accessories. • INSTRUCTION MANUAL × 1 copy • INSTRUCTION MANUAL（supplementation） × 1 copy • Warning label × 1 sheet • General Compliance Information and instructions for EU × 1 copy • Attached connectors  

■ Install the Sysmac Studio Standard Edition

Refer to the *Sysmac Studio Version 1 Operation Manual* (Cat. No. W504) for how to install.

Additional Information

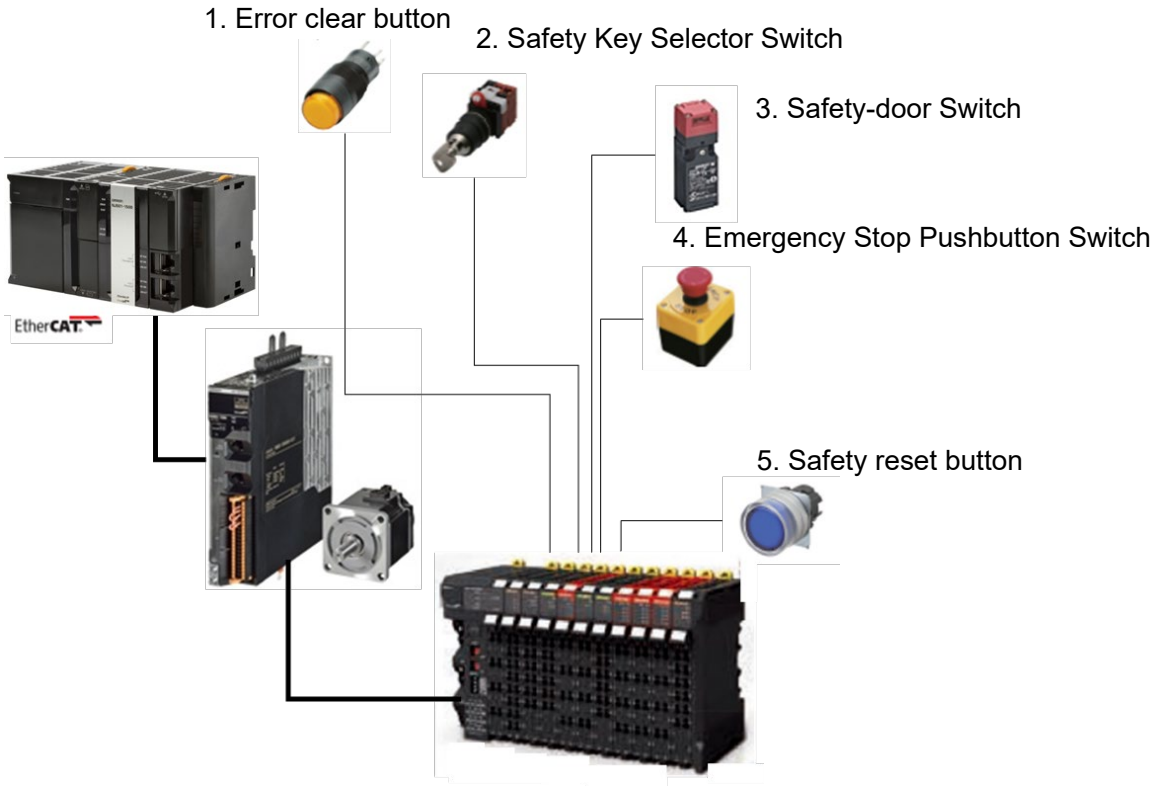
For further details on how to handle drive and motor package, please refer to *AC Servomotors/Servo Drives 1S-series with Built-in EtherCAT Communications and SS1/SLS Safety Sub-Functions User's Manual*(Cat. No. I696)

3. Performing setup

This section explains from assembling the hardware that makes up the servo system to adding the STO function via FSoE and creating a motor control program. The next section *4. Adding a Safety* Function describes how to add safety functions other than the STO function.

The operation of the servo system set up in this section is explained below.

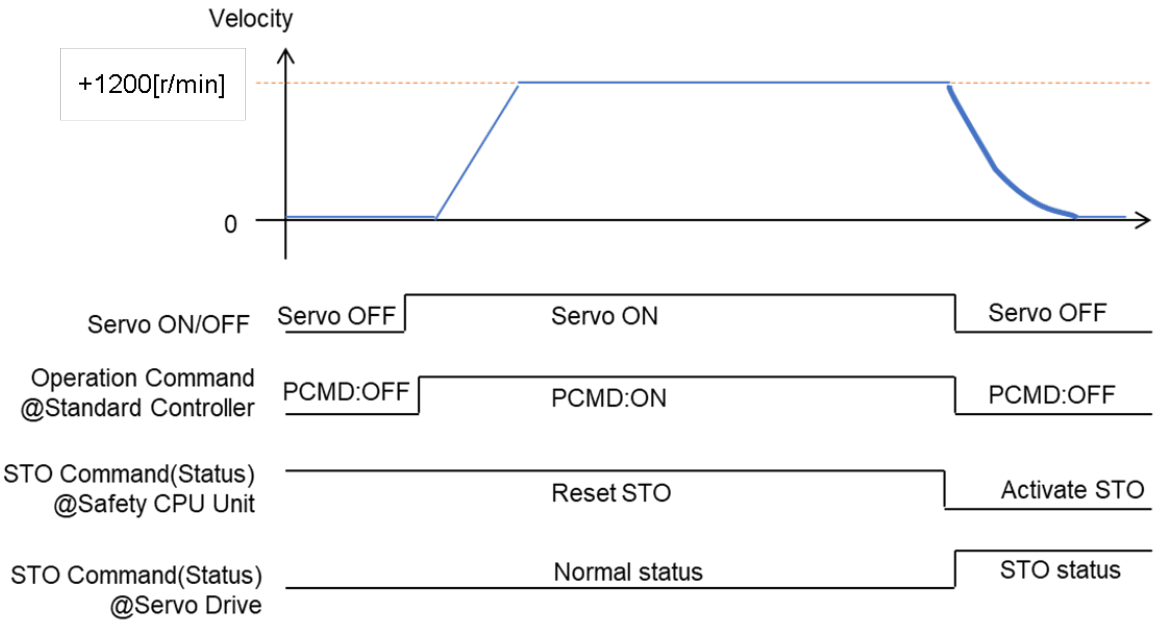
1. When the error clear button is pressed, the errors of the standard controller and Servo Drive are reset.
2. When the guard with the Safety-door Switch is opened, the motor torque is turned OFF.
3. When the Emergency Stop Pushbutton Switch is pressed, the motor torque is turned OFF.
4. When the safety reset button is pressed, the STO status is reset.



Input device	State	Operation
1. Error clear button	ON	Enable error reset command
	OFF	Disable error reset command
2. Safety Key Selector Switch ※Used in Chapter 4.	Normal operating mode	Run Servomotor at normal speed.
	Safety active mode	Enable the assigned Safety Sub-Function. ※Assignment procedure is described in chapter 4.
3. Safety-door Switch	Open	Enable STO command
	Close	Disable STO command
4. Emergency Stop Pushbutton Switch	ON	Enable STO command
	OFF	Disable STO command
5. Safety reset button	ON	Enable reset STO status command
	OFF	Disable reset STO status command

■ Operation of STO Function with Motion Control

1. When the Servo ON command is enabled, the Servo Drive turns ON the Servo.
2. When the STO function is executed, the Servo Drive shifts to the STO state and turns OFF torque.
3. When an operation command is enabled, the command velocity to the Servomotor is set to 1200 r/min.



3.1. Installation and Wiring

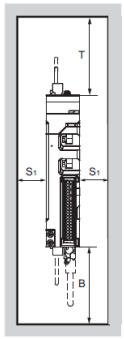
This section describes installation and wiring using the R88D-1SN01L-ECT-51.

For further about Installation and Wiring other than R88D-1SN01L-ECT-51, please refer to *AC Servomotors/Servo Drives 1S-series with Built-in EtherCAT Communications and SS1/SLS Safety Sub-Functions User's Manual* (Cat. No. I696) Chapter 4 Configuration and Wiring.

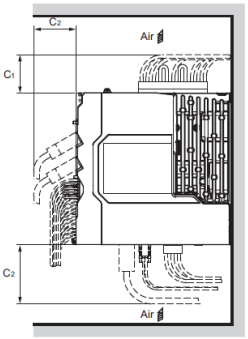
■ Space Conditions around Servo Drives

Install the Servo Drive according to the following.

● Single-unit Installation

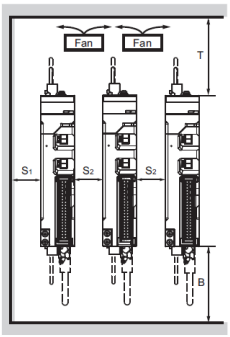


Front view

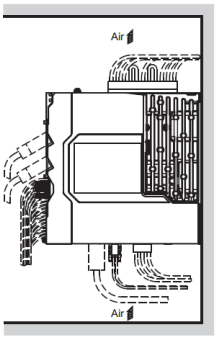


Side view

● Side-by-side Installation



Front view



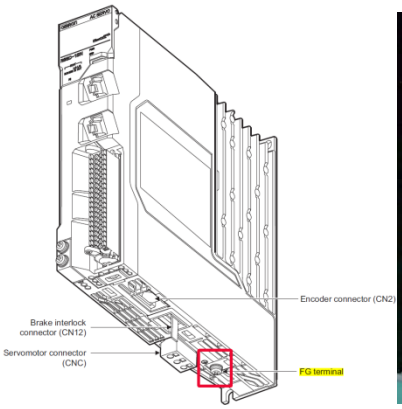
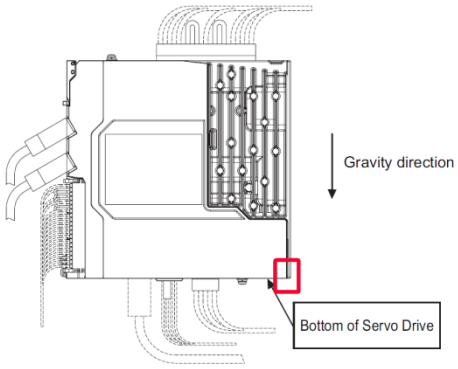
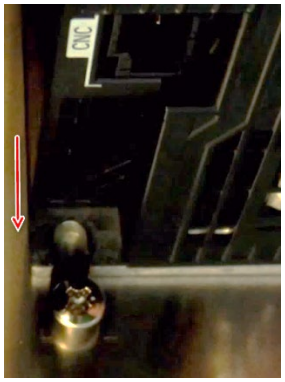
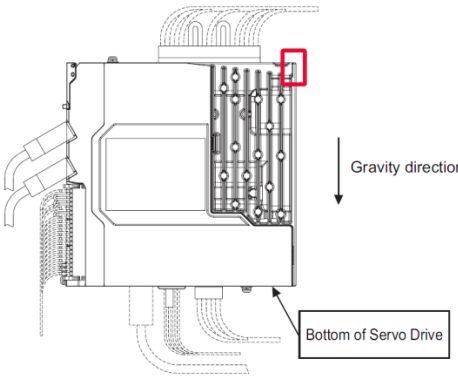
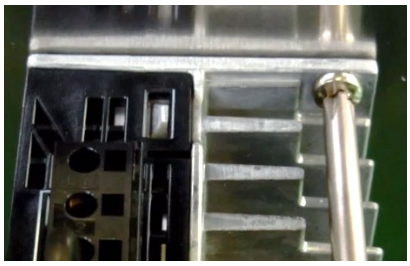
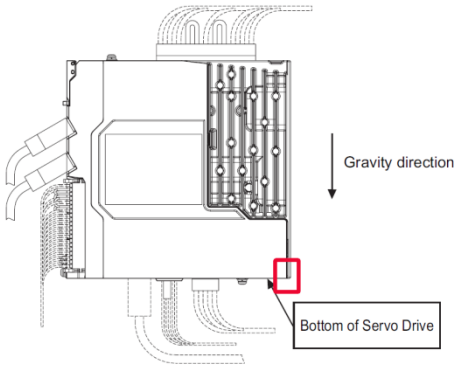
Side view

Dimension	Distance	
T	100mm min.	
B	100mm min.	
S_1	40mm min.	
S_2	10mm min. ※1	
C_1	R88D-1SN01L-ECT-51 / R88D-1SN02L-ECT-51/ R88D-1SN04L-ECT-51 / R88D-1SN01H-ECT-51/ R88D-1SN02H-ECT-51 / R88D-1SN04H-ECT-51/ R88D-1SN08H-ECT-51 / R88D-1SN10H-ECT-51	45mm min.
	R88D-1SN15H-ECT-51 / R88D-1SN20H-ECT-51/ R88D-1SN30H-ECT-51 / R88D-1SN06F-ECT-51/ R88D-1SN10F-ECT-51 / R88D-1SN15F-ECT-51/ R88D-1SN20F-ECT-51 / R88D-1SN30F-ECT-51	60mm min.
C_2	50mm min.	
C_3	70mm min.	

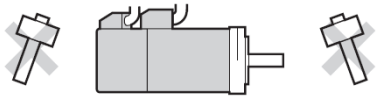
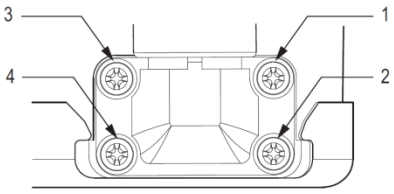
*1. Limit the operating ambient temperature of Servo Drive from 0 to 45°C when the distance is less than 10 mm.

- Install the Servo Drive on the vertical metal surface.
- To provide electrical conduction, remove any paint from the surface on which you install the Servo Drives. Also, it is recommended that you apply conductive plating if you make the mounting bracket by yourself.
- The recommended tightening torque for installing the Servo Drive is 1.5 N·m. Make sure that the threaded portion has the sufficient strength to withstand the recommended torque.

■ Servo driver installation

1.	In case of using the shield clamp, please fixe it in advance with the existing screw  
2.	Approach the drive from top to down.  
3.	Tight the upper part.  
4.	Tight the down part.  

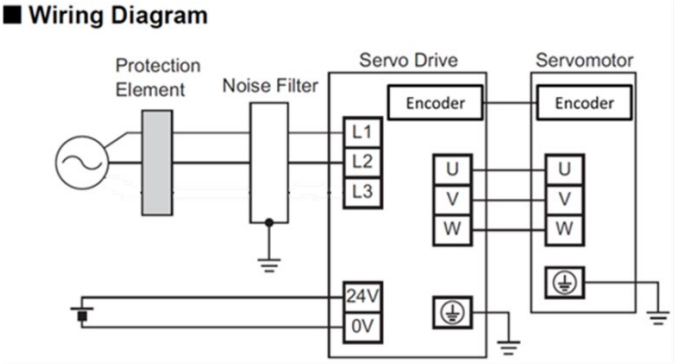
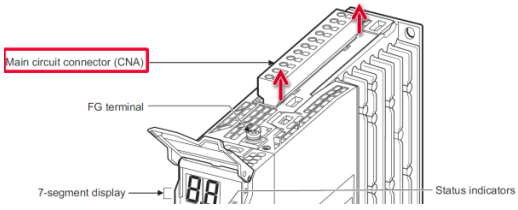
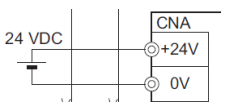
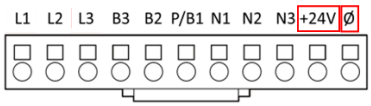
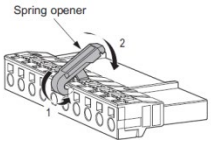
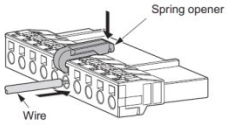
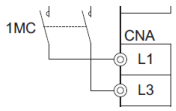
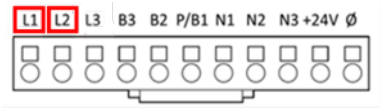
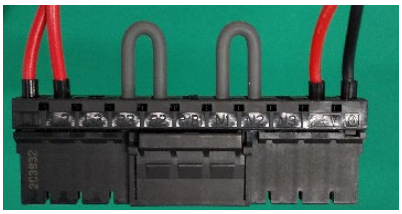
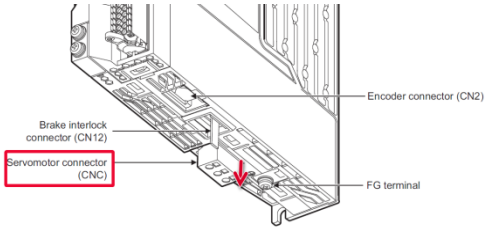
■ **Motor installation** (step 2, 3 order depends on your mechanical implementation)

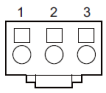
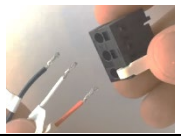
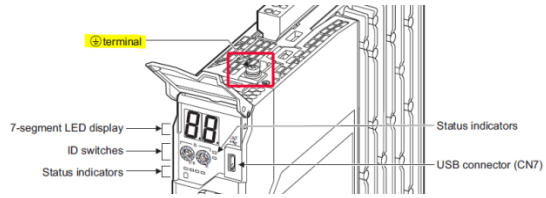
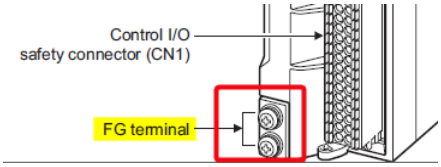
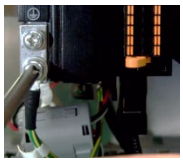
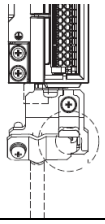
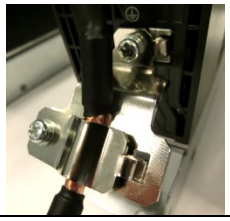
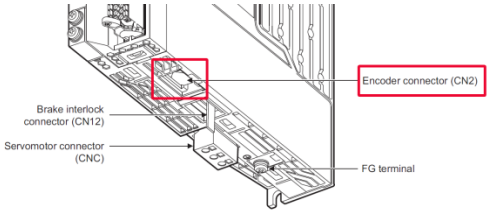
1.	Please handle the motor carefully & do not apply heavy impacts or loads during transport, installation, or removal of the motor. 
2.	Please fixe and connect the motor to the mechanical system  Note: At first, please check motor operation without any load.
3.	Please attached the power and encoder cable    Please tight screws in several times in this order :1>4>3>2

Additional Information

For further details about coupling method, please refer to *AC Servomotors/Servo Drives 1S-series with Built-in EtherCAT Communications and SS1/SLS Safety Sub-Functions User's Manual* (Cat. No. I696) Chapter 4-1 Installation Conditions.

■ Wiring

1.	Overview **■ Wiring Diagram** 
2.	Please remove power connector (CNA) from the drive. 
3.	Please wire the 24V control power supply. (stripped wires or ferrules can be used)   Please connect wires with the spring opener.  
4.	Please wire the AC power supply.   
5.	Please remove the motor connector (CNC) from the drive. 

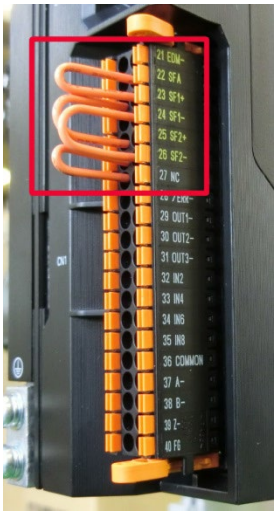
6.	Please wire U, V, W of the motor. (stripped wires) <table><tr><th>Pin No.</th><th>Name</th></tr><tr><td>1</td><td>U</td></tr><tr><td>2</td><td>V</td></tr><tr><td>3</td><td>W</td></tr></table>  
7.	Please screw the PE wire ⏚ of the main power to the drive.  
8.	Please plug back above connectors to the drive. (Power and Motor)
9.	Please fixe the FG wire from the motor cable to the drive   Or In case of using the shield clamp, please attach the cable to the clamp in order to connect the shielded section.  
10.	Please plug the encoder cable to the drive (CN2)  

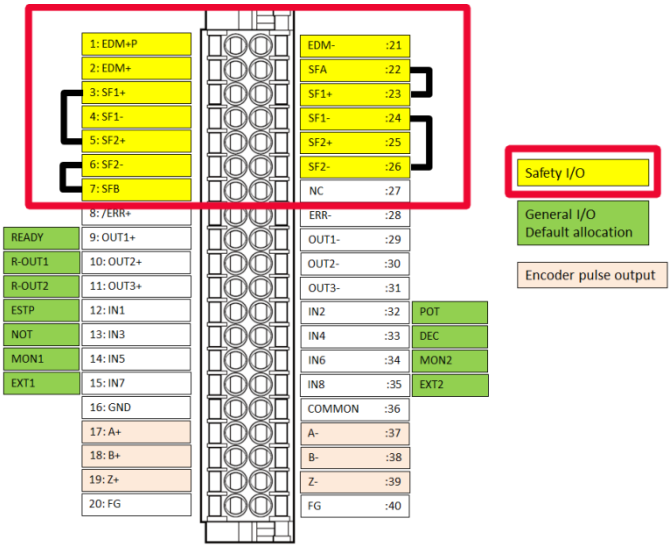
Additional Information

For further details about wiring method, please refer to *AC Servomotors/Servo Drives 1S-series with Built-in EtherCAT Communications and SS1/SLS Safety Sub-Functions User's Manual* (Cat. No. I696) Chapter 4-2 Wiring.

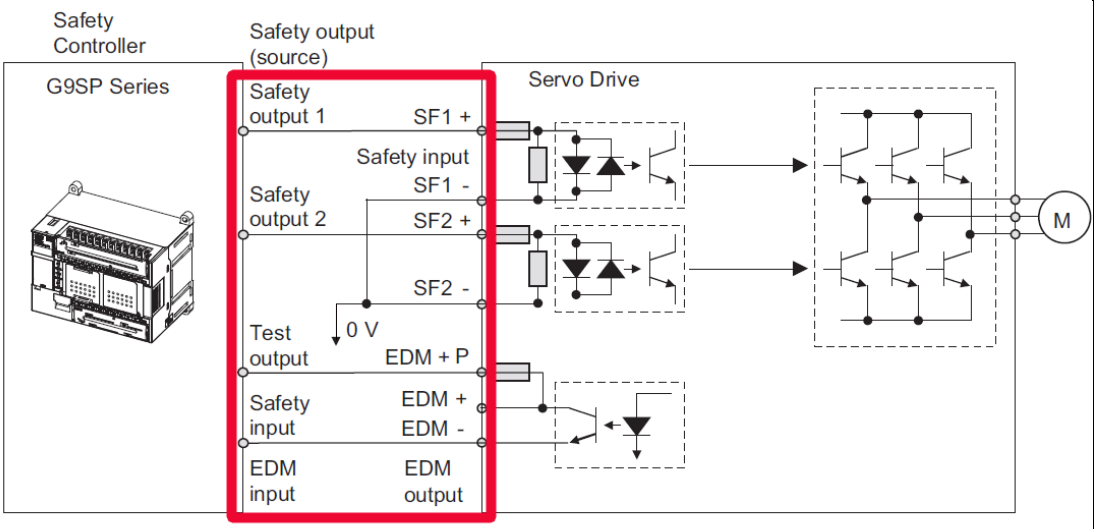
■ I/0, Safety Wiring

1. By default, STO function is inhibited and bypassed with jumpers

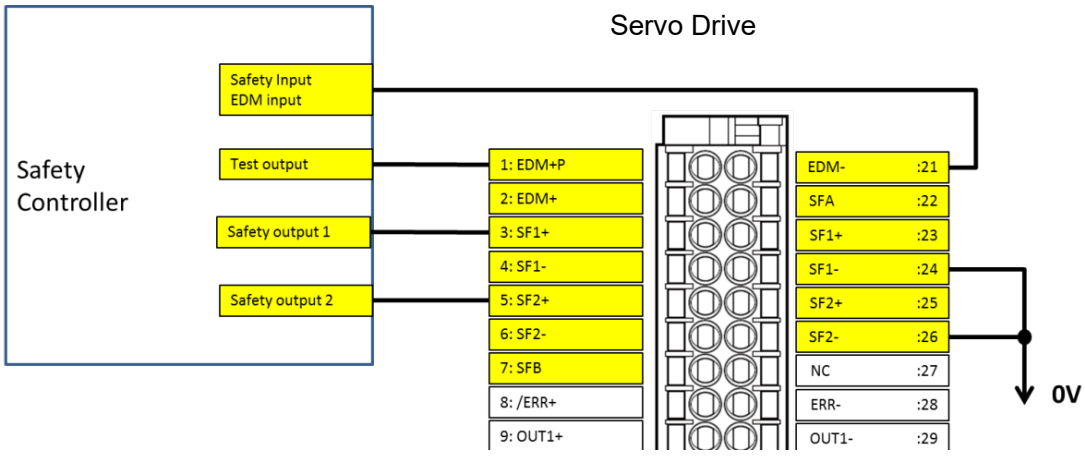




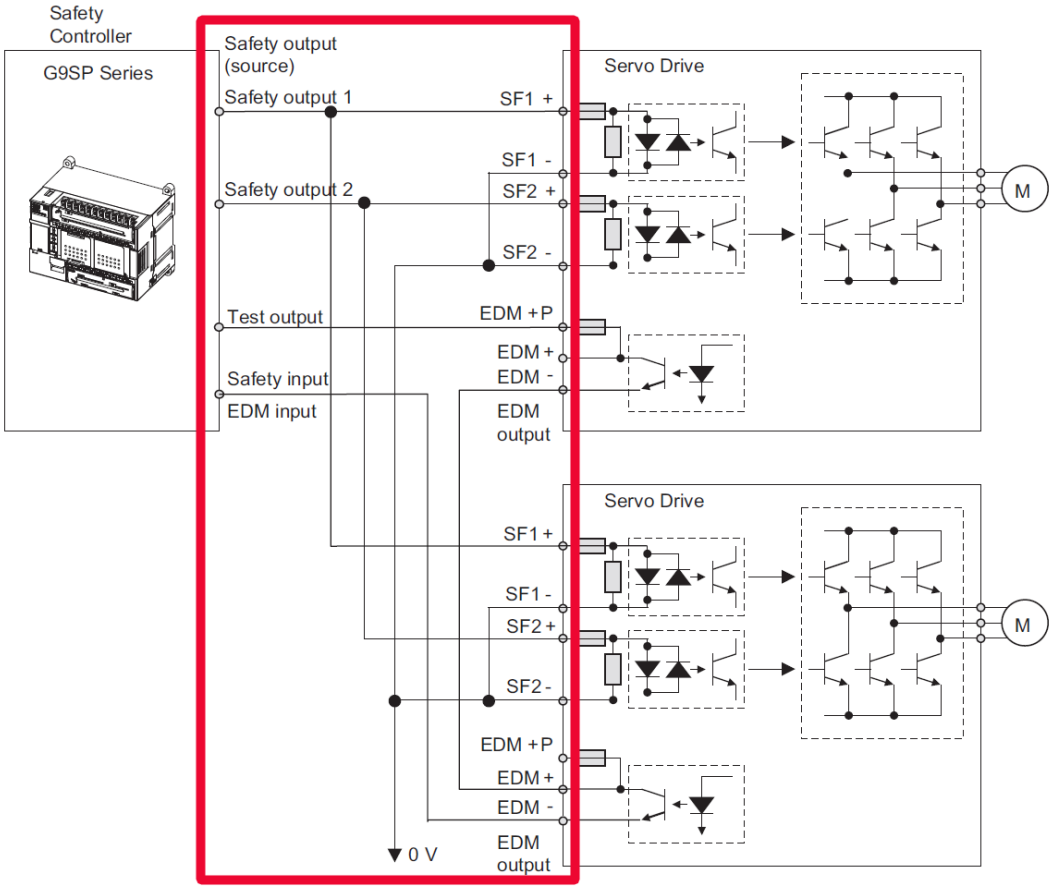
2. In case of using STO by hardwire, Please make the proper wiring between the safety controller and the drive

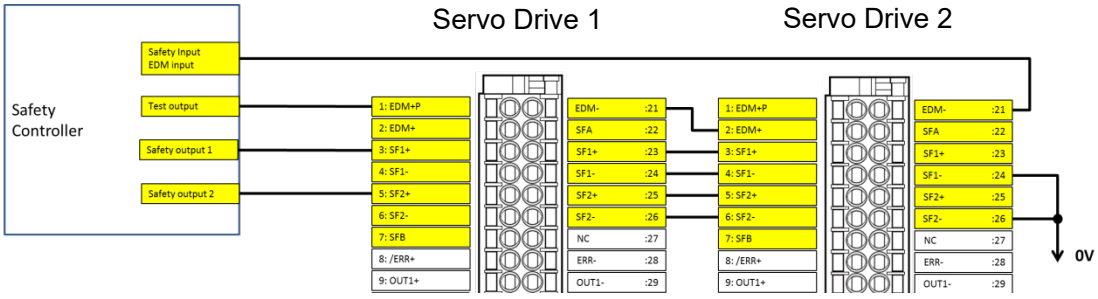


Wire SF1 and SF2 to different safety outputs.



3.	In case of using STO by hardwire for multiple servo drives, please make the proper wiring between the safety controller and drives.

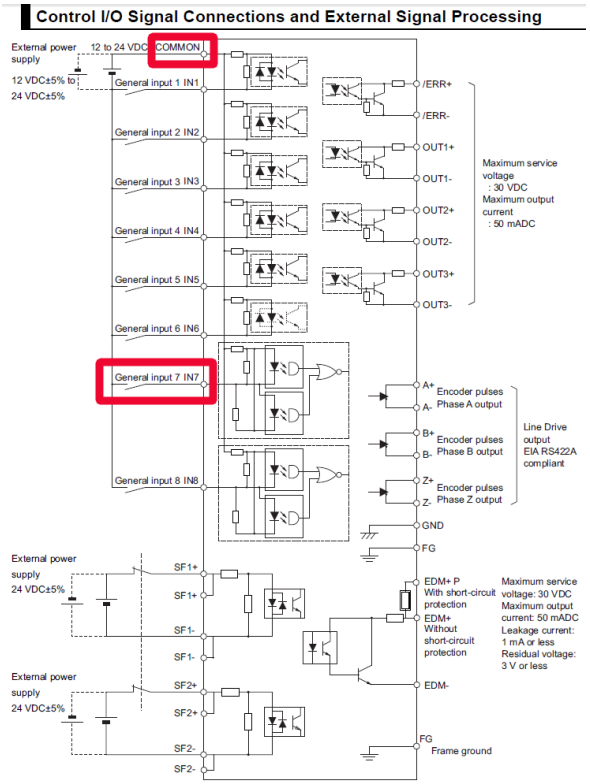




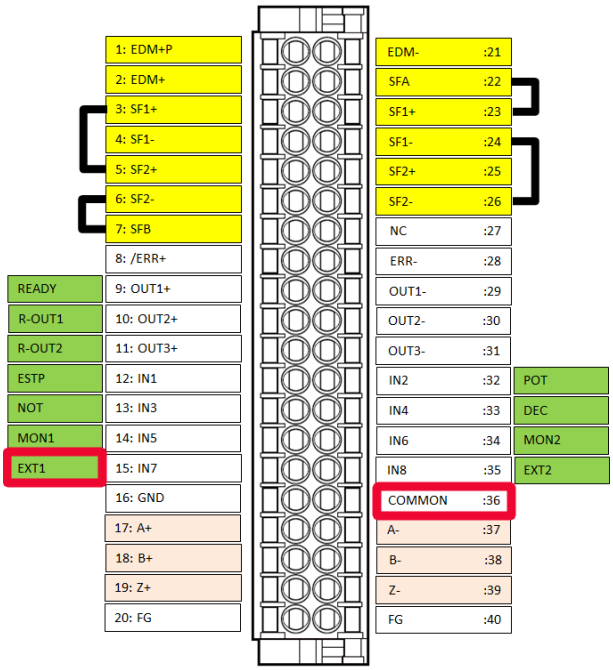
Note: When G9SP-series safety controller is used, you can connect up to four 1S-series Servo Drives

4. When general I/Os are required, please make the proper wiring.

Here is an example of latch input 1:



Servo Drive connector view:

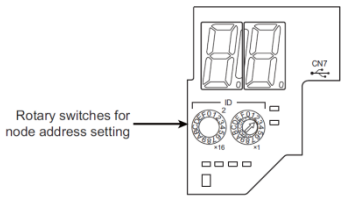
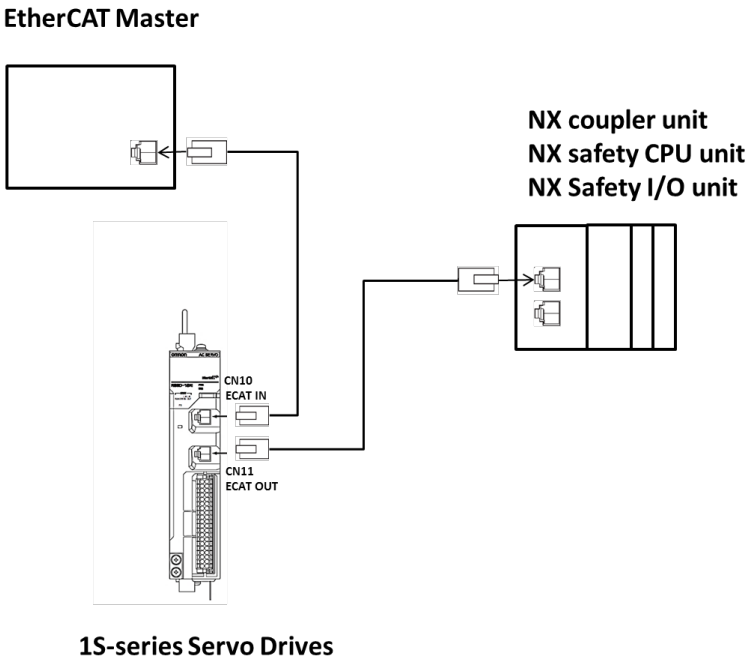


Additional Information

For further details about wiring method, please refer to *AC Servomotors/Servo Drives 1S-series with Built-in EtherCAT Communications and SS1/SLS Safety Sub-Functions User's Manual* (Cat. No. I696) Chapter 8-2 Safe Torque OFF (STO) Function.

3.2. System configuration with NJ and NX safety controller

■ EtherCAT node address configuration

1.	Please configure the EtherCAT node address of the drive to 1.   Note: You can configure the node address depending on your application
2.	In case of using NX safety, please configure the node address of the NX coupler to 2. Note: You can configure the node address depending on your application
3.	Please connect EtherCAT cables to devices  CN10 EtherCAT IN: EtherCAT cable from NJ EtherCAT Master CN11 EtherCAT OUT: EtherCAT cable to NX coupler unit 

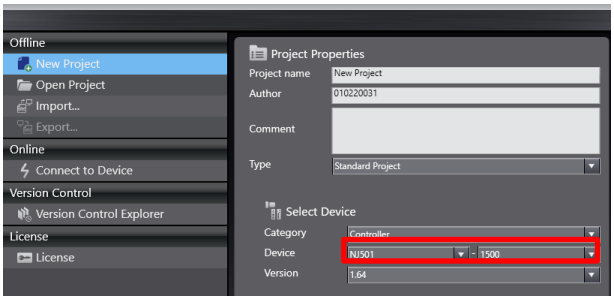
Additional Information

For further details about safety controller, please refer to the NX-series safety control units user manual Z930

3.3. Sysmac Studio project creation

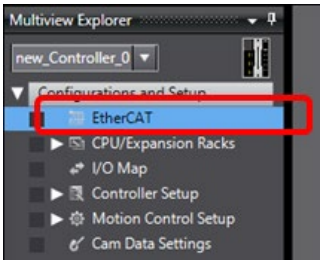
3.3.1. Creating a Network Configuration

1. Select the NJ501-1500 Controller from the list.

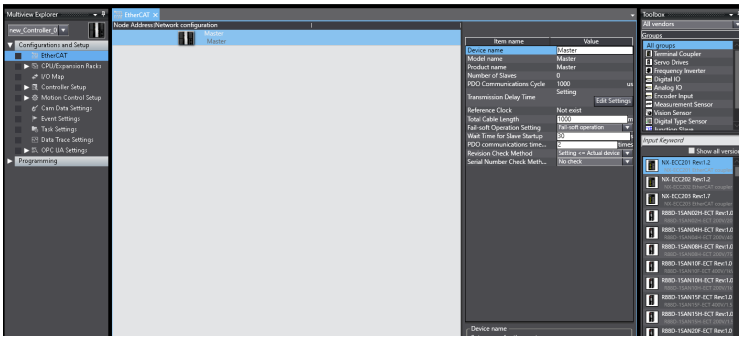


Note: When using the motor sizing tool results file, refer to the *Adding a Servo Drive and Axis from Motor Sizing Tool* Results under *Appendices*.

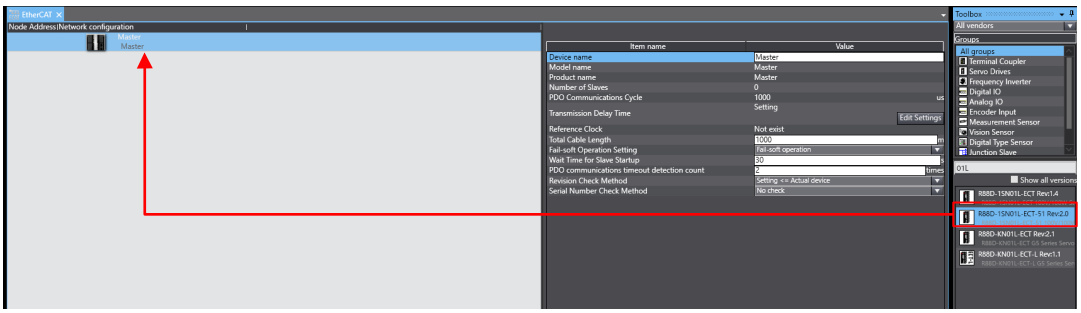
2. Double-click *EtherCAT* under *Configurations and Setup* in the Multiview Explorer.



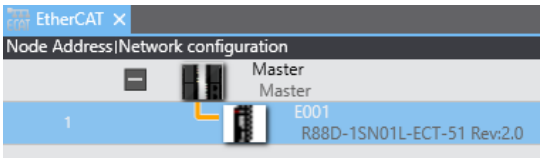
The EtherCAT Tab Page is displayed in the Edit Pane.

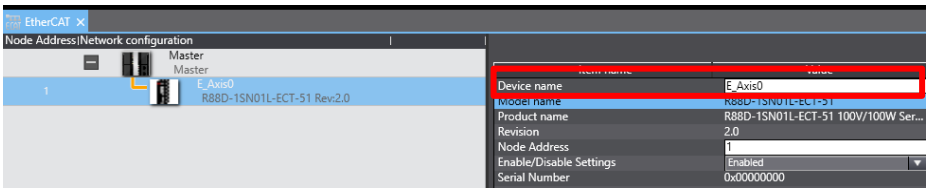
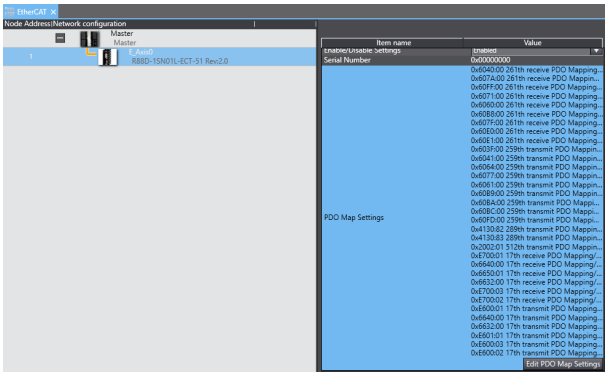
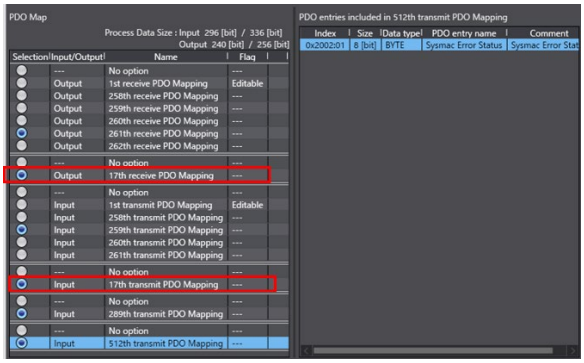
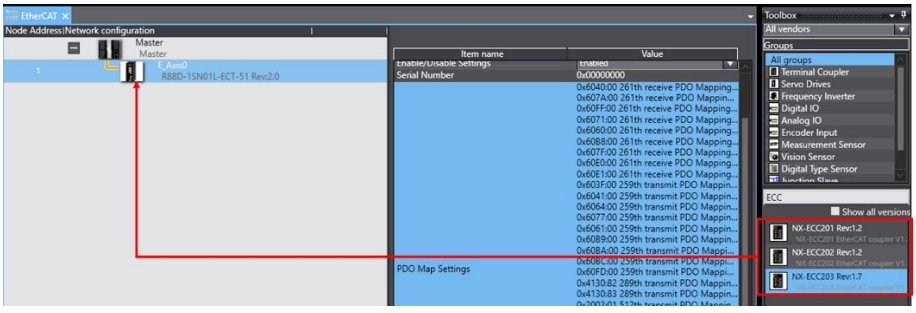
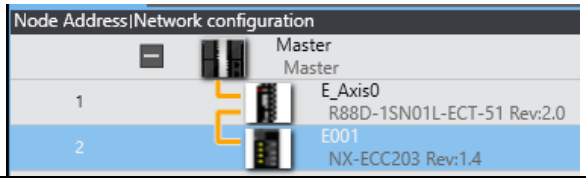


3. Drag a Servo Drive from the Toolbox to the Master in the EtherCAT Tab Page.



The Servo Drive with a node address of 1 is added under the Master.



4.	Change the device name of the Servo Drive to *E_Axis0*. 
5.	Select the Servo Drive and select *Edit PDO Mapping Settings*. Note1: If you want to edit the PDO mapping, please take it offline in advance. 
6.	Select a *safety input/output. (17th）* Note1: The PDOs for safety input/output are assigned by default. 
7.	Drag and drop the NX coupler.  NX coupler is added to Network Configuration. Node address is "2". 

Additional Information

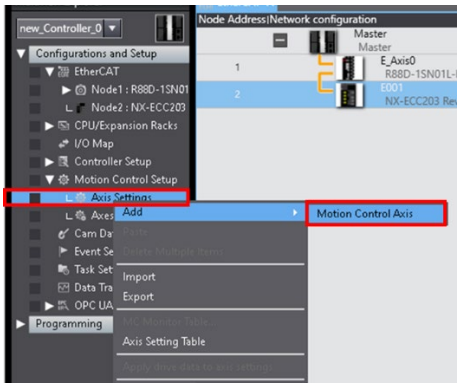
If the physical EtherCAT network configuration is already connected, you can automatically create the virtual network configuration on the Sysmac Studio from the physical network configuration.

Refer to the *Sysmac Studio Version 1 Operation Manual* (Cat. No. W504) for the procedure.

3.3.2. Setting an Axis

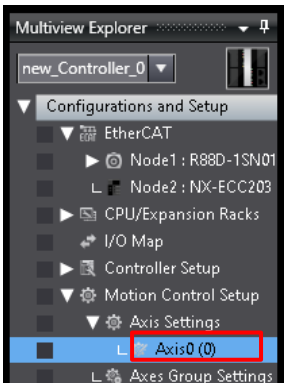
This section describes how to add the axis that is used to control the Servo Drive, assign the Servo Drive, and set the axis parameters.

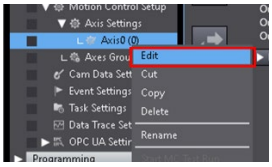
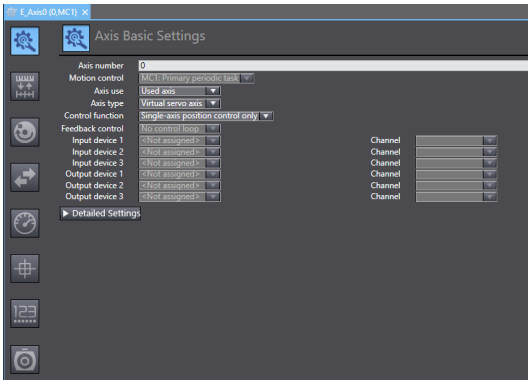
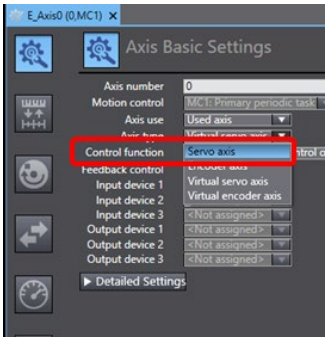
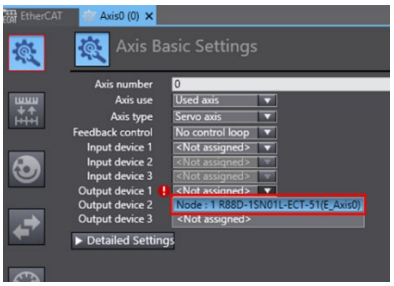
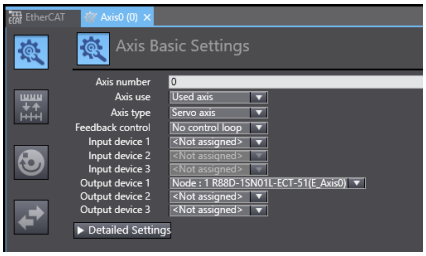
1. Right-click *Axis Settings* in the Multiview Explorer and select *Add - Motion Control Axis* from the menu.

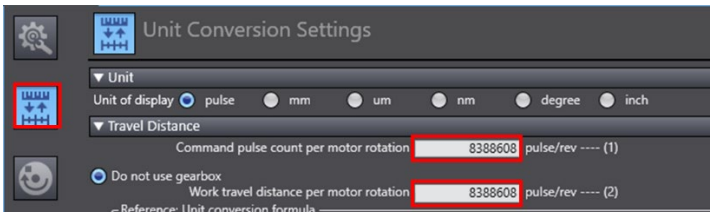
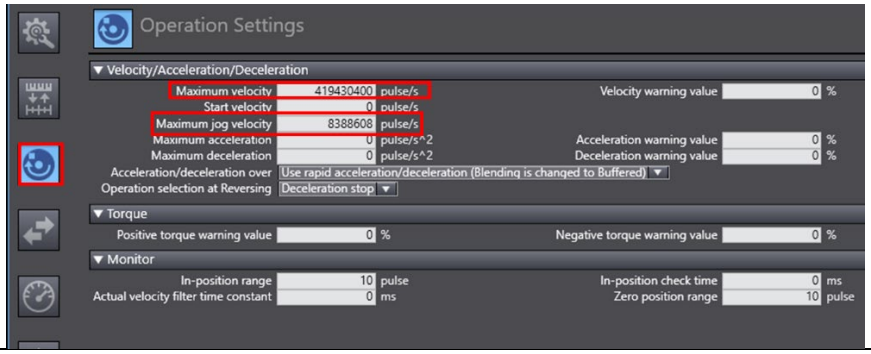
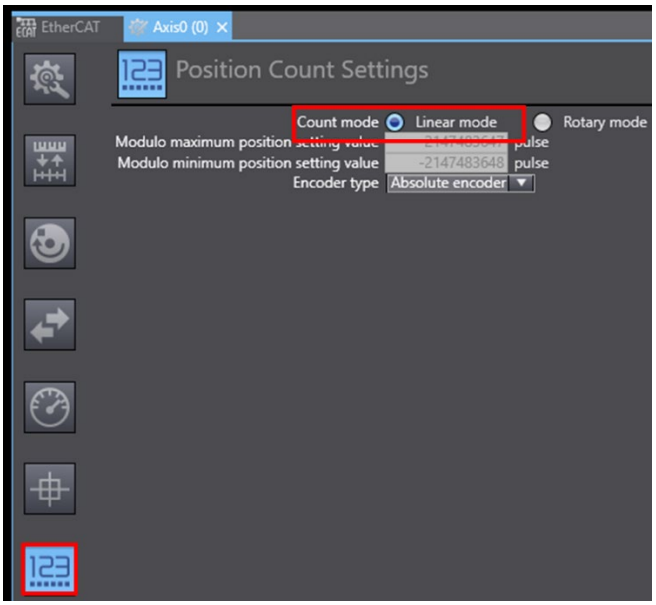


The axis *Axis0* is added to the Multiview Explorer.

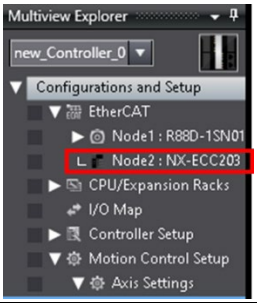
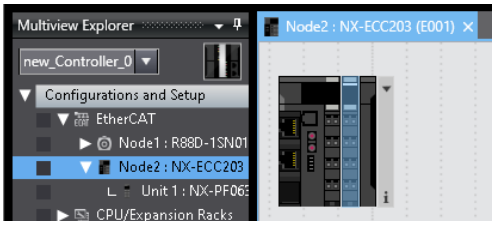
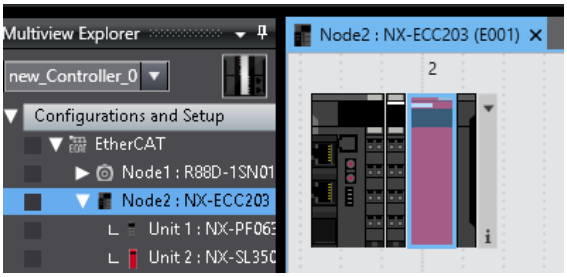
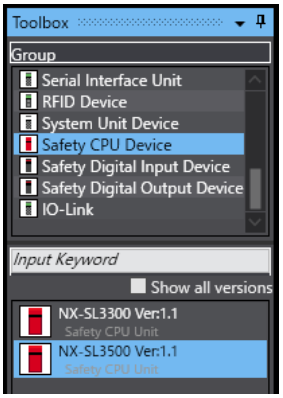
This added axis is called the axis 0.

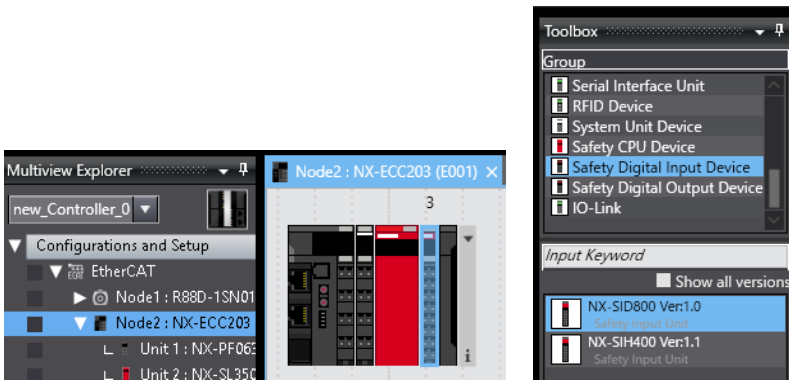
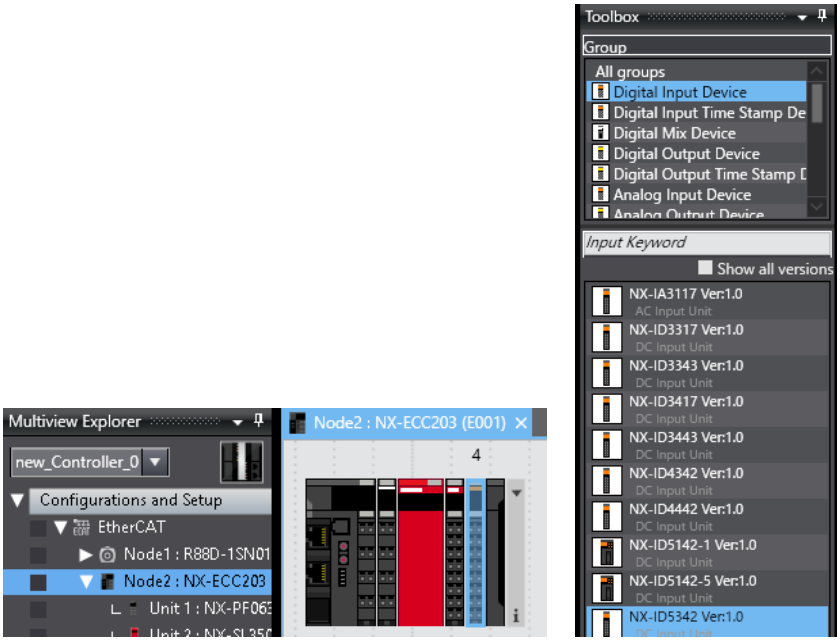


2.	Right-click *Axis0* (axis 0) in the Multiview Explorer and select *Edit* from the menu.  The Axis Basic Settings view is displayed on the Axis Parameter Settings Tab Page in the Edit Pane. 
3.	Select *Servo axis* for the *Axis type* setting. 
4.	Select the Servo Drive to use for the *Output device 1* setting.  This will assign the node: 1 Servo Drive to the Output device 1 for axis 0. 

5.	Set the parameters on the Axis Parameter Settings Tab Page. The following figure shows the axis parameters for the unit conversion settings. Unit of display: pulse Command pulse count per motor rotation: 8,388,608 pulse/rev Work travel distance per motor rotation: 8,388,608 pulse/rev 
6.	Operation Settings Maximum velocity: 419,430,400 pulse/s (3,000 r/min) Maximum jog velocity: 8,388,608 pulse/s (60 r/min) 
7.	Position Count Settings Count mode: Linear mode 

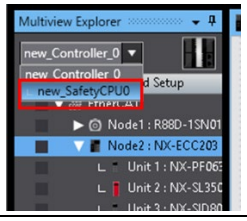
3.3.3. Setting the Network Configuration

1.	Double-click *NX-ECC203*. 
2.	Drag a system unit device to the location where you want to add it in the CPU and Expansion Racks Tab Page. In this example, drag the NX-PF0630 Additional I/O Power Supply Unit.  
3.	Drag a safety CPU device to the location where you want to add it in the CPU and Expansion Racks Tab Page. In this example, drag the NX-SL3500 Safety CPU Unit.  

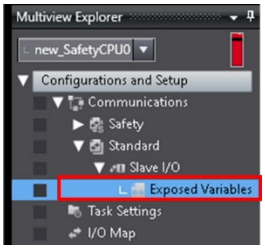
4.	Drag a safety digital input device to the location where you want to add it in the CPU and Expansion Racks Tab Page. In this example, drag the NX-SID800 Safety Input Unit. 
5.	Drag a digital input device to the location where you want to add it in the CPU and Expansion Racks Tab Page. In this example, drag the NX-ID4342 Digital Input Unit. 
6.	Turn ON the power supply to all devices.

3.3.4. Setting to Transfer Data from the Standard Controller to the Safety Controller

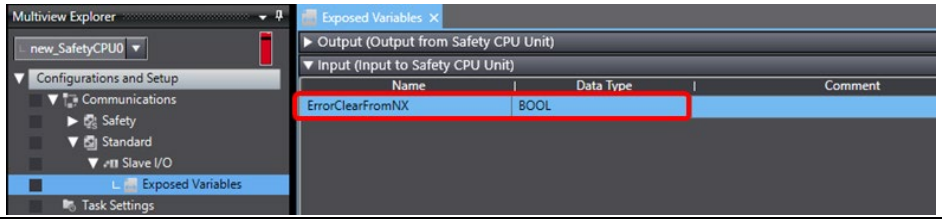
1. Select *new_SafetyCPU0* from the list.



2. Double-click *Exposed Variables*.



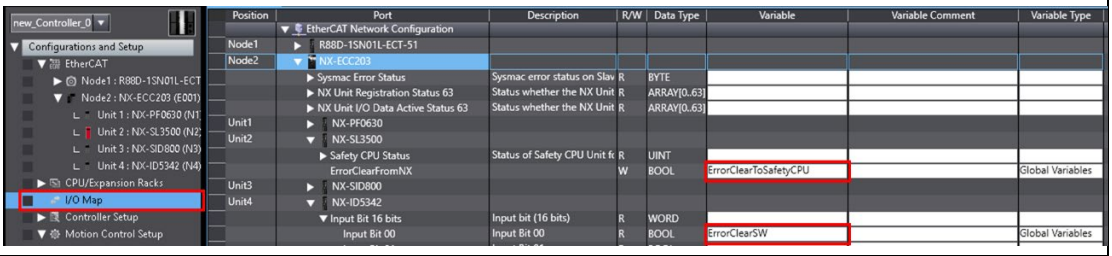
3. Add the *ErrorClearFromNX* BOOL variable to Input (Input to the Safety CPU Unit).



4. Select *new_Controller_0* from the list.

5. Open the I/O Map and create device variables.

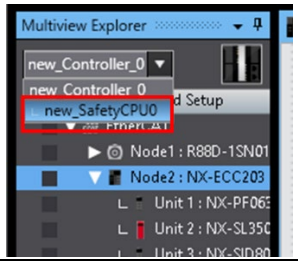
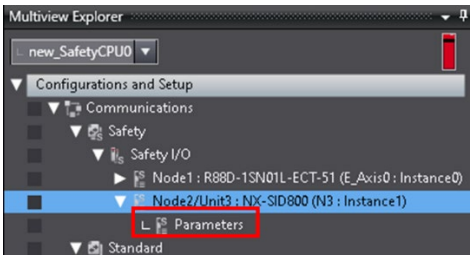
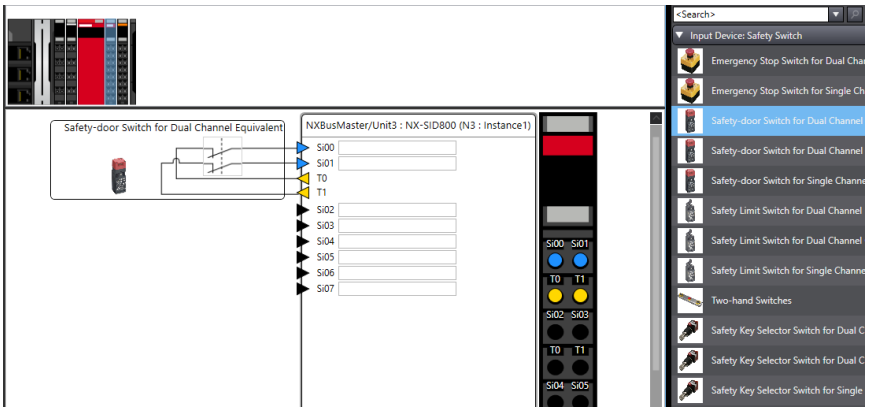
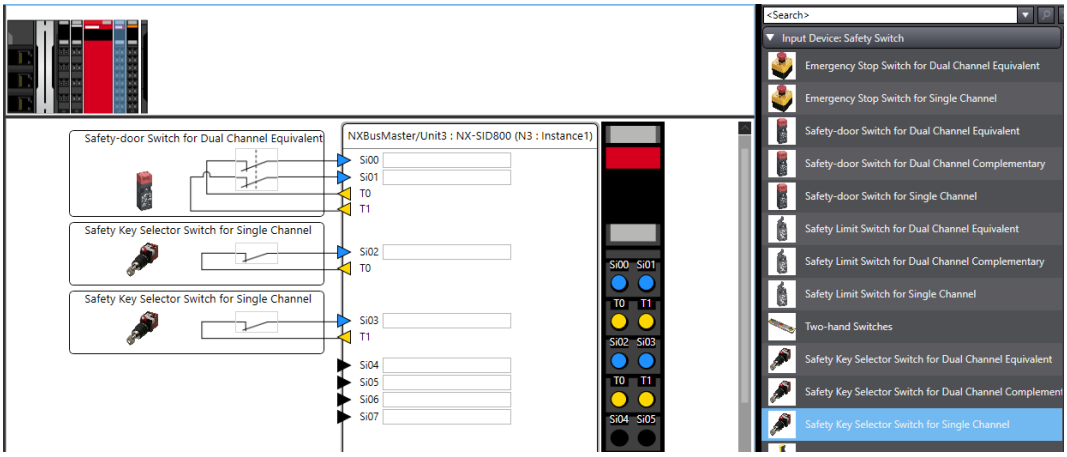
Port	Variable name
ErrorClearFromNX	ErrorClearToSafetyCPU
Input Bit 00	ErrorClearSW



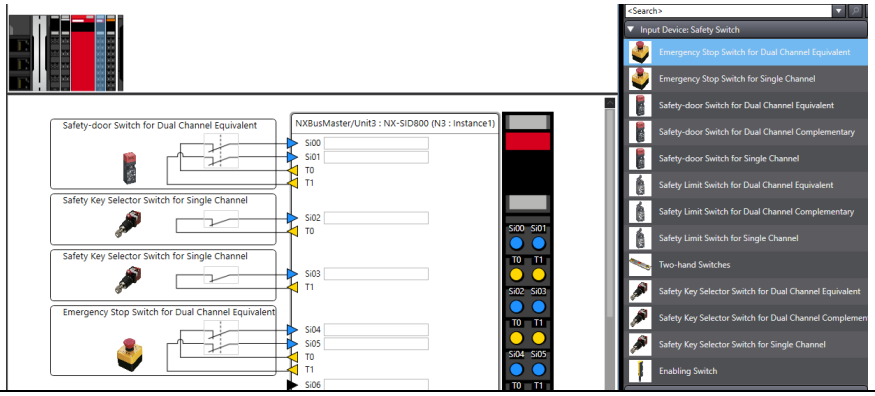
6. Double-click *Section0* to create a ladder program that transfers *ErrorClearSW* to the safety controller.

3.3.5. Setting the Safety Controller

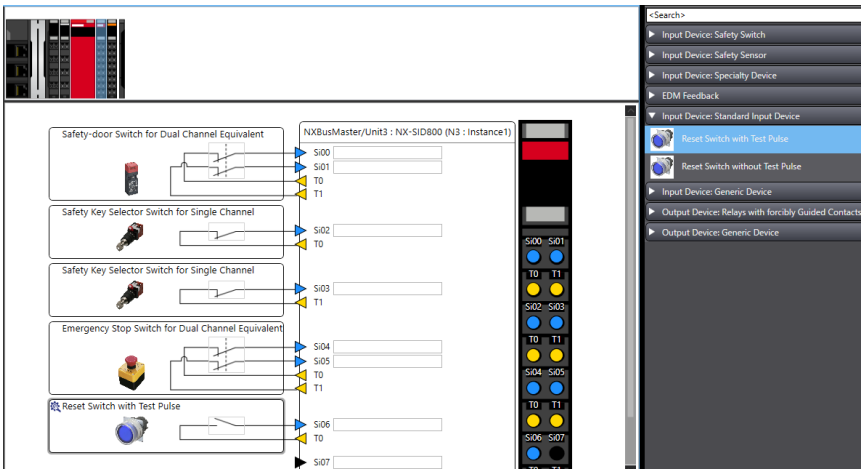
This section describes how to set safety input devices.

1.	Select *new_SafetyCPU0* from the list. 
2.	Double-click *Parameters*. 
3.	Drag a Safety-door Switch to the desired I/O terminal. 
4.	Drag two safety key selector switches for single channel to the desired I/O terminals. <u>Note1:</u> Used in Chapter 4. 

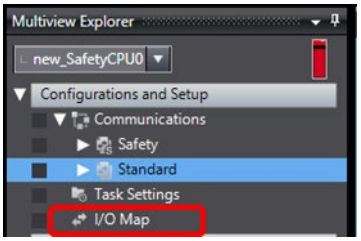
5. Drag an emergency stop pushbutton switch to the desired I/O terminal.



6. Drag a reset switch to the desired I/O terminal.

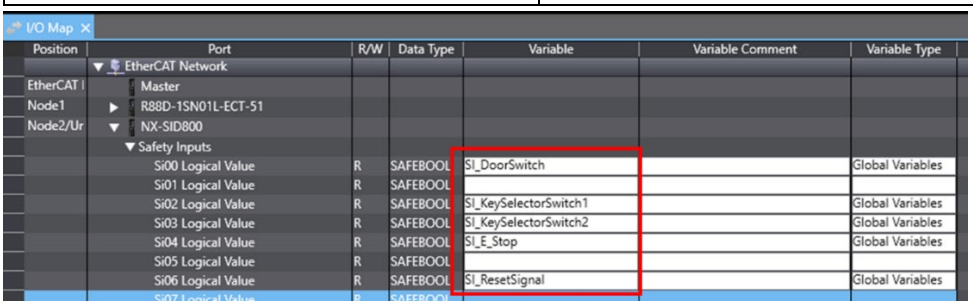


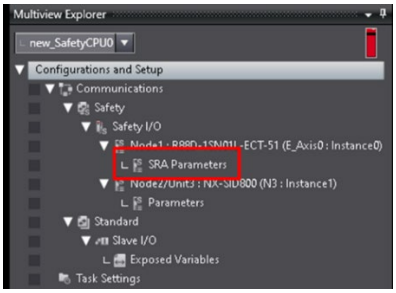
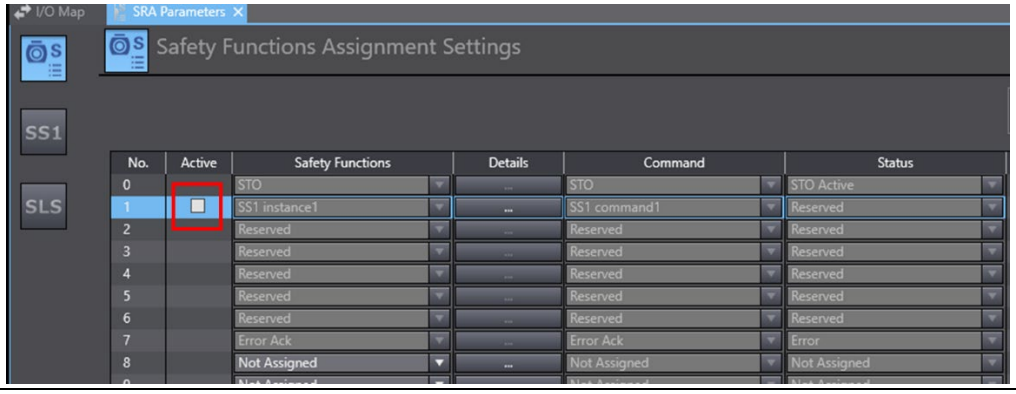
7. Double-click *I/O Map*.



8. Create device variables for the safety input devices.

Port	Variable name
Si00 Logical Value	SI_DoorSwitch
Si02 Logical Value	SI_KeySelectorSwitch1
Si03 Logical Value	SI_KeySelectorSwitch2
Si04 Logical Value	SI_E_Stop
Si06 Logical Value	SI_ResetSignal



9.	Double-click *SRA Parameters*. 
10.	Deactivate safety functions except for the STO function. Clear the selections of the *Active* Check Boxes for SS1 instance1 to deactivate the unused safety functions. 

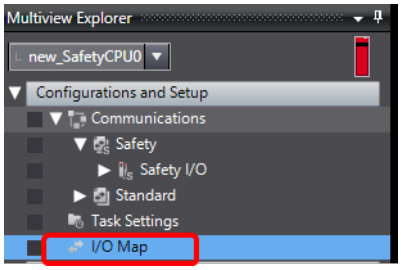
3.3.6. Creating a Safety Program

Create a safety program by following the steps below:

1. Create device variables.
2. Create a safety program using the Automatic Programming function.
3. Modify the created safety program.

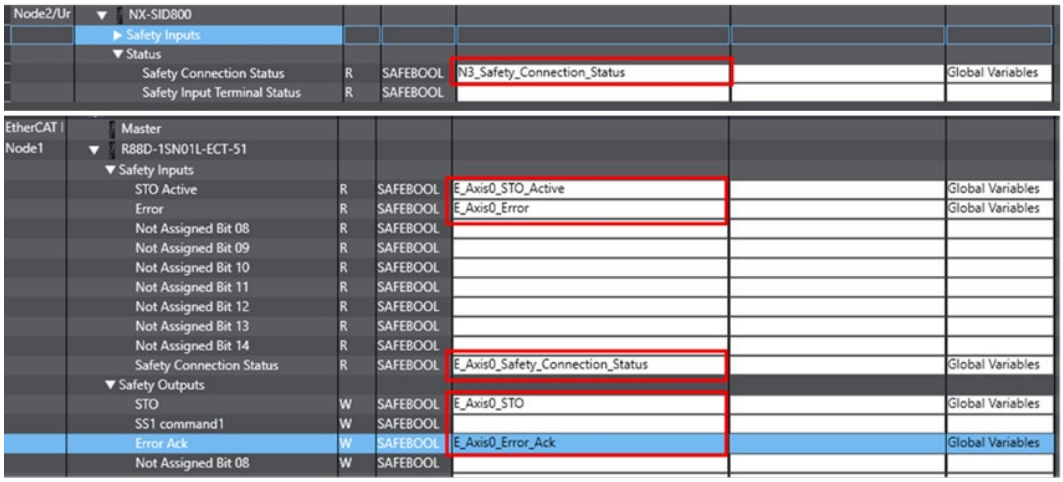
1. Create device variables.

1. Select *new_SafetyCPU0* from the list and double-click *I/O Map*.

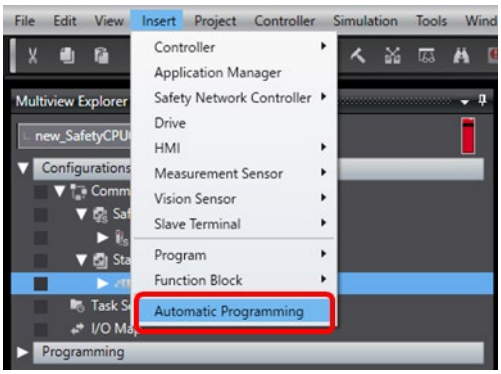
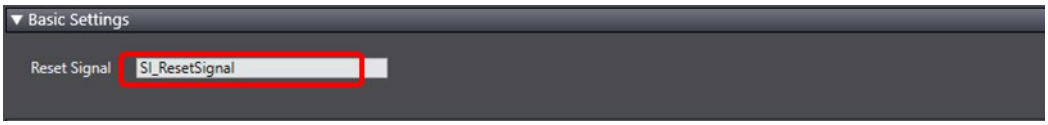
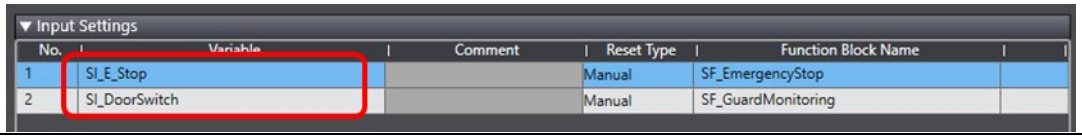
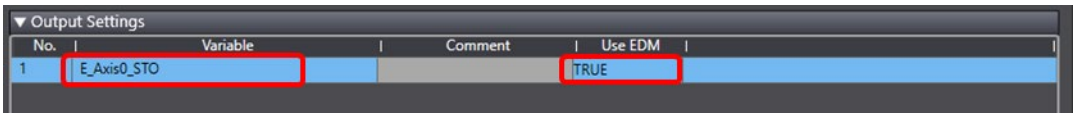
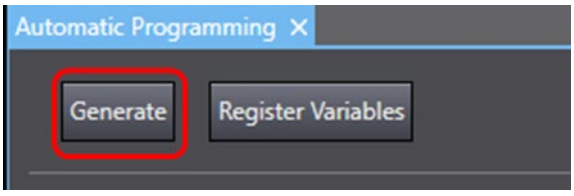
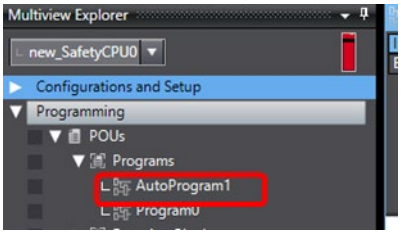


2. Create device variables.

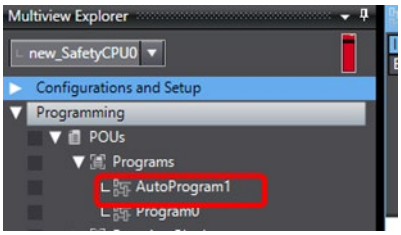
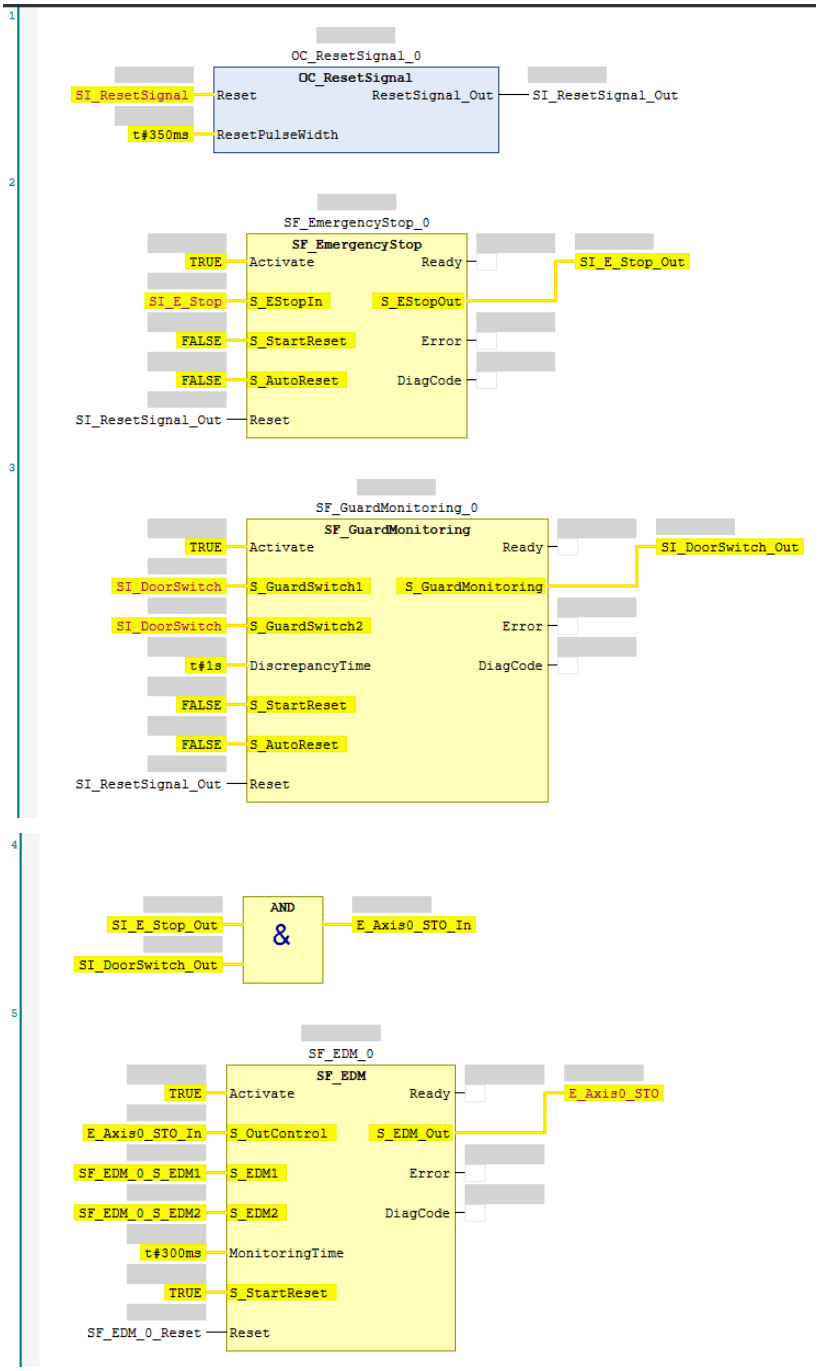
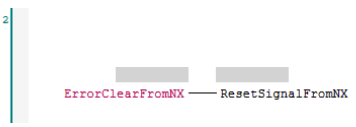
Port	Variable name
Safety Connection Status for NX-SID800	N3_Safety_Connection_Status
STO Active for R88D-1SN01L-ECT-51	E_Axis0_STO_Active
Error for R88D-1SN01L-ECT-51	E_Axis0_Error
Safety Connection Status for R88D-1SN01L-ECT-51	E_Axis0_Safety_Connection_Status
STO for R88D-1SN01L-ECT-51	E_Axis0_STO
Error Ack for R88D-1SN01L-ECT-51	E_Axis0_Error_Ack

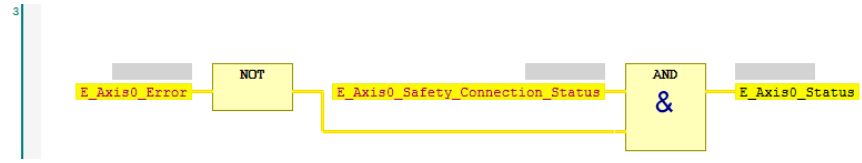
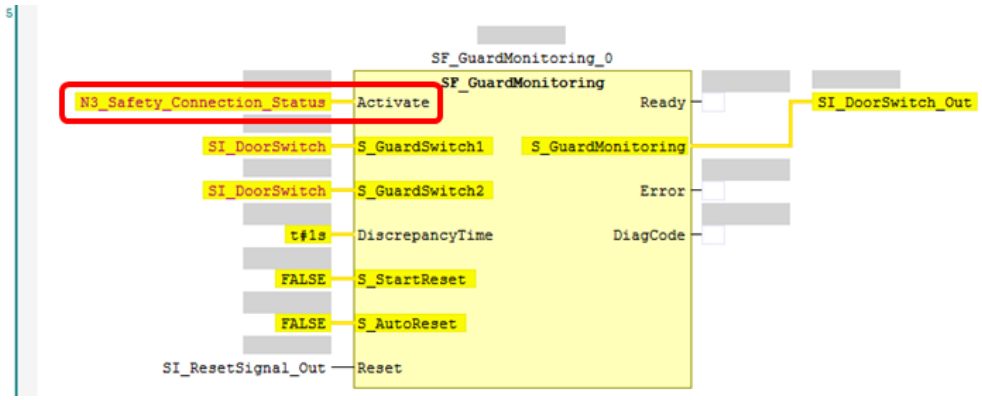
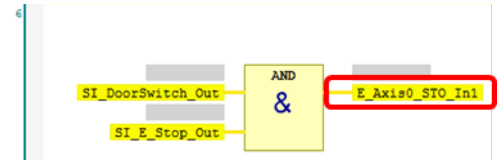
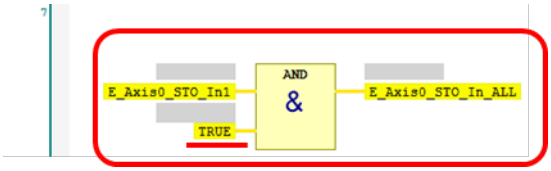


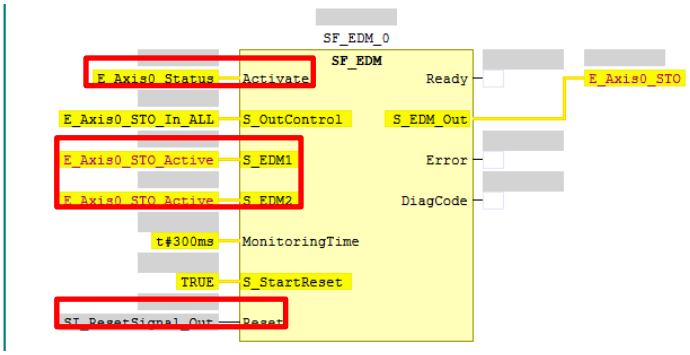
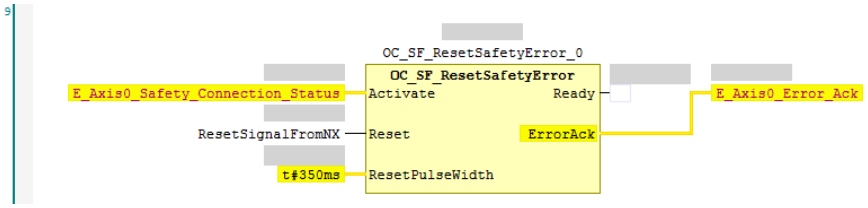
2. Create a safety program using the Automatic Programming function.

1.	Click *Automatic Programming* from the Insert Menu. 
2.	Set the reset signal to *SI_ResetSignal* in the Basic Settings Field. 
3.	Set *SI_E-Stop* and *SI_DoorSwitch* in the Input Settings Field. 
4.	Set *E_Axis0_STO* in the Output Settings Field. Set the *Use EDM* Column to *TRUE*. 
5.	Set the *E_Axis0_STO* Column to *0* for the *SI_E-Stop* and *SI_DoorSwitch* variables in the Expected Value Settings Field. 
6.	Click the *Generate* Button to create a safety program.  AutoProgram1 is added. 

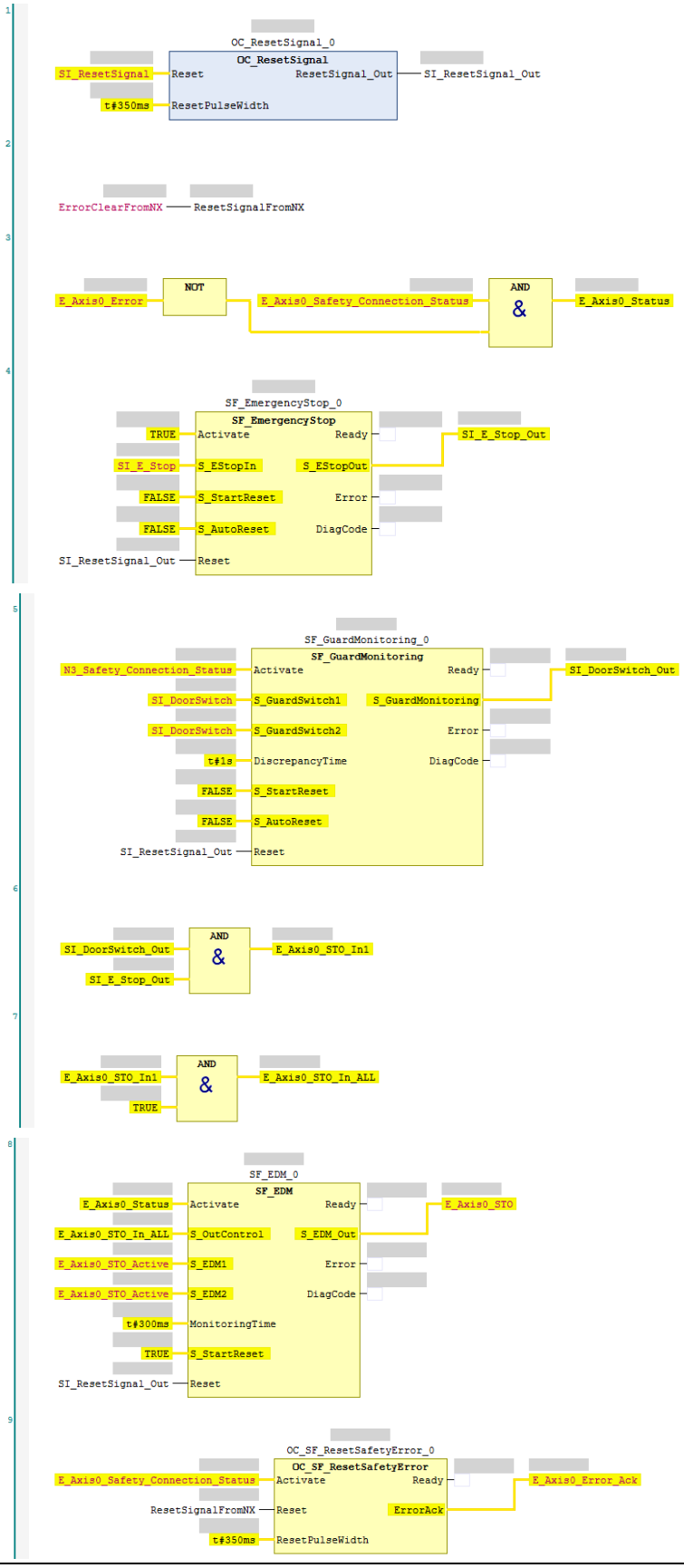
3. Modify the created safety program.

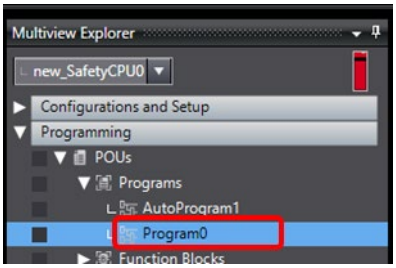
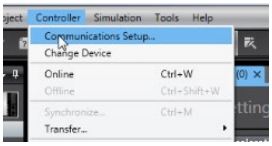
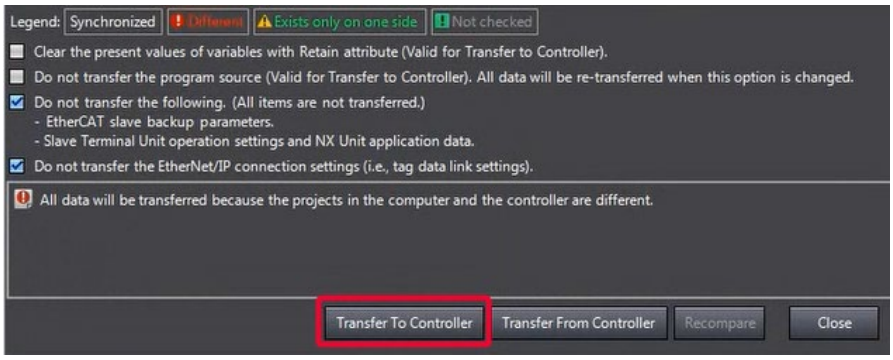
1.	Double-click *AutoProgram1*.  The program shown below appears. 
2.	Add the code to assign *ErrorClearFromNX* to the *ResetSignalFromNX* local variable. 

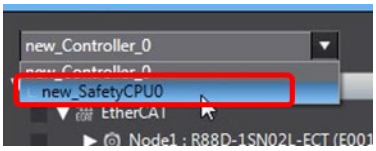
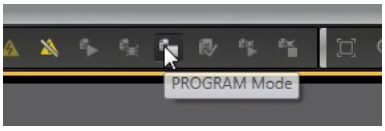
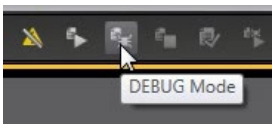
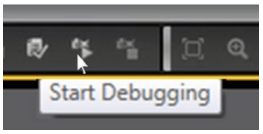
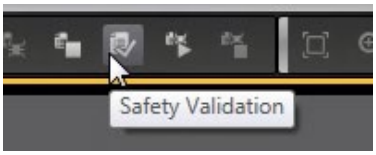
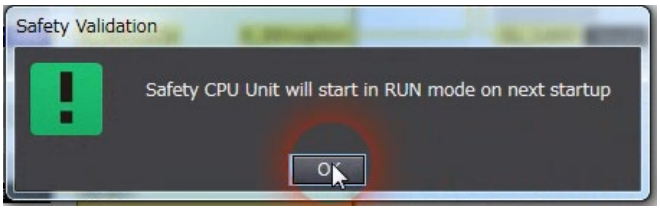
3.	Add the following code. This is used to enable the function block that uses safety functions of the Servo Drive. 
4.	Set the input parameter to the *Activate* input variable to *N3_Safety_Connection_Status* in the SF_GuardMonitoring function block. When the FSoE communications are established for the NX-SID800 Safety Input Unit, this function block is enabled. 
5.	Change the output variable from *E_Axis0_STO_IN* to *E_Axis0_STO_IN1*. 
6.	Add the following code. The STO command is enabled by the emergency stop input or a Safety-door Switch, and sometimes by another device such as a robot. When the other device enables the STO command, assign the STO signal from the other device to *TRUE*. 

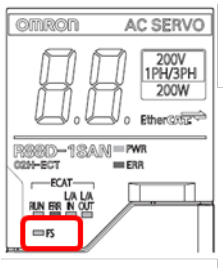
7.	Set the input parameter to the *Activate* input variable to *E_Axis0_Status* and the input parameter to the *Reset* input variable to *SI_ResetSignal_Out* and the input parameter to the *S_EDM1/S_EDM2* input variable to *E_Axis0_STO_Active* in the SF_EDM function block When the FSoE communications are established between the safety controller and Servo Drive and there is no error of safety functions in the Servo Drive, this function block is enabled. 
8.	Add the code to reset errors of safety functions in the Servo Drive. 

9.	Check that the created program is the same as shown below.



10.	Delete *Program0*. 
11.	Connect to the standard controller. Change the connection method.  Test the connection.  Confirm that *Test OK* is displayed and connect to the standard controller. 
12.	Transfer to the standard controller. Click the Synchronization Button to synchronize with the standard controller.  Transfer to the standard controller. 

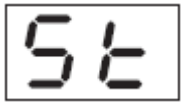
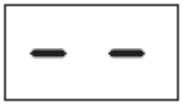
13.	Download the safety application. Select *new_SafetyCPU0* from the list.  Click the PROGRAM Mode Button to switch to PROGRAM mode.  Click the DEBUG Mode Button to enter DEBUG mode.  Click the Start Debugging Button to start DEBUG mode.  Click the Safety Validation Button.  The safety application is now ready to run.  Click the Run Button. 

14.	The FSoE communications are now established. The FS indicator is lit in green. 

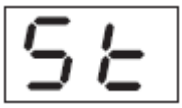
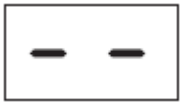
FS	Displays FSoE communications status.	Green	ON	FSoE slave connection established
			Flashing	FSoE slave connection establishment in progress
		Red	Flashing	Safety Parameter Error, Safety Communications Timeout, or other errors
		—	OFF	The safety functions are disabled by FSoE, the power is not supplied, or a fatal error including Self-diagnosis Error

3.3.7. Checking Operation of the STO Function

■ **Checking operation of the STO function using the Emergency Stop Pushbutton Switch**

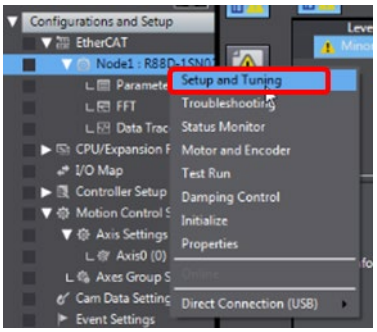
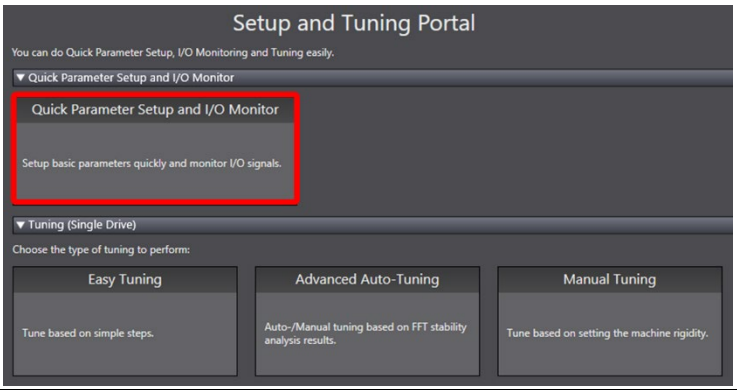
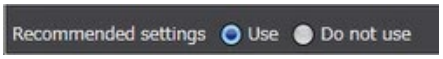
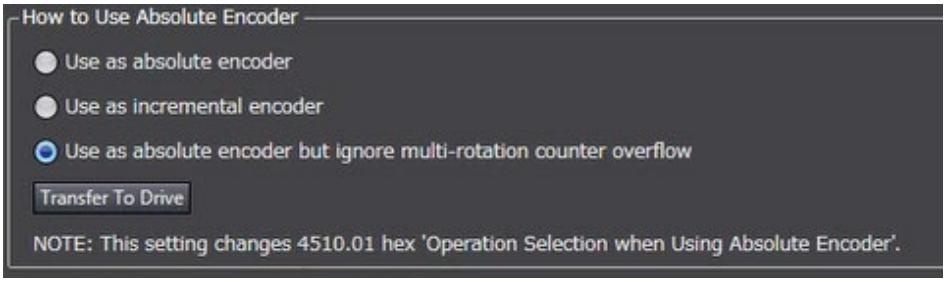
1.	Press the safety rest button. 
2.	Press the Emergency Stop Pushbutton Switch.  Check that the 7-segment LED display shows ‘st’. 
3.	Release the Emergency Stop Pushbutton Switch and press the safety rest button.  Check that STO is released and the 7-segment LED display shows ‘--’. 

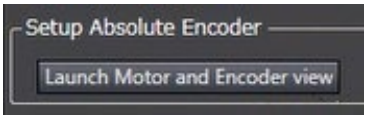
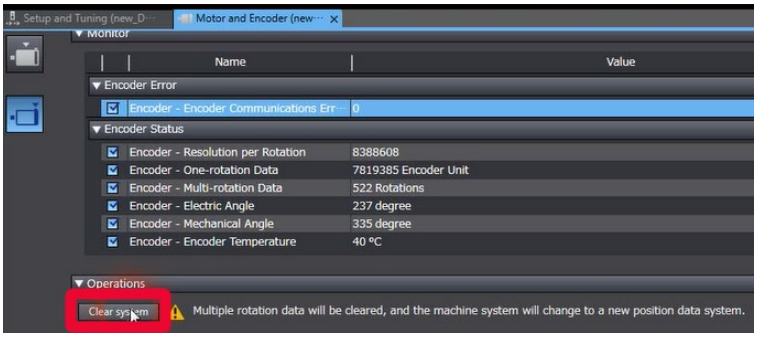
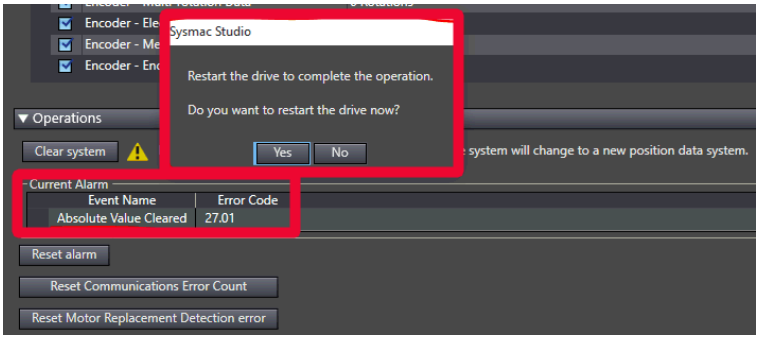
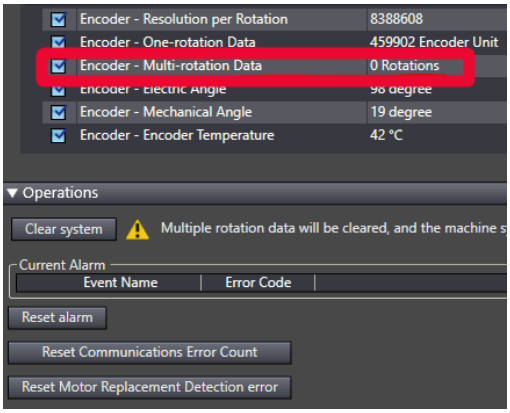
■ **Checking operation of STO function using Safety-door Switch**

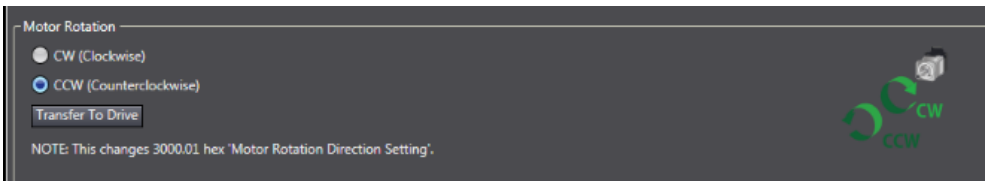
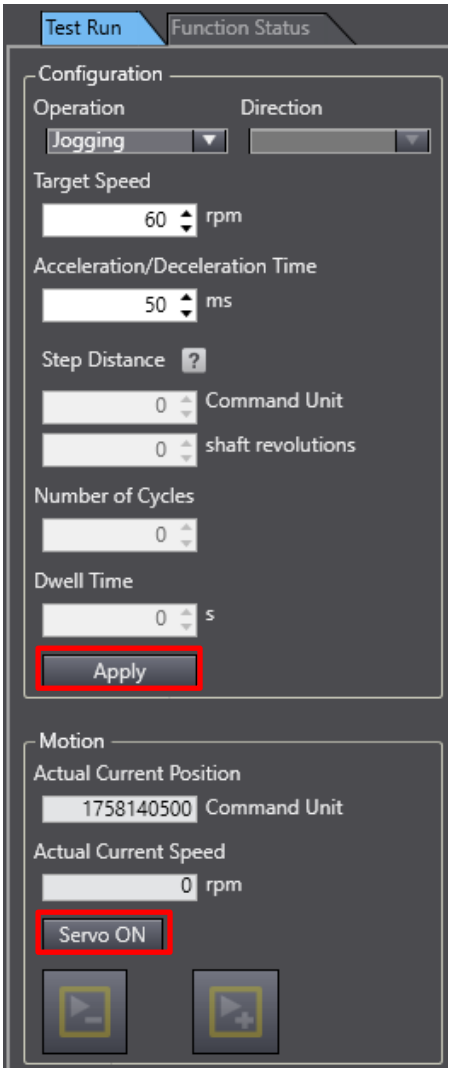
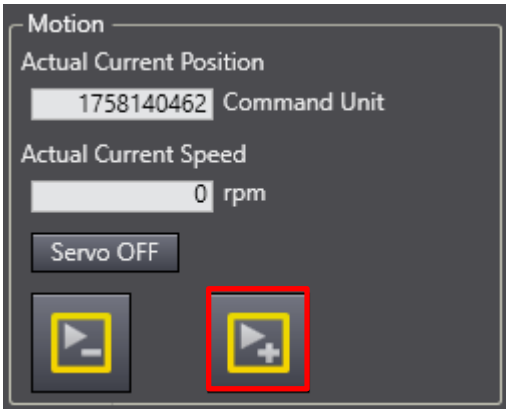
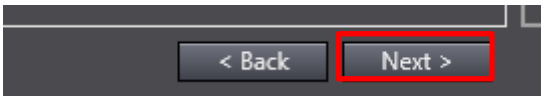
1.	Press the safety rest button. 
2.	Open the guard with the Safety-door Switch.  Check that the 7-segment LED display shows ‘st’. 
3.	Close the guard and press the safety reset switch.  Check that STO is released and the 7-segment LED display shows ‘--’. 

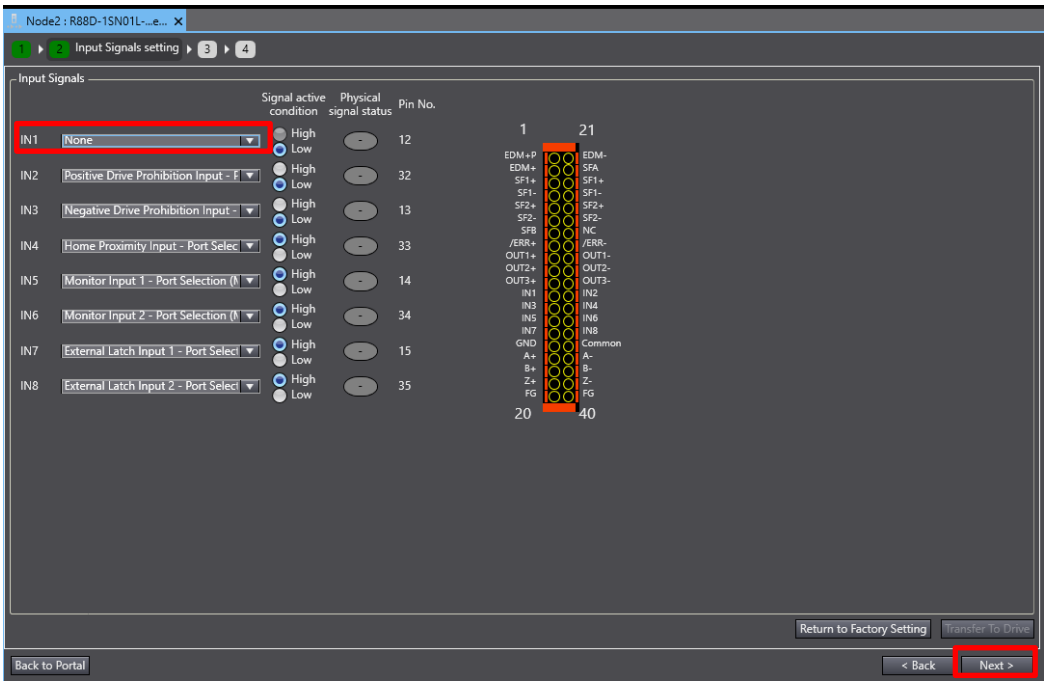
3.4. Motor, ABS Encoder and I/O Setup

■ Quick Parameter Setup and I/O Monitor Wizard

1.	Right-click the Servo Drive and select *Setup and Tuning* from the menu. 
2.	Click the *Quick Parameter Setup and I/O Monitor* Button. 
3.	Select whether or not an OMRON Controller is connected.  When using I/O features of the Servo Drive in the motion control (MC) function module of the OMRON Controller, select *Use* for the recommended settings. (Related inputs: IN2: POT, IN3: NOT, IN4: DEC, IN7: EXT1, IN8: EXT2, How to Use Absolute Encoder: Use as absolute encoder but ignore multi-rotation counter overflow)
4.	Only if you are using a motor with absolute encoder, Selects the operating method for the absolute encoder.  Absolute encoder can be used as an incremental encoder if needed. When the OMRON Controller is used, it is recommended to keep the default value 'Use as absolute encoder but ignore multi-rotation counter overflow' (as described in step 3).

5.	Set up the absolute encoder (if required).  Use this function when clearing the multiple rotation data or when replacing a Servomotor in the actual machine. Resetting multiple rotation data Click the Clear system Button.  The following message appears: *Restart the drive to complete the operation.* Click the Yes Button.  Multiple rotation data of the encoder has been cleared. 

6.	Select the motor rotation direction and transfer the settings to the Servo Drive. 
7.	Perform a test run to check the behavior of the Servomotor. Click the Apply Button in the Test Run tab page and then click the Servo ON Button to start the test run.   Note: When the Error Stop Input (ESTP) (Error No. 87.00) occurs, check wiring connection or turn OFF the Error Stop Input (IN1) as explained in the next step.  Click the Next Button.

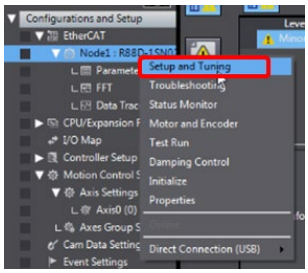
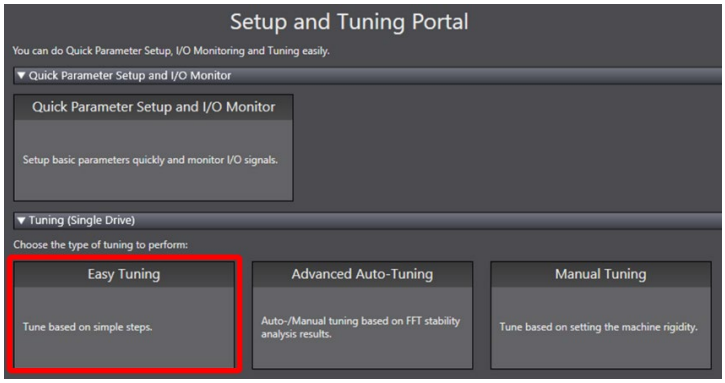
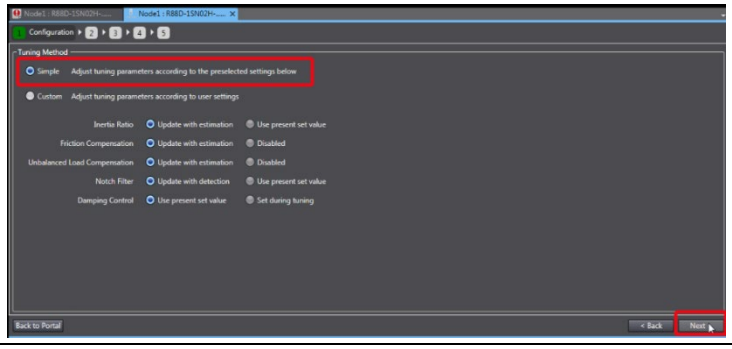
8.	Set input signals and transfer the settings to the Servo Drive. Perform a test run to confirm that the settings are correct. The Error Stop Input (ESTP) is ON by default. Turn it OFF as follows if necessary. When ESTP is ON, the Error No. 87.00 is displayed on the Servo Drive. 
9.	Set output signals if necessary and transfer the settings to the Servo Drive. Perform a test run to confirm that the settings are correct.
10.	Click the *Finish* Button. 

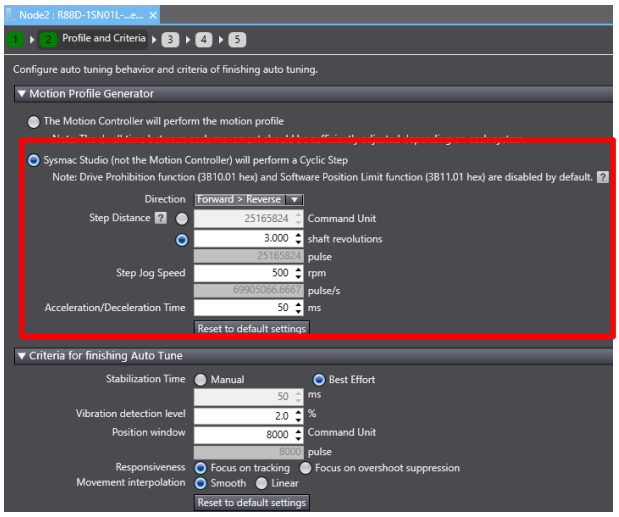
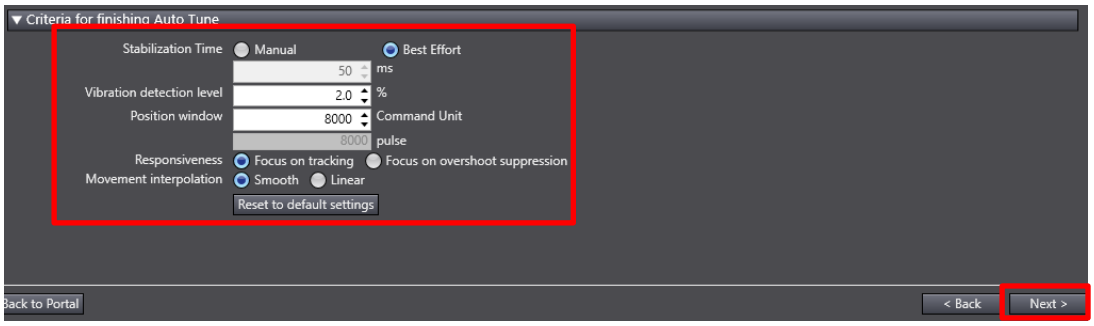
3.5. Gain tuning

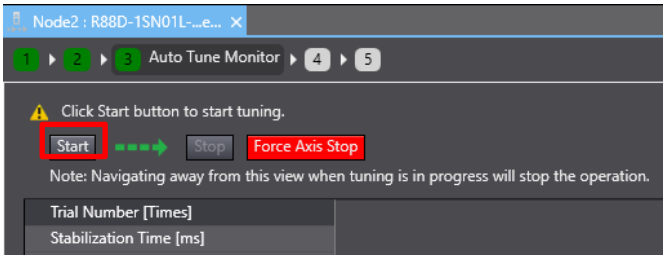
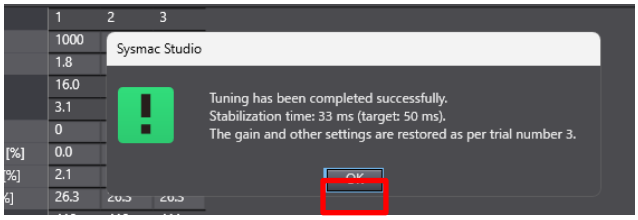
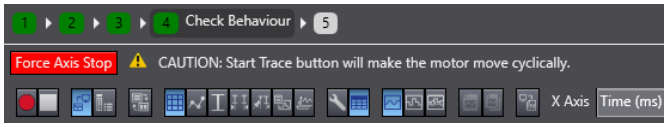
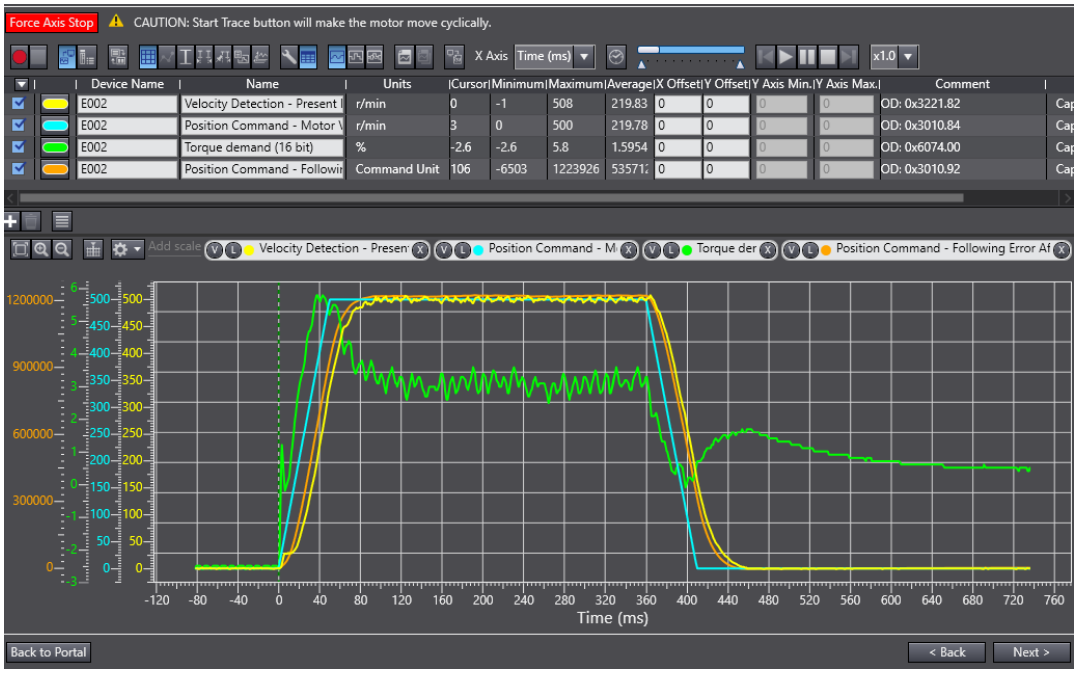
The 1S series provides two auto-tuning functions. For details on the procedures, refer to *Easy Tuning* and *Advanced Auto-Tuning* respectively.

3.5.1. Easy Tuning

This function adjusts the gain automatically while the Servomotor is actually operated based on commands from the Controller or operation conditions that are set on the Sysmac Studio. It is possible to select the single drive or multiple drives tuning method. In the system with the synchronized axes, you can adjust the gain at the same time in a short time by the use of the easy tuning for multiple drives. For the setup and tuning of multiple axes, refer to the *AC Servo System Startup Guide for Multi-axis Setup and Tuning* (Cat. No. I827).

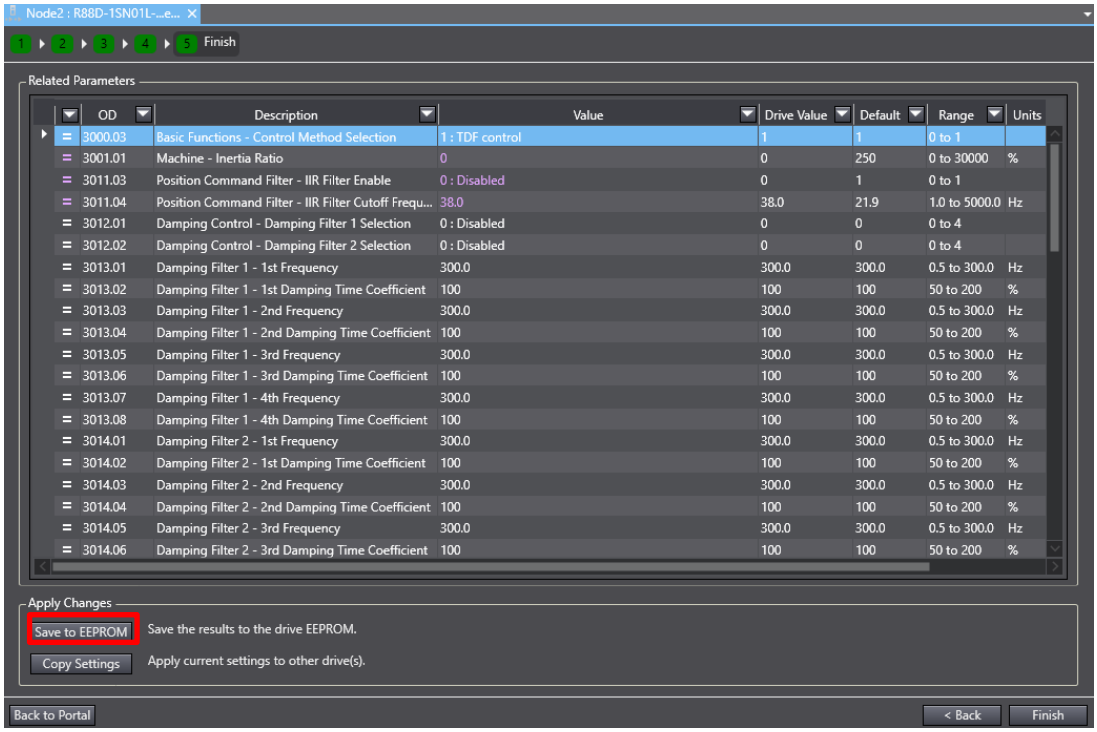
1.	Right-click the Servo Drive and select *Setup and Tuning* from the menu. 
2.	Click the *Easy Tuning* Button. 
3.	Select *Simple* for the tuning method and click the *Next* Button. 

4.	Profile and Criteria Set the motion profile generator. 
5.	Set the criteria for finishing auto tuning. Click the Next Button.  • When you select *Manual* for stabilization time, gain will be increased gradually until the stabilization time reaches the specified time. Specify the following error for the position window to determine that the positioning is completed. If a vibration above the vibration detection level is detected during tuning, an adjustment failure will occur. • When you select *Best Effort* for the stabilization time, gain will be increased gradually so that the vibration does not exceed the vibration detection level. Set the vibration detection level so that the machine does not vibrate. The lower the vibration detection level, the less likely it is to generate vibration, but the gain is less likely to increase.

6.	Click the *Start* Button. Be careful because the Servomotor will start running.  Easy Tuning has been completed.  Click the Next Button. 
7.	Click the *Start Trace* Button. The Servomotor will run, and the traced data will be displayed in the graph area.   Click the Next Button. 

8. Check the tuning results of the gain parameters.

Click the *Save to EEPROM* Button to save the gain parameters.

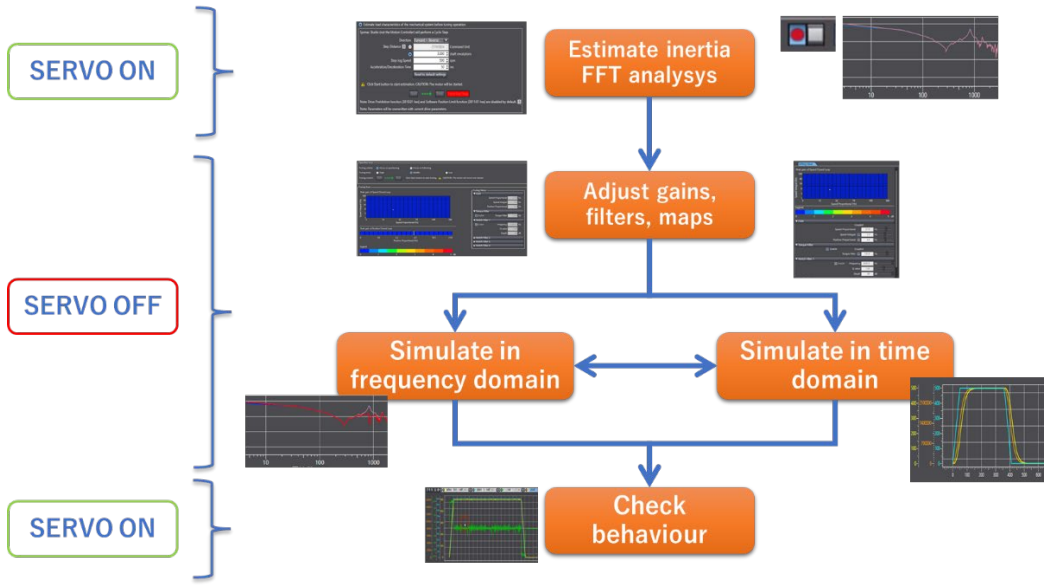
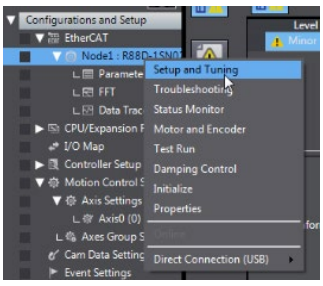
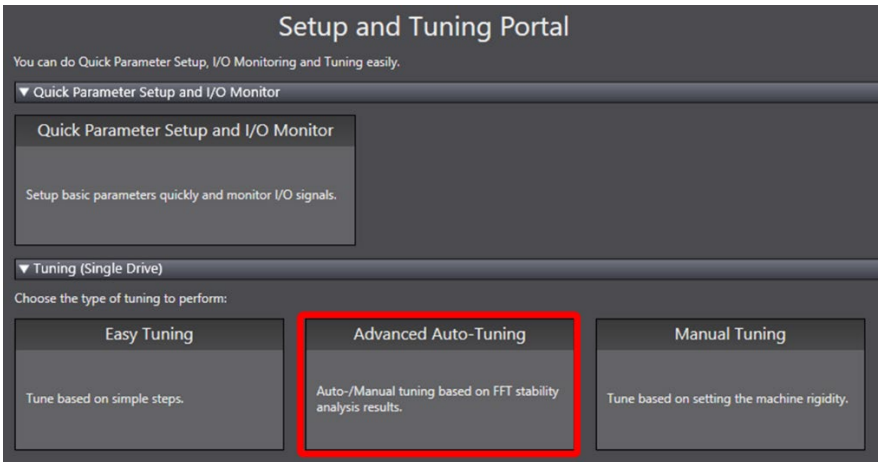


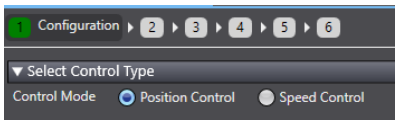
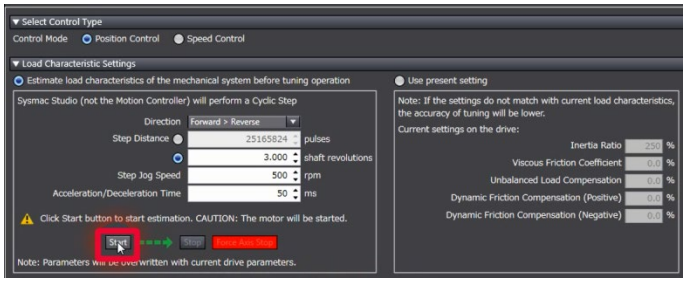
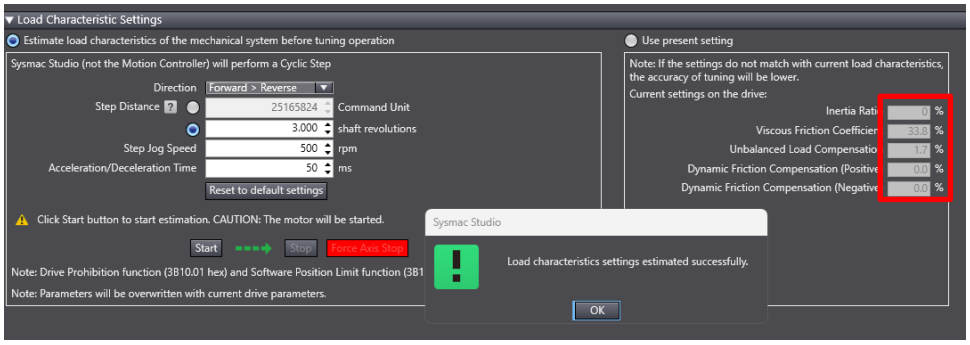
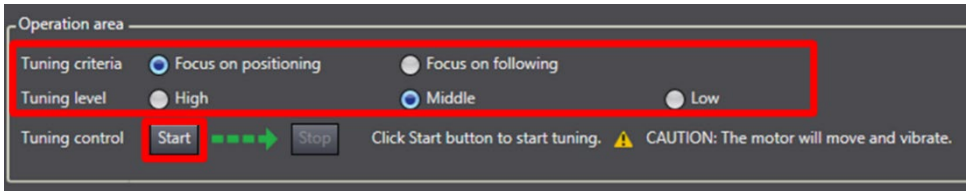
Click the Finish Button.

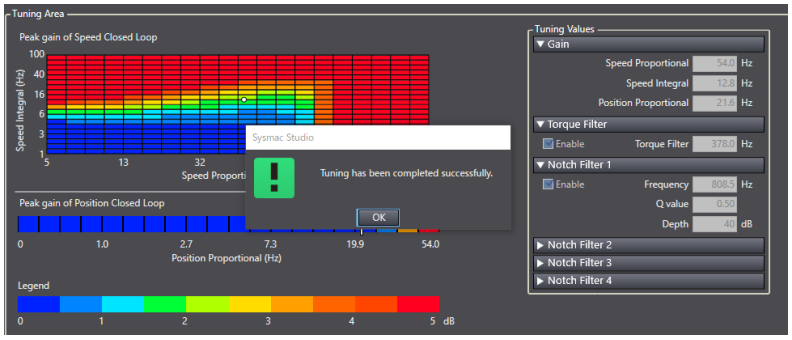
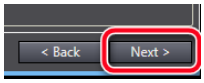
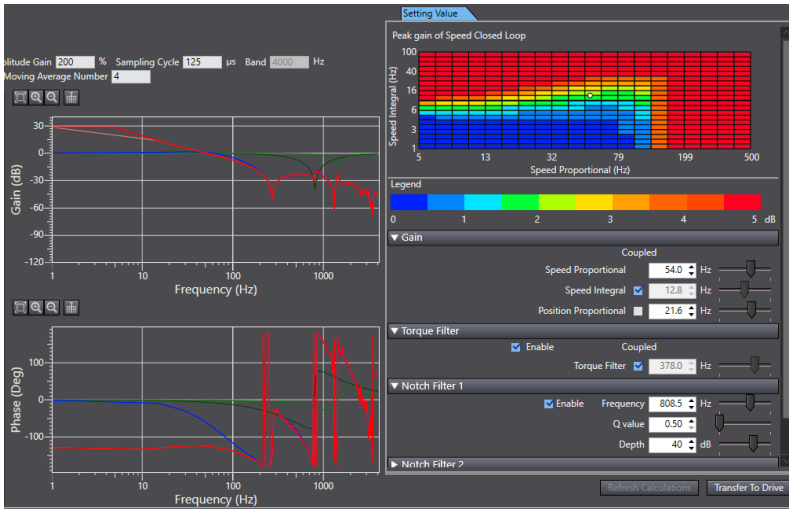
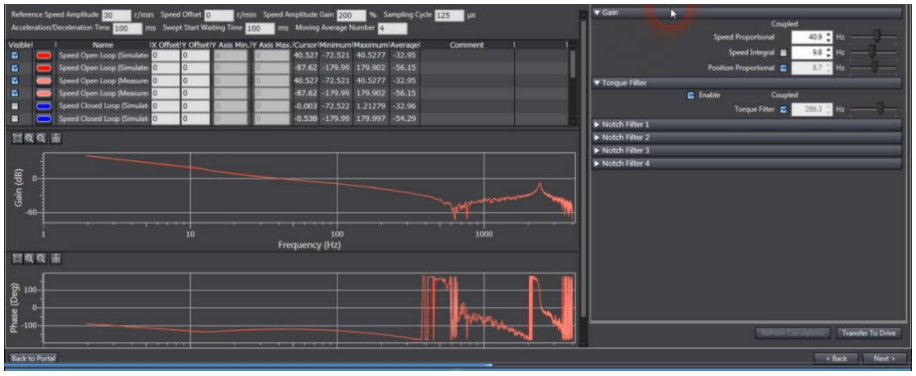
3.5.2. Advanced Auto-Tuning

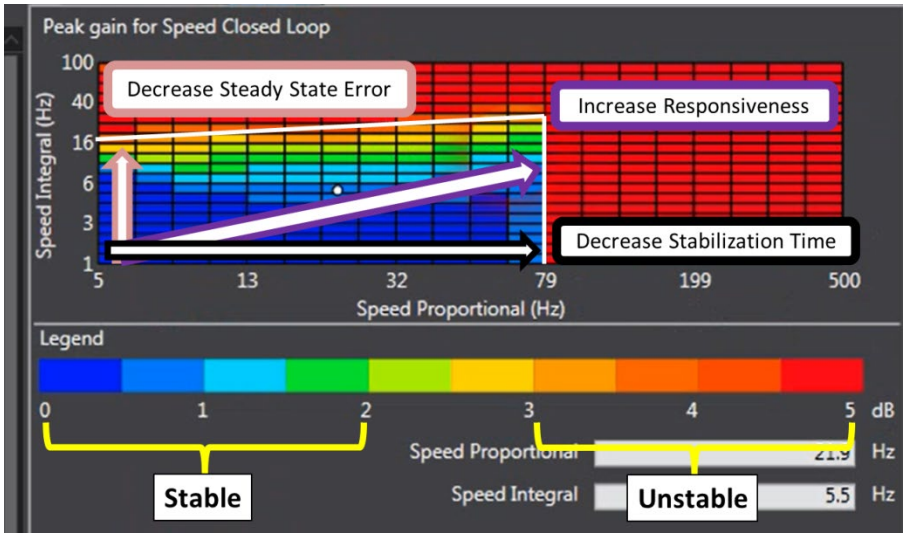
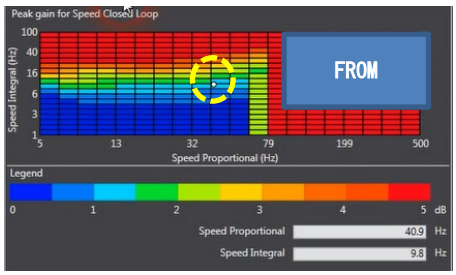
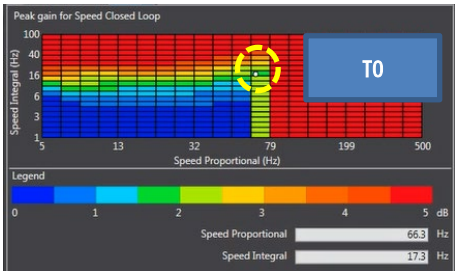
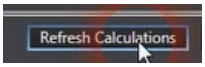
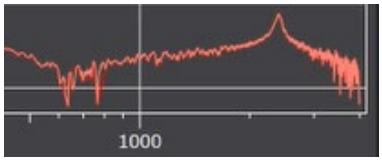
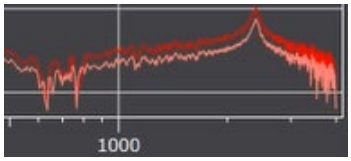
This function uses FFT measurement data-based simulation to adjust the gain and filter settings automatically. Repeating actual Servomotor operation is not necessary, and a fine adjustment is possible in a short period of time.

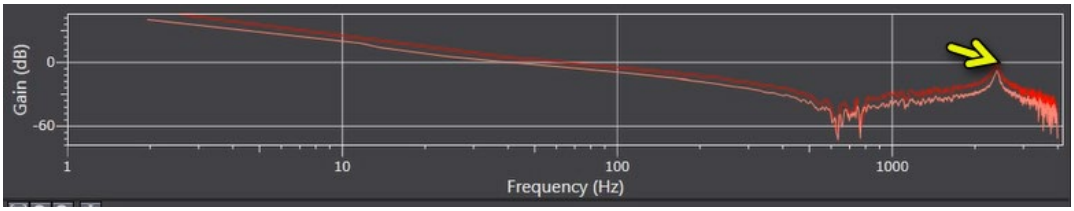
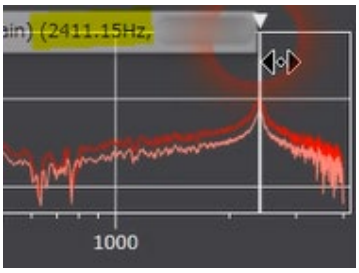
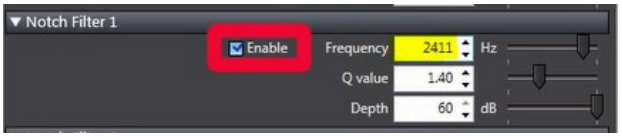
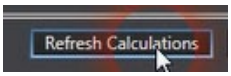
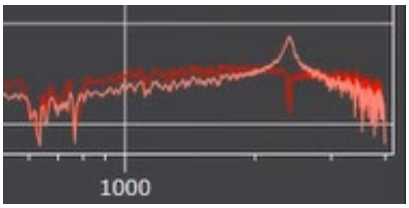
■ **How to Perform Advanced Auto-Tuning**

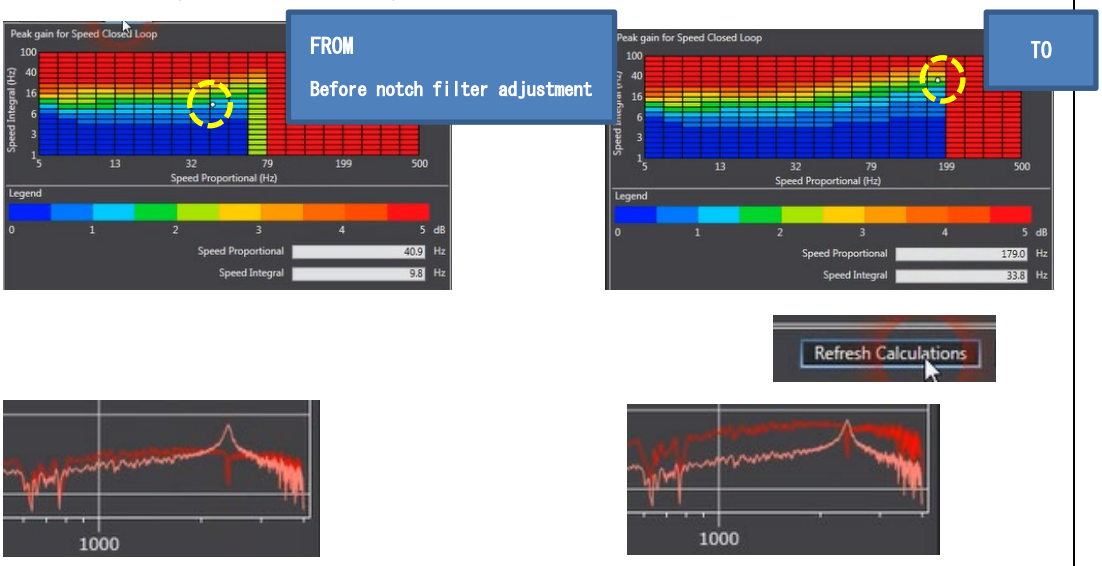
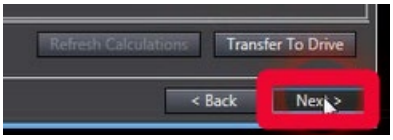
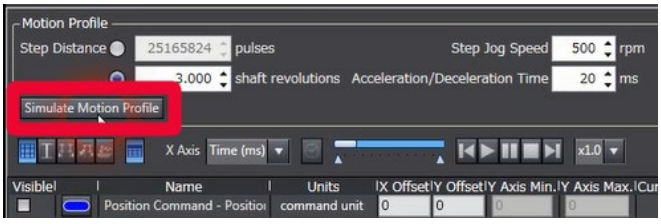
Over view	 Below example explain the way to tune a 1S servo drive and motor with Advanced Auto-Tuning. This method of tuning decrease dramatically the number of tests and trial with actual machine.
1.	Please right click to the drive and select “setup and tuning” 
2.	Please select Advanced Auto-Tuning 

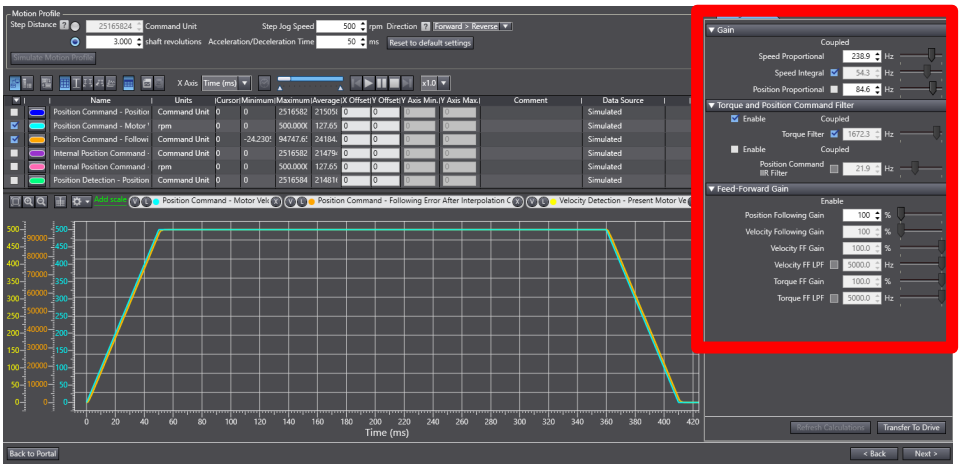
3.	Configuration (Wizard Step 1) Please select your control mode  Please estimate the load characteristics by pushing start (the motor will move) If Easy Tuning has been performed already, please select “use present setting”  Load characteristics have been updated  Click Next 
4.	Advanced Auto-Tuning (Wizard Step 2) Set the tuning finish criteria and the tuning level. Click Start to start auto tuning. (The Servomotor rotates, and the cycle of measuring FFT characteristics and adjusting gains and filters is repeated.)  ● Although vibrations may occur when Advanced Auto-Tuning is being executed, the tuning process will be completed successfully.

	Advanced Auto-Tuning has been completed.  Click Next 
5.	<u>Frequency response simulation</u> (Wizard Step 3) The Advanced Auto-Tuning results will be displayed in Bode diagrams.  Check the result. If you are satisfied with it, proceed to step 12 (Wizard step 5). If you need more tuning, perform step 6.
6.	<u>FFT measurement</u> Please start the trace (FFT measurement will be performed, the motor will move slightly)  FFT measurement and simulated values are displayed (Gain and Phase) 

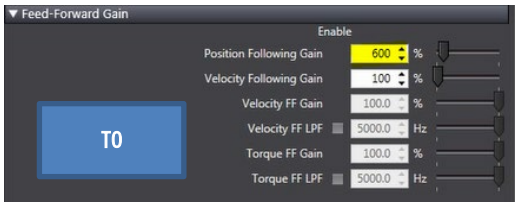
7.	<u>Adjust gain and simulate</u> Adjust the gain to a proper value and push “refresh simulation”       Pink curve is the measured value Red curve is the simulated value

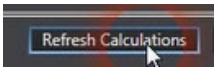
8.	<u>Adjust notch filters and simulate</u> After increasing gains, the gain simulation shows a peak near 0dB. This peak shows a resonance frequency:  Activate the cursor to measure the frequency   Activate the 1st notch filter to remove this resonance frequency at 2411 Hz:   

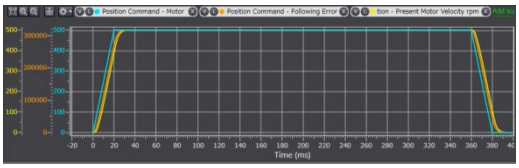
9.	<u>Increase gain with Maps and simulate</u> After activating the notch filter, gain can be increased and performance improved  Click Next 
10.	<u>Time response simulation</u> (Wizard step 4) In time response simulation, the motion profile can be simulated. Please push “Simulate Motion Profile”  The chart is updated and shows: - The speed command, speed detection simulation and following error simulation. If necessary, please adjust gains:



If your application required a small tracking error, here is an example of position following gain adjustment:



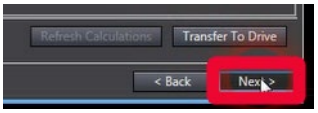




Following error has been reduced.

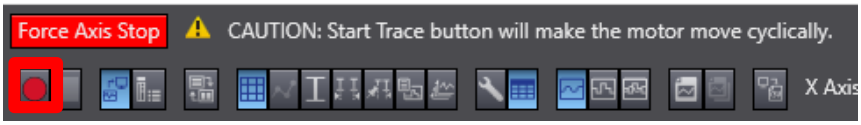
11. When satisfied with the simulation result, please transfer parameters to the drive

Click Next



12. <u>Check behavior</u> (Wizard step 5)

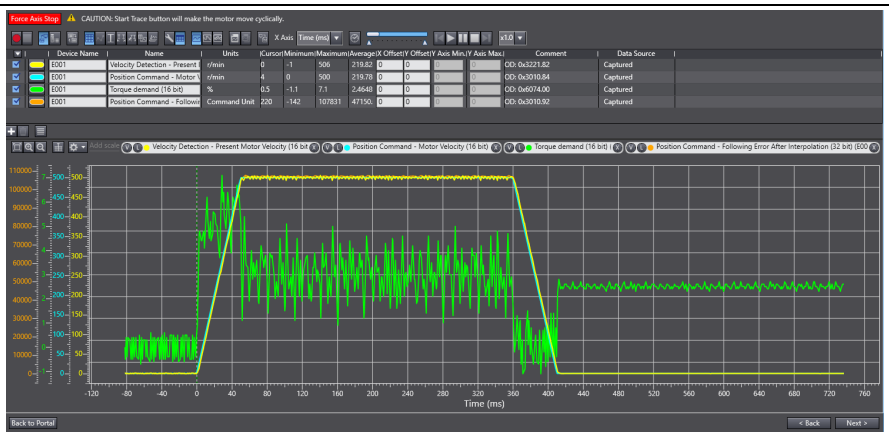
Push start trace (the motor will move following the previous configuration in Wizard step 3)



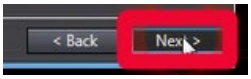
(motion profile in Wizard step 3)

The chart is updated and shows:

- The speed command, speed detection, following error and torque.



If satisfied, please click next



13

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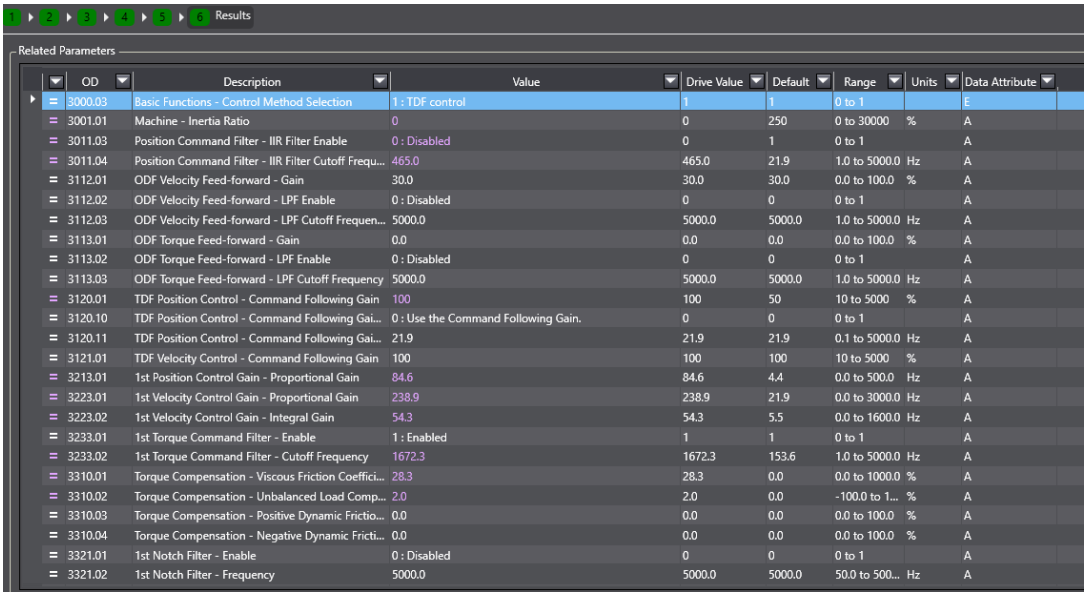
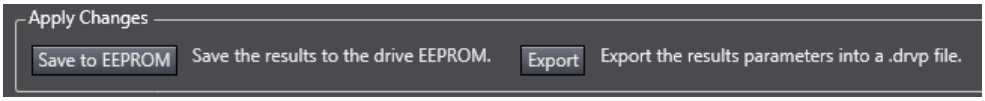
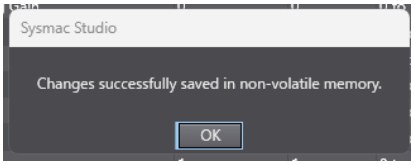
Results (Wizard step 6)



	OD	Description	Value	Drive Value	Default	Range	Units	Data Attribute
=	3000.03	Basic Functions - Control Method Selection	1 : TDF control	1	1	0 to 1		E
=	3001.01	Machine - Inertia Ratio	0	0	250	0 to 30000	%	A
=	3011.03	Position Command Filter - IIR Filter Enable	0 : Disabled	0	1	0 to 1		A
=	3011.04	Position Command Filter - IIR Filter Cutoff Frequ...	465.0	465.0	21.9	1.0 to 5000.0	Hz	A
=	3112.01	ODF Velocity Feed-forward - Gain	30.0	30.0	30.0	0.0 to 100.0	%	A
=	3112.02	ODF Velocity Feed-forward - LPF Enable	0 : Disabled	0	0	0 to 1		A
=	3112.03	ODF Velocity Feed-forward - LPF Cutoff Frequen...	5000.0	5000.0	5000.0	1.0 to 5000.0	Hz	A
=	3113.01	ODF Torque Feed-forward - Gain	0.0	0.0	0.0	0.0 to 100.0	%	A
=	3113.02	ODF Torque Feed-forward - LPF Enable	0 : Disabled	0	0	0 to 1		A
=	3113.03	ODF Torque Feed-forward - LPF Cutoff Frequency	5000.0	5000.0	5000.0	1.0 to 5000.0	Hz	A
=	3120.01	TDF Position Control - Command Following Gain	100	100	50	10 to 5000	%	A
=	3120.10	TDF Position Control - Command Following Gai...	0 : Use the Command Following Gain.	0	0	0 to 1		A
=	3120.11	TDF Position Control - Command Following Gai...	21.9	21.9	21.9	0.1 to 5000.0	Hz	A
=	3121.01	TDF Velocity Control - Command Following Gain	100	100	100	10 to 5000	%	A
=	3213.01	1st Position Control Gain - Proportional Gain	84.6	84.6	4.4	0.0 to 500.0	Hz	A
=	3223.01	1st Velocity Control Gain - Proportional Gain	238.9	238.9	21.9	0.0 to 3000.0	Hz	A
=	3223.02	1st Velocity Control Gain - Integral Gain	54.3	54.3	5.5	0.0 to 1600.0	Hz	A
=	3233.01	1st Torque Command Filter - Enable	1 : Enabled	1	1	0 to 1		A
=	3233.02	1st Torque Command Filter - Cutoff Frequency	1672.3	1672.3	153.6	1.0 to 5000.0	Hz	A
=	3310.01	Torque Compensation - Viscous Friction Coeffici...	28.3	28.3	0.0	0.0 to 1000.0	%	A
=	3310.02	Torque Compensation - Unbalanced Load Comp...	2.0	2.0	0.0	-100.0 to 1...	%	A
=	3310.03	Torque Compensation - Positive Dynamic Frictio...	0.0	0.0	0.0	0.0 to 100.0	%	A
=	3310.04	Torque Compensation - Negative Dynamic Fricti...	0.0	0.0	0.0	0.0 to 100.0	%	A
=	3321.01	1st Notch Filter - Enable	0 : Disabled	0	0	0 to 1		A
=	3321.02	1st Notch Filter - Frequency	5000.0	5000.0	5000.0	50.0 to 500...	Hz	A

Save to EEPROM





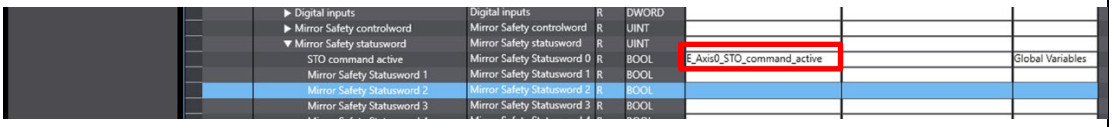
Finish

3.6. Creating a Motor Control Program

■ Creating a Standard Program

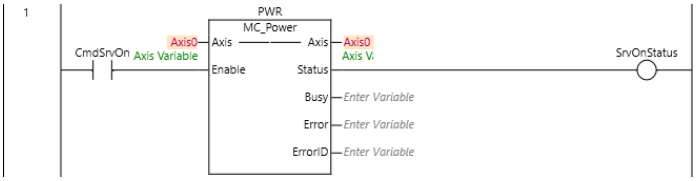
1. Open the I/O Map and create a device variable.

Port	Variable name
STO command active for R88D-1SN01L-ECT-51	E_Axis0_STO_command_active



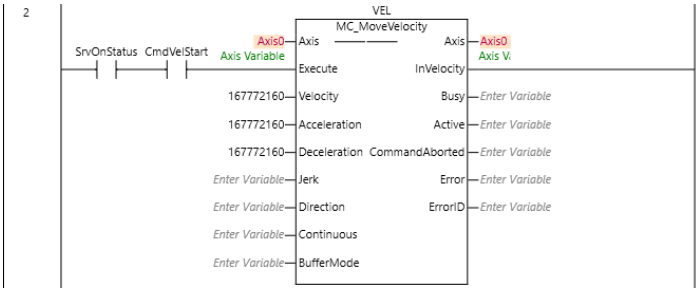
2. Create the following code:

1. The Servo is turned ON or OFF.

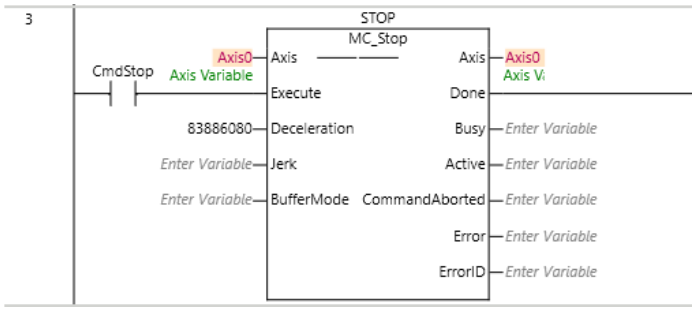


2. The Servomotor is run.

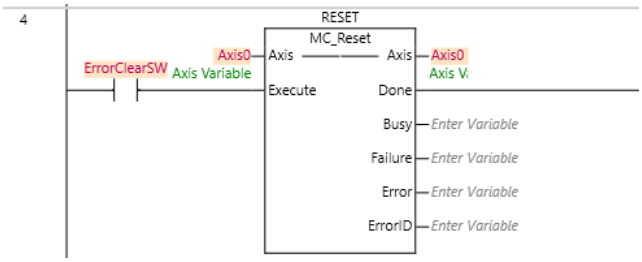
Set the velocity in the command unit specified in the *Setting an Axis*.



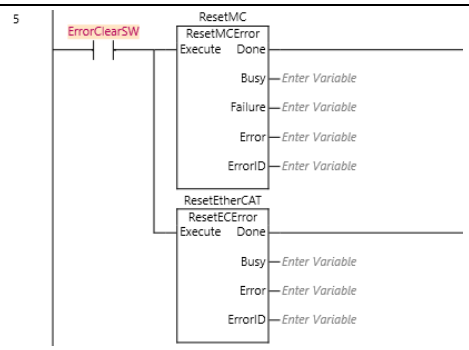
3. The Servomotor is stopped.



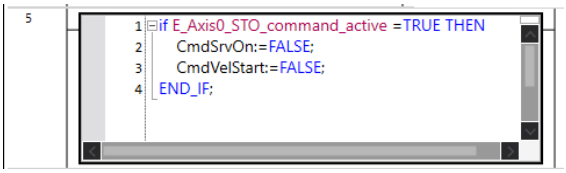
4. The errors of the Servo Drive are reset.



5. The errors of the standard controller are reset.

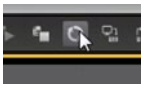


6. When the Servo Drive goes into the STO state, the Servo ON command and the motor start command are turned OFF.

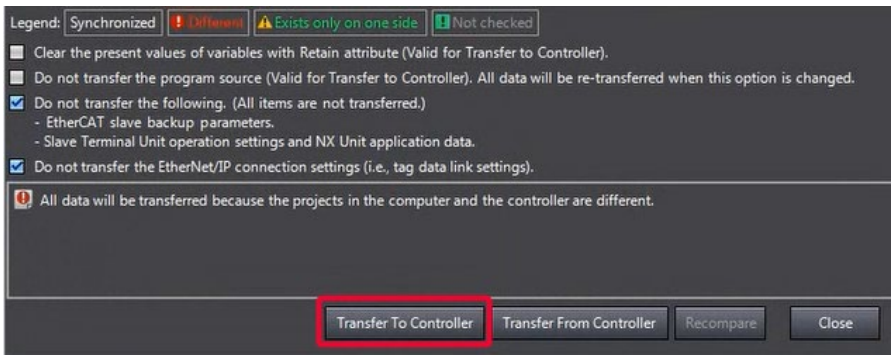


3. Transfer to the standard controller.

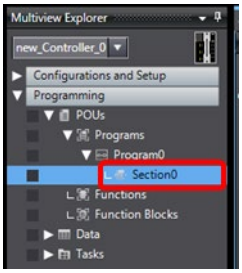
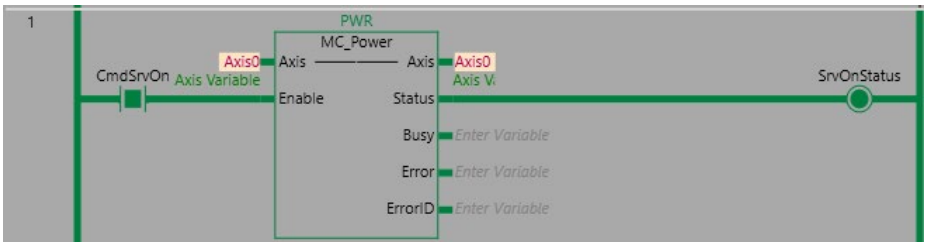
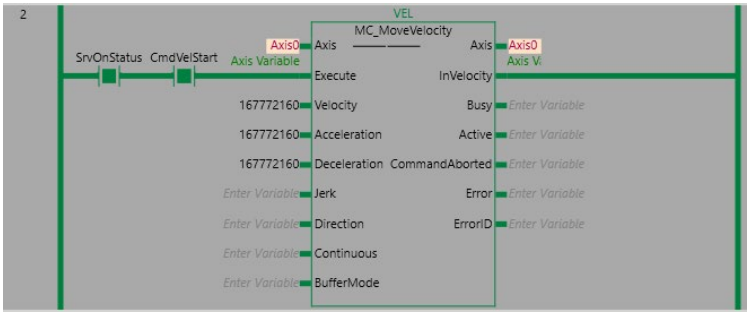
Click the Transfer To Controller Button.

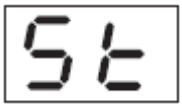
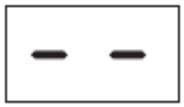


Transfer to the standard controller.



■ Checking Operation

1.	Press the safety rest button. 
2.	Double-click *Section0* to display the section. 
3.	Right-click *CmdSrvOn* and select *Set/Reset − Set*.  Check that the 7-segment LED display shows ‘oE.’. 
4.	Right-click *CmdVelStart* and select *Set/Reset − Set*.  Check that the Servomotor rotates at about 1200 r/min.

5.	Press the Emergency Stop Pushbutton Switch.  Check that the 7-segment LED display shows ‘st’. 
6.	Release the Emergency Stop Pushbutton Switch and press the safety rest button.  Check that STO is released and the 7-segment LED display shows ‘--’. 

4. Adding a Safety Function

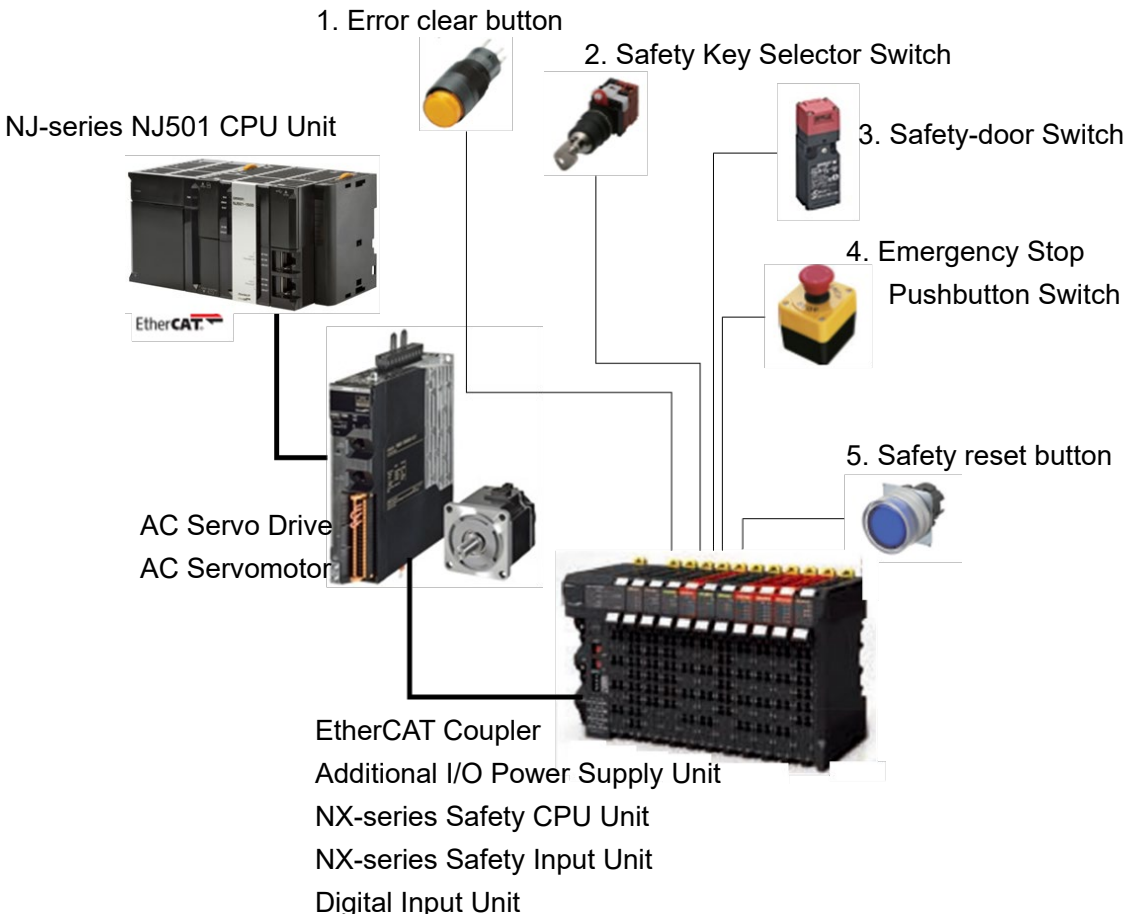
This section describes how to add a safety function to the servo system built in *3. Performing setup*. Refer to the section of the safety function to add.

4.1. Adding the Safe Stop 1 (SS1) Function

This section describes how to add the SS1 function to the project created in *3. Performing setup*.

The operation of the servo system set up in this section is explained below.

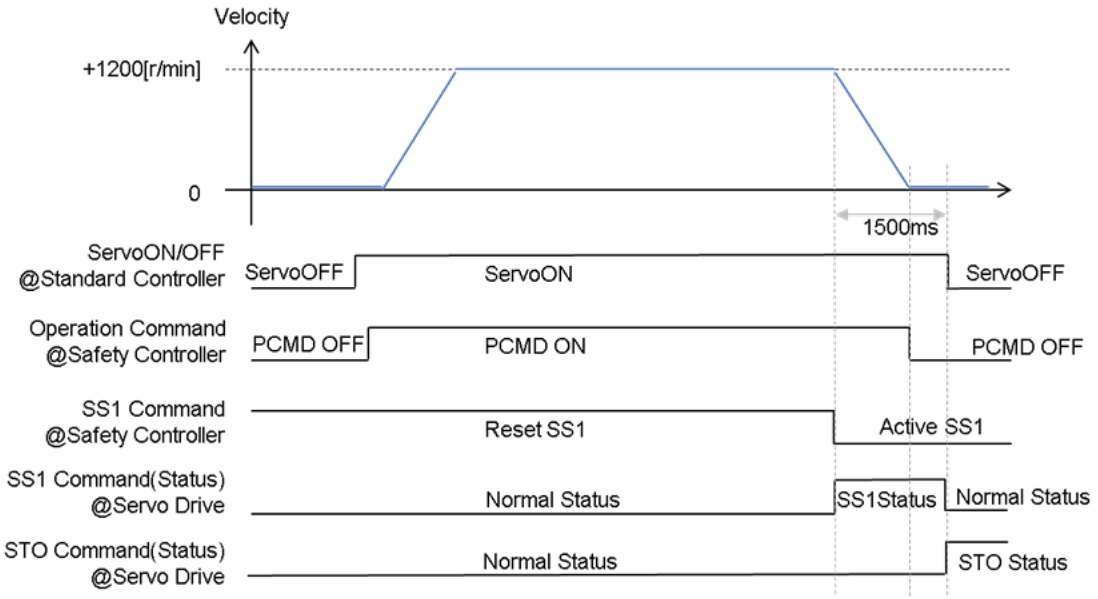
1. When the error clear button is pressed, the errors of the standard controller and Servo Drive are reset.
2. When the Safety Key Selector Switch is operated to switch to safety active mode, the standard controller lets the Servomotor decelerate to a stop.
   The Servo Drive activates the STO function using the SS1 function to turn OFF the motor torque.
3. When the safety reset button is pressed, the STO status is reset.



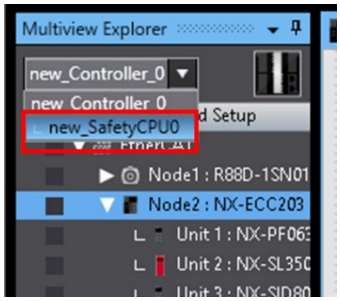
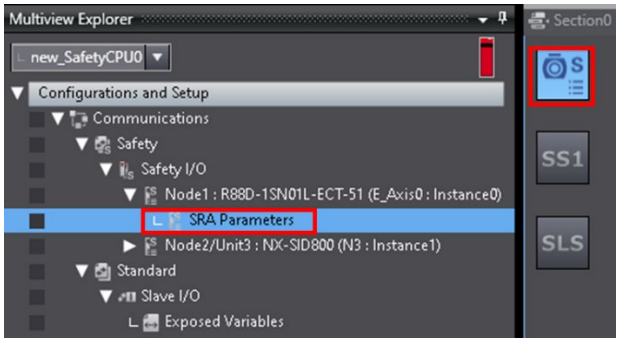
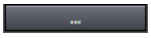
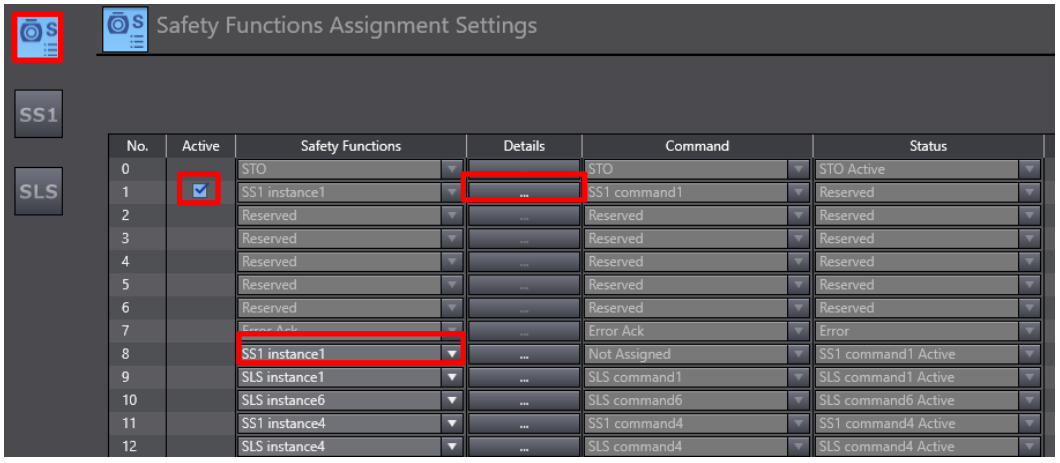
Input device	State	Operation
1. Error clear button	ON	Enable error reset command
	OFF	Disable error reset command
2. Safety Key Selector Switch	Normal operating mode	Run Servomotor at normal velocity.
	Safety active mode	Make Servomotor decelerate to a stop and activate STO function using SS1 function.
3. Safety-door Switch	Open	SS1 function deactivated: Enable STO command SS1 function activated (during deceleration): Enable STO command SS1 function activated (after STO activation from SS1): Disable STO command
	Close	Disable STO command
4. Emergency Stop Pushbutton Switch	ON	Enable STO command
	OFF	Disable STO command
5. Safety reset button	ON	Enable reset STO status command
	OFF	Disable reset STO status command

■ **Operation of SS1 Function Interlocked with Motion Control**

1. When the Servo ON command is enabled, the Servo Drive turns ON the Servo.
2. When an operation command is enabled, the command velocity to the Servomotor is set to 1200 r/min.
3. The standard controller lets the Servomotor decelerate to a stop.
   When the SS1 function is executed, the Servo Drive shifts to the STO state after the wait time (SS1 time to STO 1) and turns OFF torque.



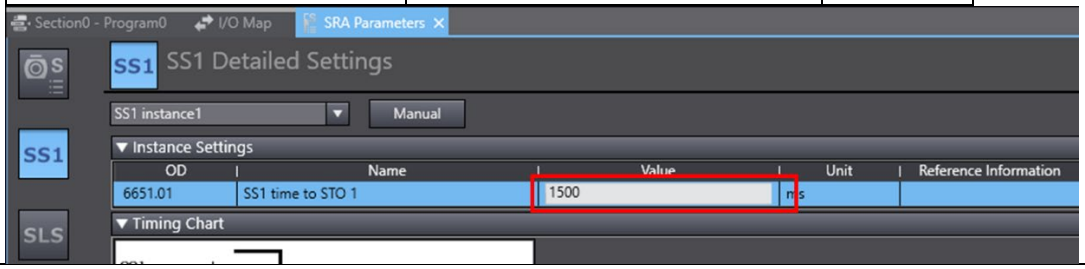
4.1.1. Setting the Safety Controller

1.	Select *new_SafetyCPU0* from the list. 
2.	Double-click *SRA Parameters* and click the *Safety Function Assignment Settings* Button. 
3.	Check the No. 1 checkbox and assign ‘SS1 instance1’ to No. 8. Click the  Button to display the SS1 Detailed Settings view. You can also use the  Button to display the SS1 Detailed Settings view. 

4. Set SS1 parameters.

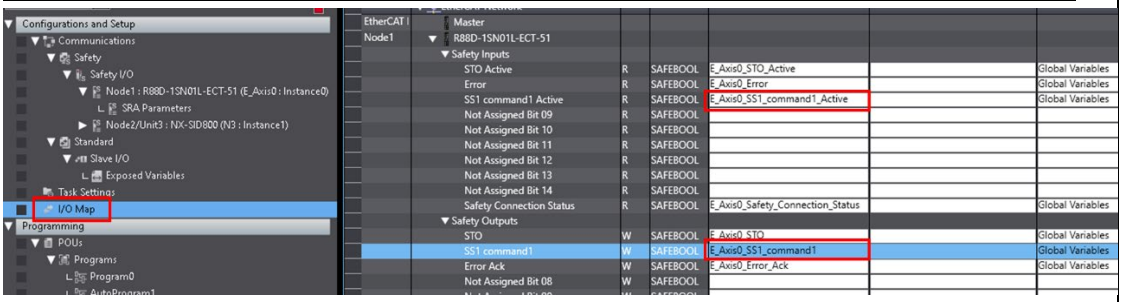
In this guide, set them as follows.

Name	Value	Unit
SS1 time to STO 1	1500	ms



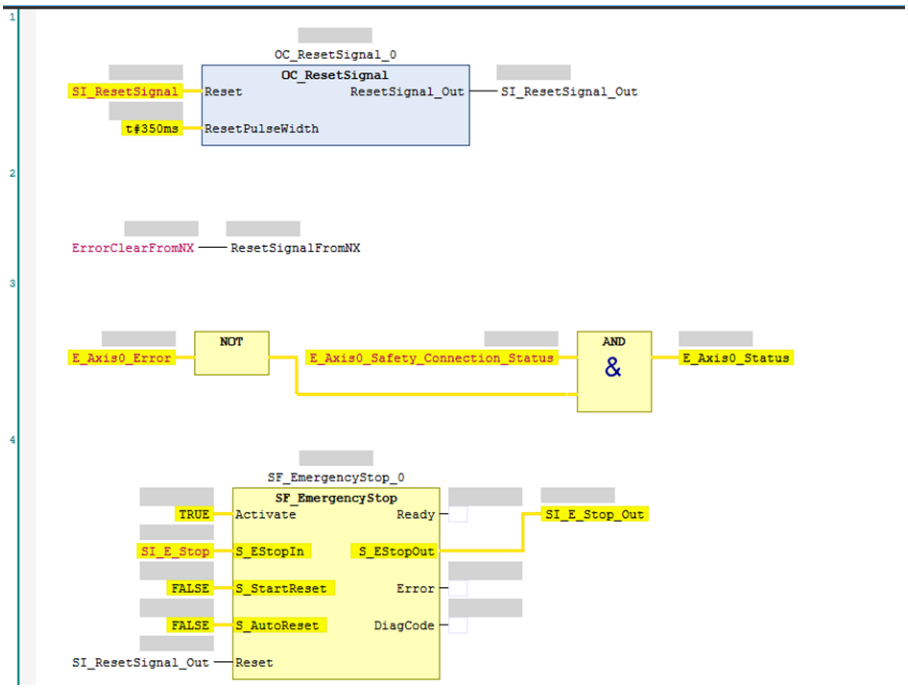
6. Open the I/O Map and create device variables.

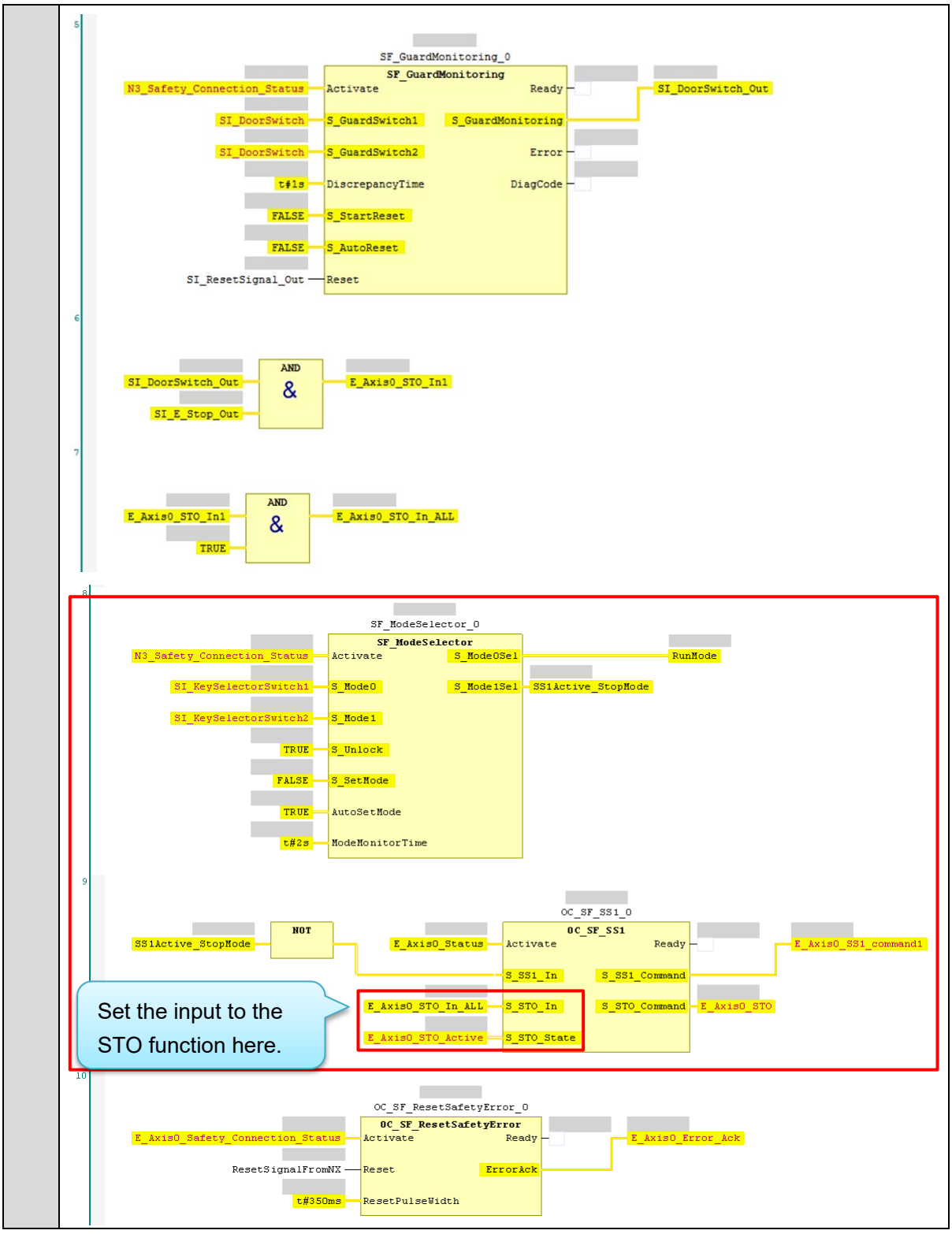
Port	Variable name
SS1 command1 Active for R88D-1SN01L-ECT-51	E_Axis0_SS1_command1_Active
SS1 command1 for R88D-1SN01L-ECT-51	E_Axis0_SS1_command1



6. Create a safety program.

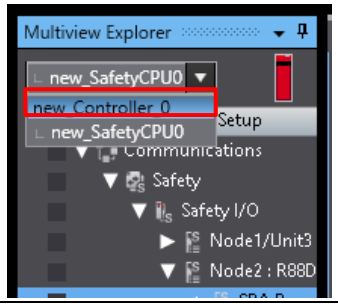
Add the following code to AutoProgram1.



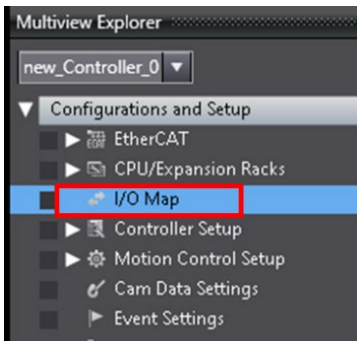

SF_GuardMonitoring_0
SF_GuardMonitoring
N3_Safety_Connection_Status
Activate
Ready
SI_DoorSwitch_Out
SI_DoorSwitch
S_GuardSwitch1
S_GuardMonitoring
SI_DoorSwitch
S_GuardSwitch2
Error
t#1s
DiscrepancyTime
DiagCode
FALSE
S_StartReset
FALSE
S_AutoReset
SI_ResetSignal_Out
Reset
AND
&
SI_DoorSwitch_Out
SI_E_Stop_Out
E_Axis0_STO_In1
AND
&
E_Axis0_STO_In1
TRUE
E_Axis0_STO_In_ALL
SF_ModeSelector_0
SF_ModeSelector
N3_Safety_Connection_Status
Activate
S_Mode0Sel
RunMode
SI_KeySelectorSwitch1
S_Mode0
S_Mode1Sel
SS1Active_StopMode
SI_KeySelectorSwitch2
S_Mode1
TRUE
S_Unlock
FALSE
S_SetMode
TRUE
AutoSetMode
t#2s
ModeMonitorTime
OC_SF_SS1_0
OC_SF_SS1
SS1Active_StopMode
NOT
E_Axis0_Status
Activate
Ready
E_Axis0_SS1_command1
S_SS1_In
S_SS1_Command
E_Axis0_STO_In_ALL
S_STO_In
S_STO_Command
E_Axis0_STO
E_Axis0_STO_Active
S_STO_State
Set the input to the STO function here.
OC_SF_ResetSafetyError_0
OC_SF_ResetSafetyError
E_Axis0_Safety_Connection_Status
Activate
Ready
E_Axis0_Error_Ack
ResetSignalFromNX
Reset
ErrorAck
t#350ms
ResetPulseWidth

4.1.2. Setting the Standard Controller

1. Select *new_Controller_0* from the list.

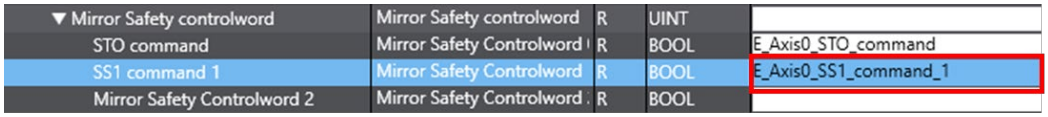


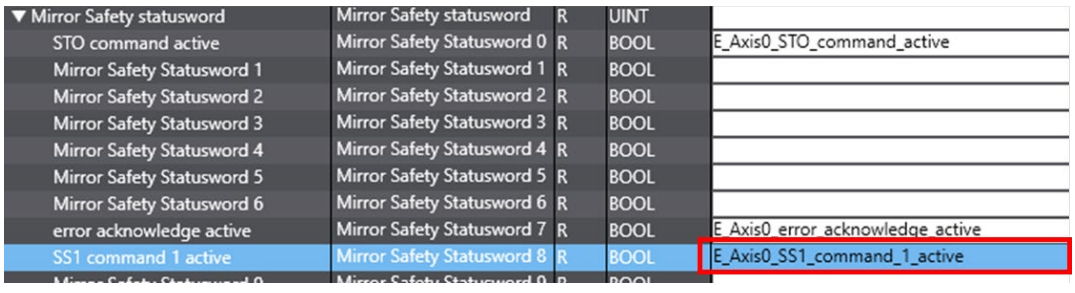
2. Double-click *I/O Map*.



3. Create device variables.

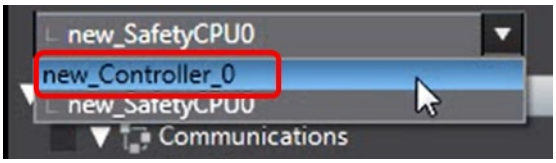
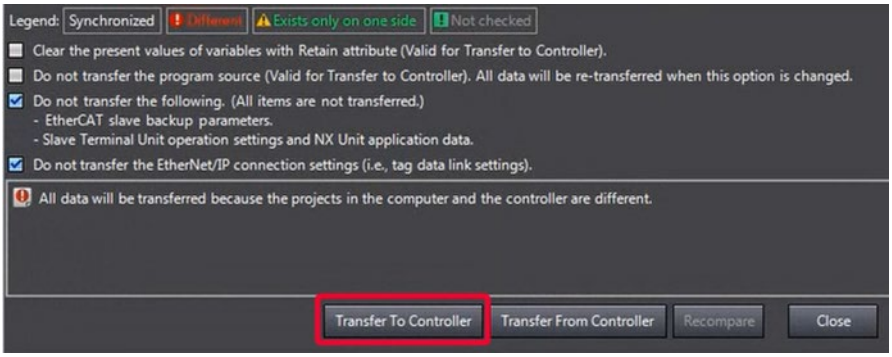
Port	Variable name
SS1 command1 for R88D-1SN01L-ECT-51	E_Axis0_SS1_command_1
SS1 command1 active for R88D-1SN01L-ECT-51	E_Axis0_SS1_command_1_active

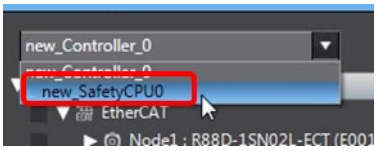
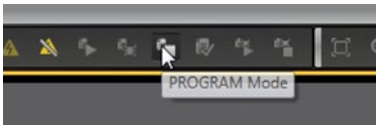
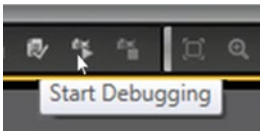
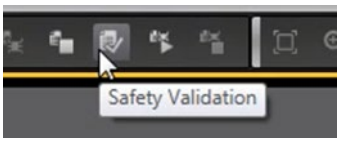
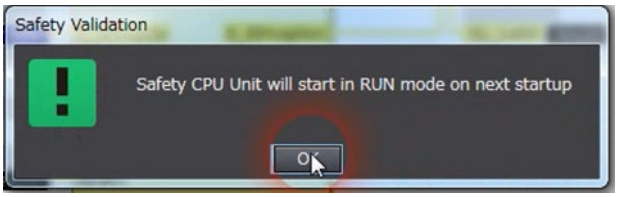
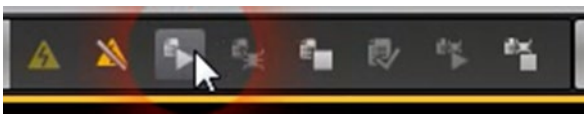
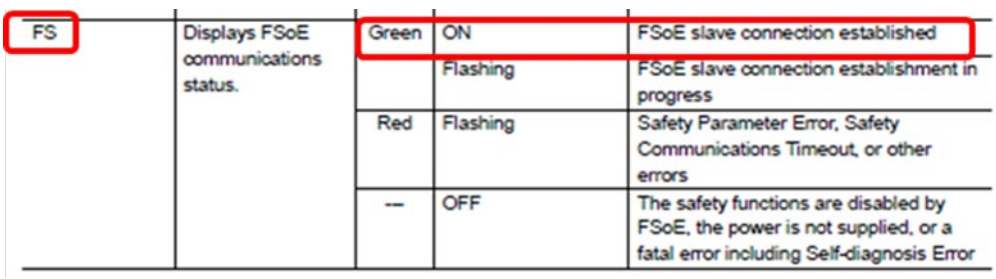




4.	Create code for the standard program. Add the code to change the command velocity. • When the SS1 function is active, reduce the command velocity to 0 r/min.

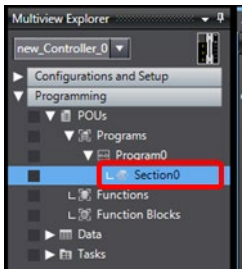
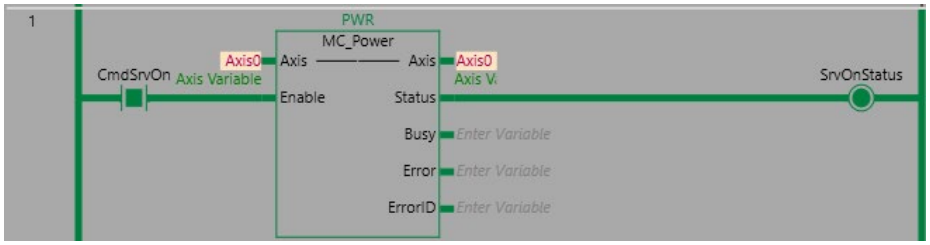
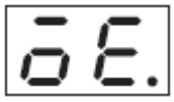
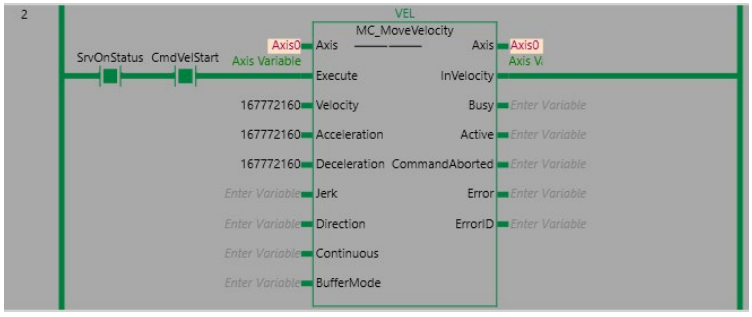
When the SS1 function is active, reduce the command velocity to 0 [r/min] (0% of command velocity).

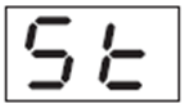
5.	Transfer to the standard controller. Select *new_Controller_0* from the list.  Connect to the standard controller.  Click the Synchronization Button to synchronize with the standard controller.  Transfer to the standard controller. 

6.	Download the safety application. Select *new_SafetyCPU0* from the list.  Click the PROGRAM Mode Button to switch to PROGRAM mode.  Click the DEBUG Mode Button to enter DEBUG mode.  Click the Start Debugging Button to start DEBUG mode.  Click the Safety Validation Button.  Click the OK Button.  Click the Run Button. 
7.	The FSoE communications are now established. The FS indicator is lit in green. 

FS	Displays FSoE communications status.	Green	ON	FSoE slave connection established
			Flashing	FSoE slave connection establishment in progress
		Red	Flashing	Safety Parameter Error, Safety Communications Timeout, or other errors
		---	OFF	The safety functions are disabled by FSoE, the power is not supplied, or a fatal error including Self-diagnosis Error

4.1.3. Checking Operation of the SBC Function Interlocked with the SS1 Function

1.	Check that the Safety Key Selector Switch is in normal operating mode. 
2.	Press the safety reset button. 
3.	Double-click *Section0* to display the section. 
4.	Right-click *CmdSrvOn* and select *Set/Reset* – *Set*.  Check that the 7-segment LED display shows ‘oE.’. 
5.	Right-click *CmdVelStart* and select *Set/Reset* – *Set*.  Check that the Servomotor rotates at about 1200 r/min.

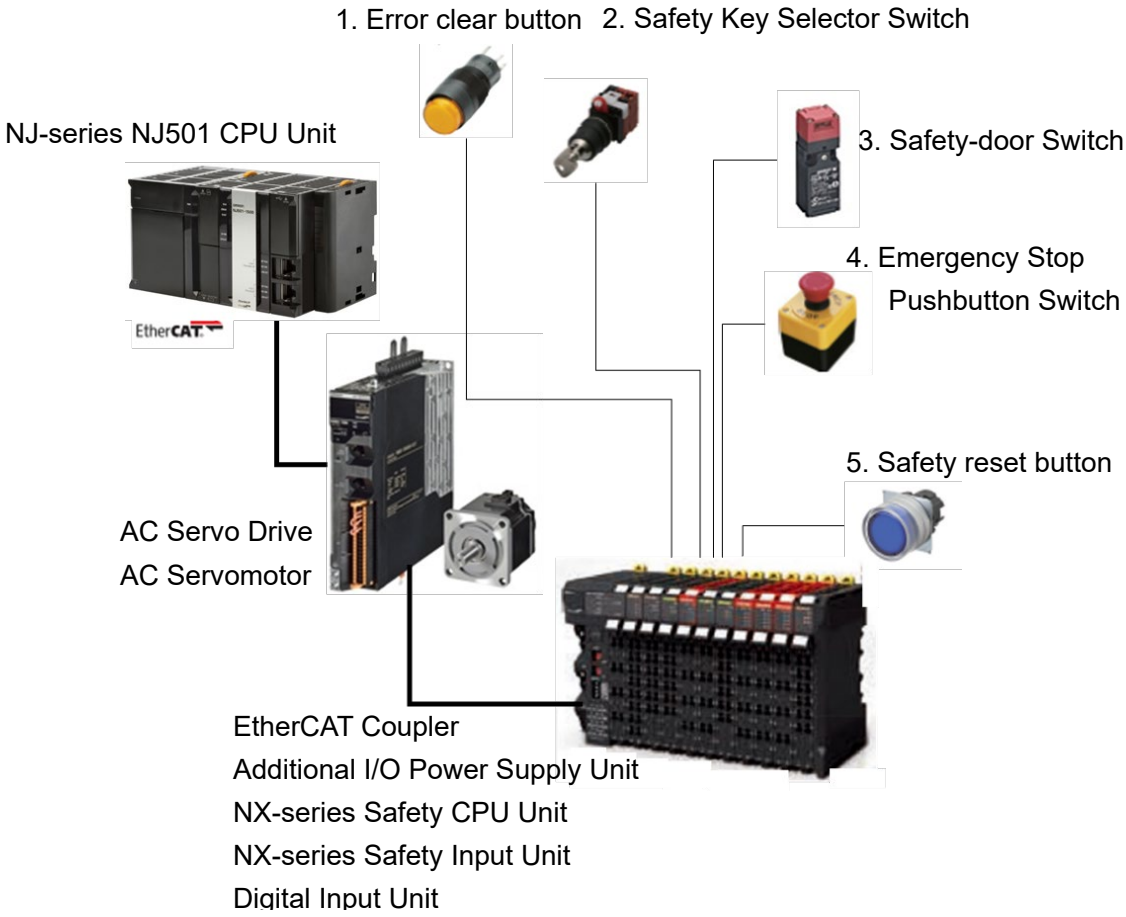
6.	Operate the Safety Key Selector Switch to switch to safety active mode.  The Servomotor decelerates to a stop and the Servo Drive goes into STO state. Check that the brake is applied. (Make sure that no SBC stuck-at-high error is detected.) Check that the 7-segment LED display shows ‘st’. 

4.2. Adding the Safely-limited Speed (SLS) Function

This section describes how to add the SLS function to the project created in *3. Performing setup*.

The operation of the servo system set up in this section is explained below.

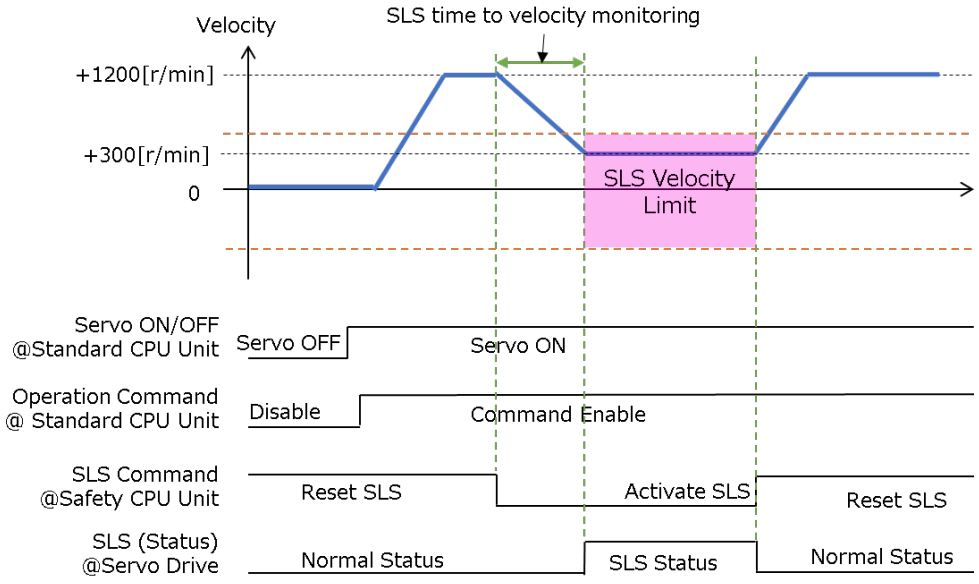
1. When the error clear button is pressed, the errors of the standard controller and Servo Drive are reset.
2. When the Safety Key Selector Switch is operated to switch to safety active mode, the standard controller changes the velocity command value to low speed. The Servo Drive activates the SLS function and monitors the motor velocity.
3. When the guard with the Safety-door Switch is opened while the SLS function is inactive, the motor torque is turned OFF.
4. When the Emergency Stop Pushbutton Switch is pressed, the motor torque is turned OFF.
5. When the safety reset button is pressed, the STO status is reset.



Input device	State	Operation
1. Error clear button	ON	Enable error reset command
	OFF	Disable error reset command
2. Safety Key Selector Switch	Normal operating mode	Run Servomotor at 1200 [r/min] and deactivate SLS function.
	Safety active mode	Run Servomotor at 300 [r/min] and activate SLS function. When velocity exceeds SLS velocity limit, Servo Drive goes into STO state and Excessive Limit Value Error occurs.
3. Safety-door Switch	Open	SLS function deactivated: Enable STO command SLS function activated: Disable STO command
	Close	Disable STO command
4. Emergency Stop Pushbutton Switch	ON	Enable STO command
	OFF	Disable STO command
5. Safety reset button	ON	Enable reset STO status command
	OFF	Disable reset STO status command

■ **Operation of SLS Function with Motion Control**

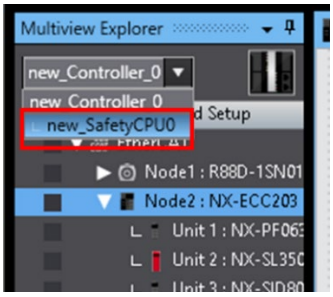
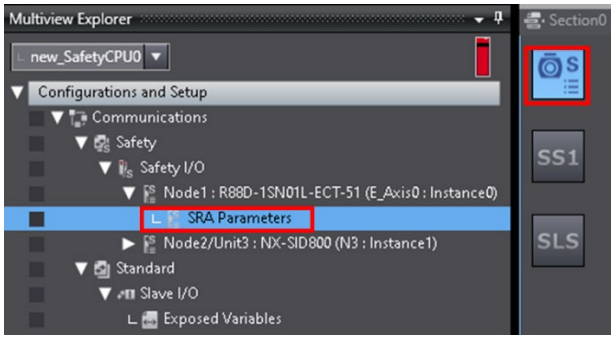
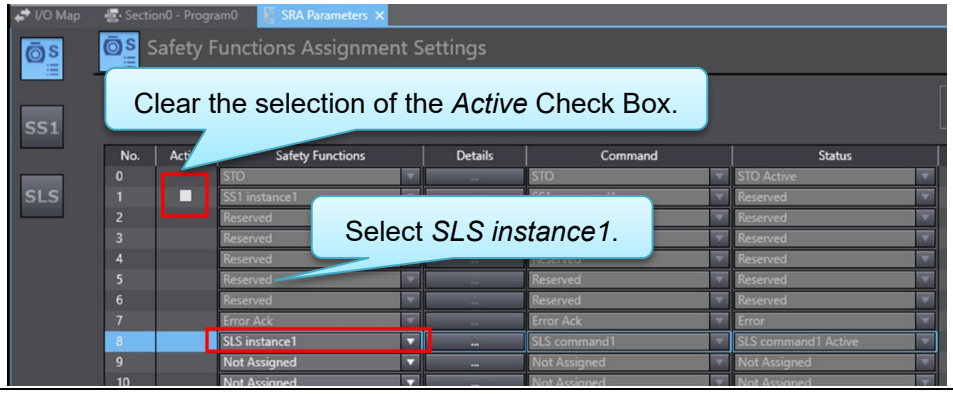
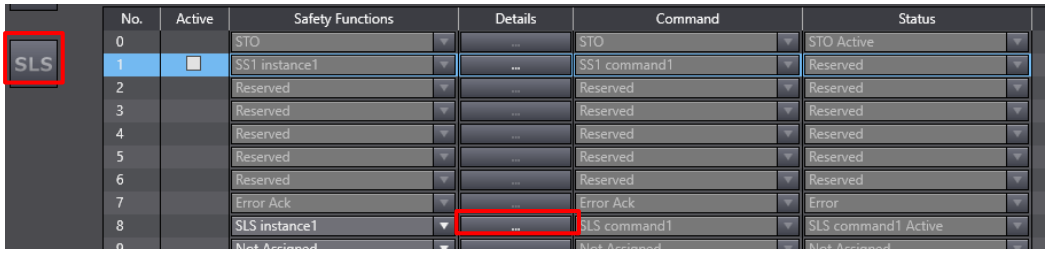
1. When the Servo ON command is enabled, the Servo Drive turns ON the Servo.
2. When an operation command is enabled, the command velocity to the Servomotor is set to 1200 r/min.
3. When the SLS function is executed, the Servo Drive shifts to the SLS state after the wait time (SLS time to velocity monitoring 1) and monitors the motor velocity.
   The standard controller sets the command velocity to the Servomotor to 300 r/min.
4. When the SLS function is released, the Servo Drive goes into the normal state and stops monitoring the motor velocity.
   The standard controller sets the command velocity to the Servomotor to 1200 r/min.



Precautions for Correct Use

While using the SLS function, errors may occur during normal operation depending on the operating conditions and operating environment.
For further details, please refer to *AC Servomotors/Servo Drives 1S-series with Built-in EtherCAT Communications and SS1/SLS Safety Sub-Functions User's Manual* (Cat. No. I696) Chapter 8-4 Safely Limited Speed (SLS) Function.

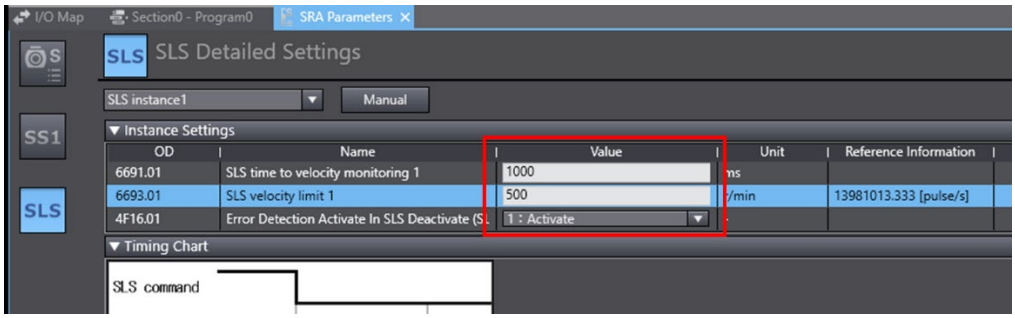
4.2.1. Setting the Safety Controller

1.	Select *new_SafetyCPU0* from the list. 
2.	Double-click *SRA Parameters* and click the *Safety Function Assignment Settings* Button. 
3.	Assign SLS instance1. 
4.	Click the SLS Button or the ... Button to display the SLS Detailed Settings view. 

5. Set SLS parameters.

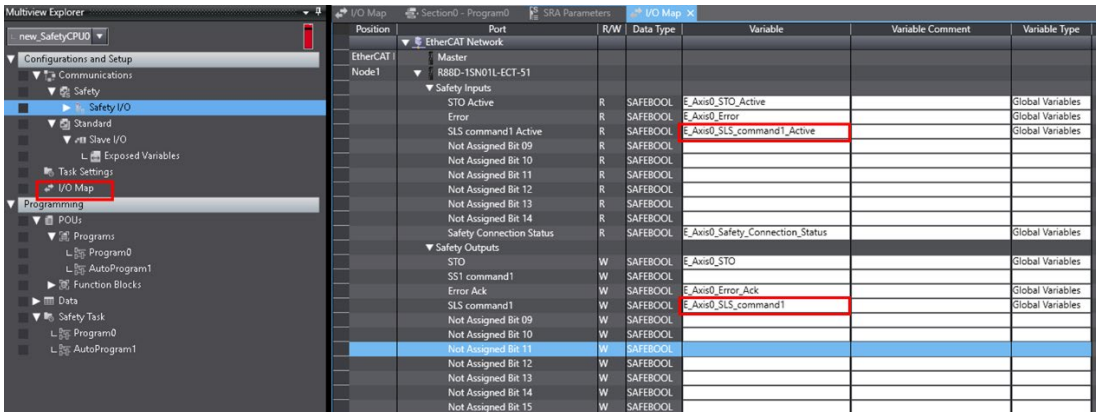
In this Guide, set as follows:

Name	Value	Unit
SLS time to velocity monitoring 1	1000	ms
SLS velocity limit 1	500	r/min
Error Detection Activate In SLS Deactivate(SLS1)	Activate	-



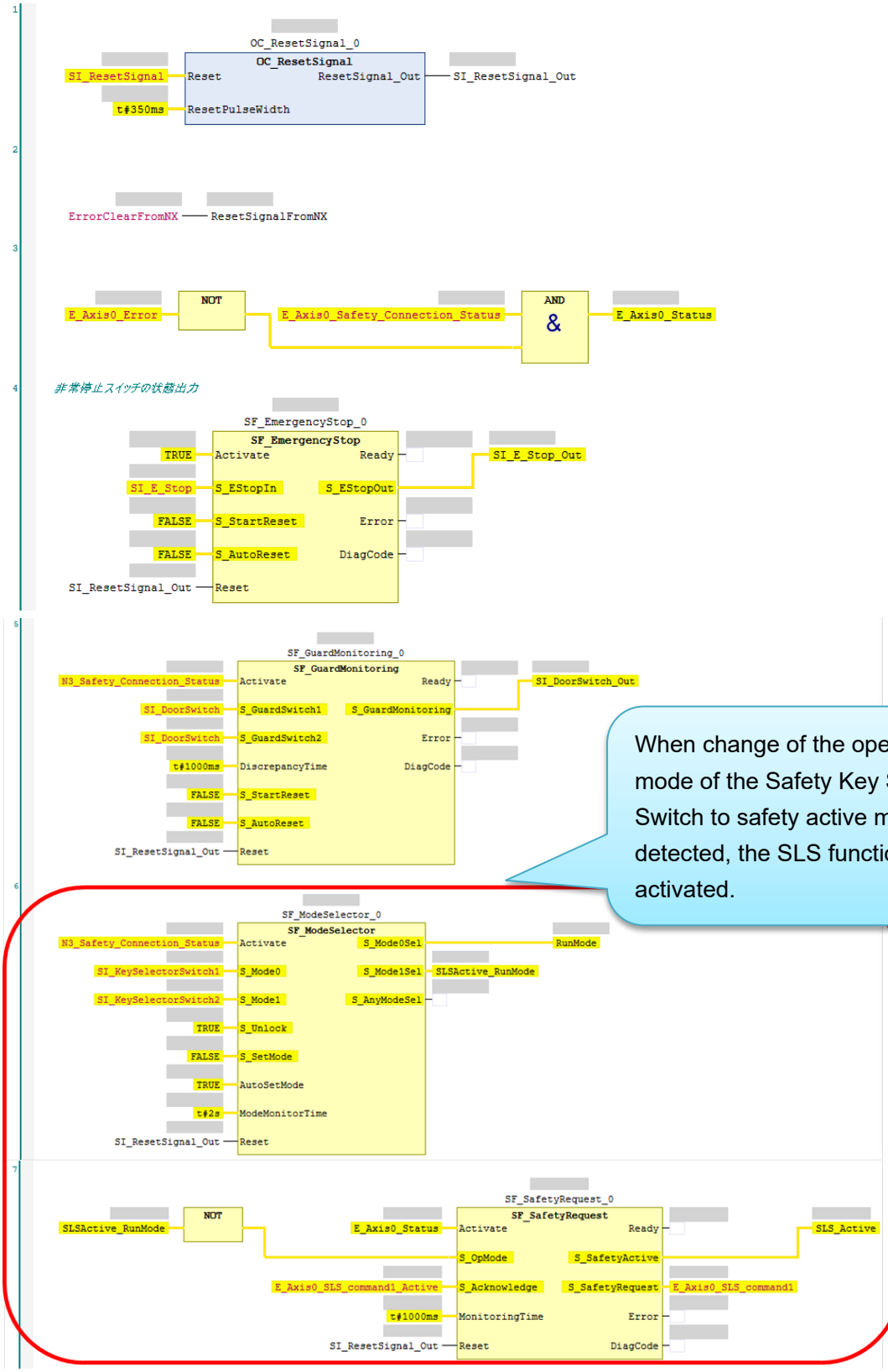
6. Open the I/O Map and create device variables.

Port	Variable name
SLS command1 Active for R88D-1SN01L-ECT-51	E_Axis0_SLS_command1_Active
SLS command1 for R88D-1SN01L-ECT-51	E_Axis0_SLS_command1

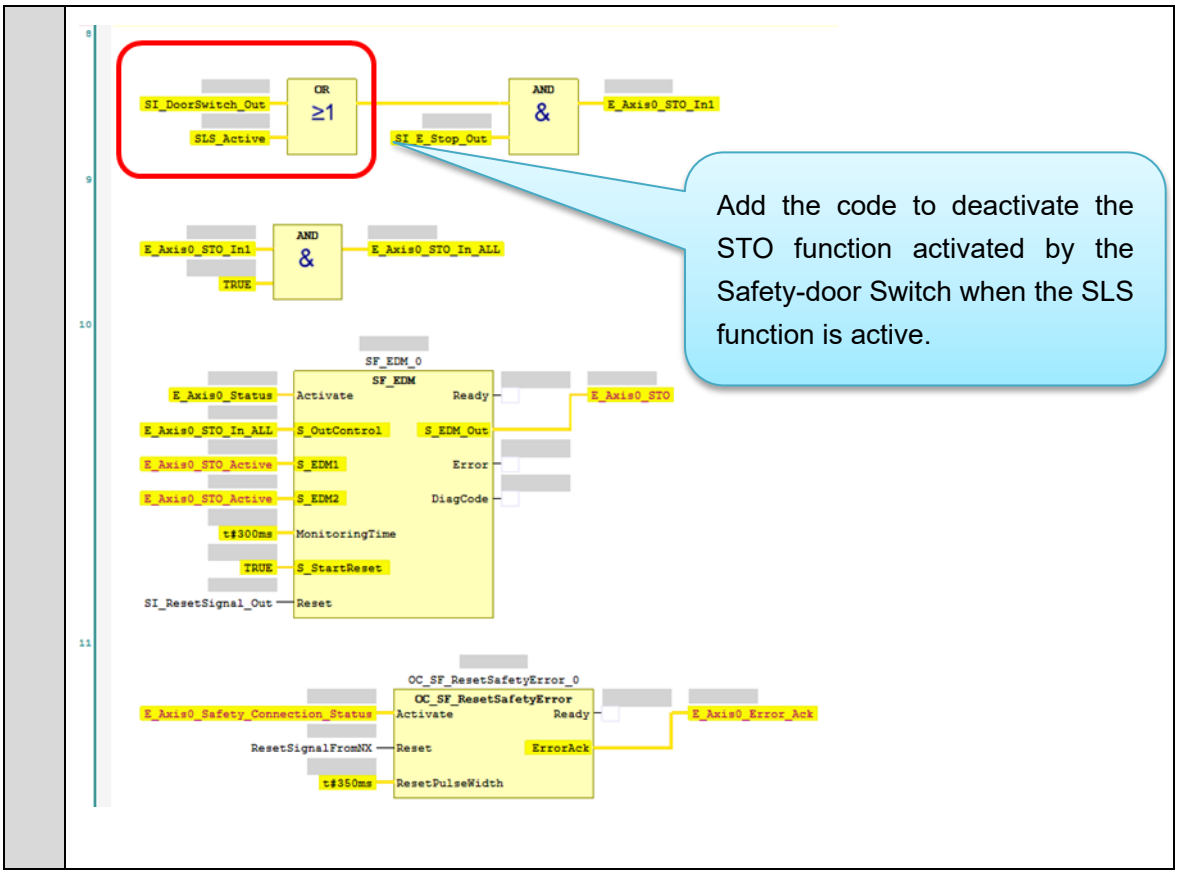


7. Create a safety program.

Add the following code to AutoProgram1.

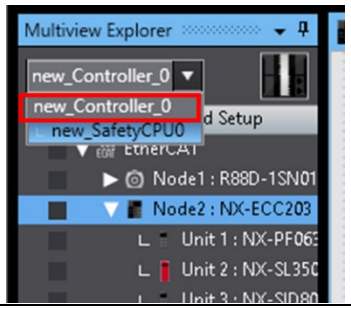


When change of the operating mode of the Safety Key Selector Switch to safety active mode is detected, the SLS function is activated.

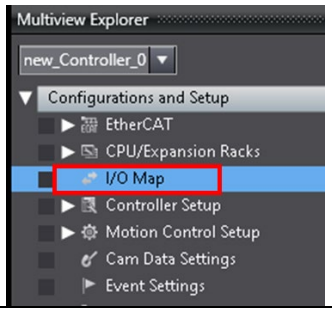

SI_DoorSwitch_Out
SLS_Active
OR
≥1
AND
&
SI_E_Stop_Out
E_Axis0_STO_In1
E_Axis0_STO_In1
TRUE
AND
&
E_Axis0_STO_In_ALL
SF_EDM_0
SF_EDM
E_Axis0_Status
Activate
Ready
E_Axis0_STO
E_Axis0_STO_In_ALL
S_OutControl
S_EDM_Out
E_Axis0_STO_Active
S_EDM1
Error
E_Axis0_STO_Active
S_EDM2
DiagCode
t#300ms
MonitoringTime
TRUE
S_StartReset
SI_ResetSignal_Out
Reset
OC_SF_ResetSafetyError_0
OC_SF_ResetSafetyError
E_Axis0_Safety_Connection_Status
Activate
Ready
E_Axis0_Error_Ack
ResetSignalFromNX
Reset
ErrorAck
t#350ms
ResetPulseWidth
Add the code to deactivate the STO function activated by the Safety-door Switch when the SLS function is active.

4.2.2. Setting the Standard Controller

1. Select *new_Controller_0* from the list

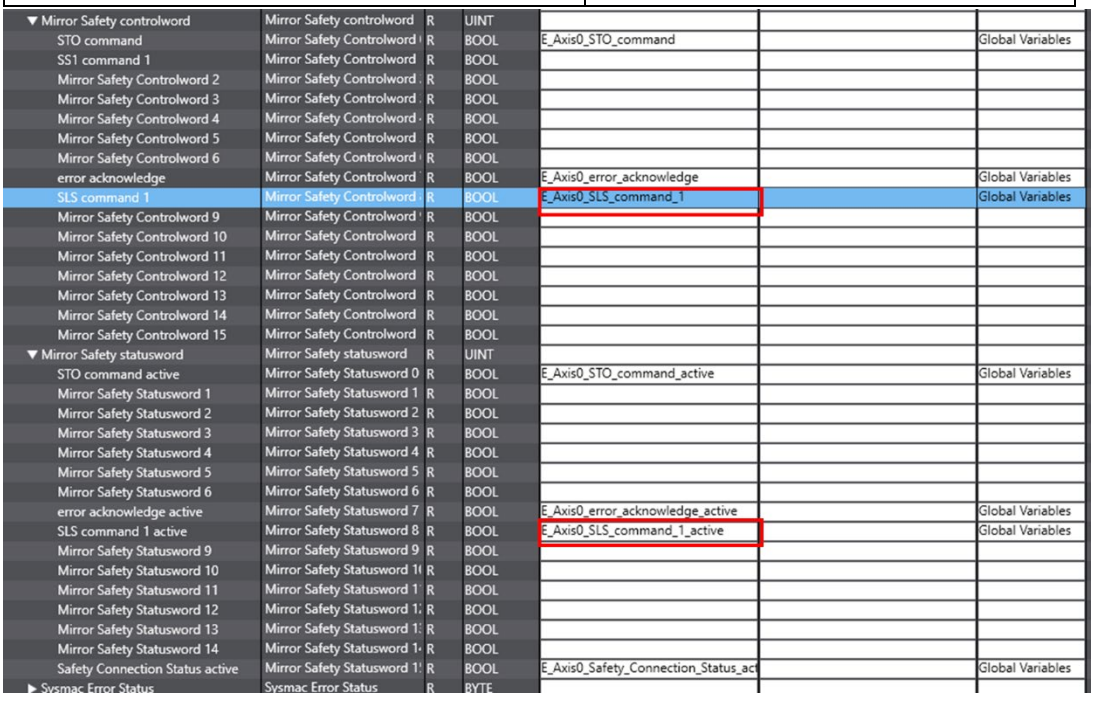


2. Double-click *I/O Map*.



3. Create device variables.

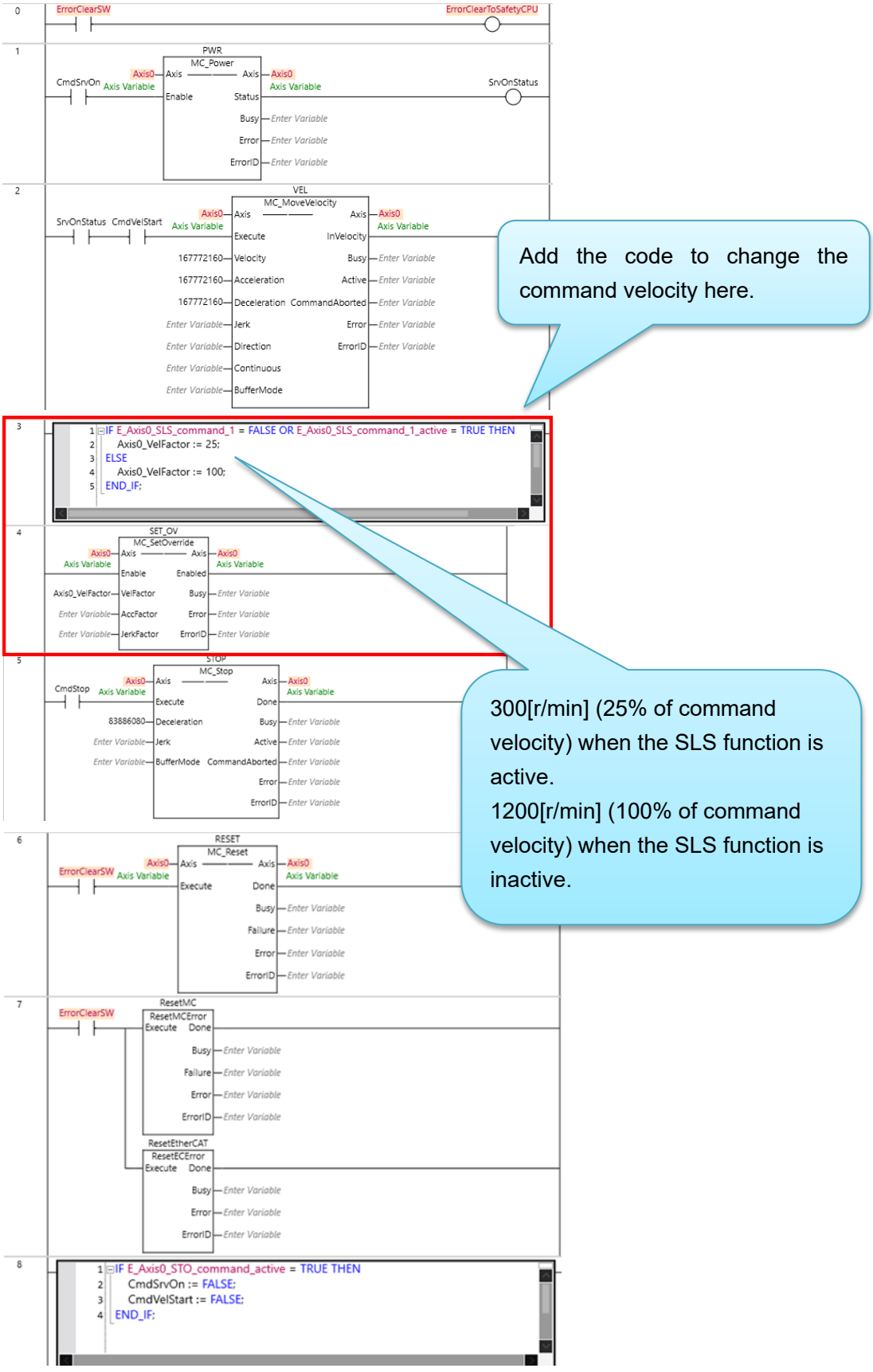
Port	Variable name
SLS command 1 for R88D-1SN01L-ECT-51	E_Axis0_SLS_command_1
SLS command 1 active for R88D-1SN01L-ECT-51	E_Axis0_SLS_command_1_active



4. Create a standard program.

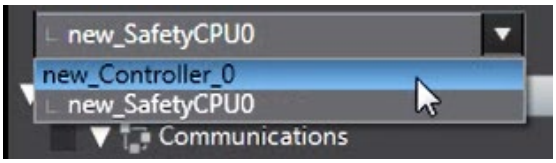
Add the code to change the command velocity.

- When the SLS function is active, reduce the command velocity to 300 r/min.
- When the SLS function is inactive, increase the command velocity to 1200 r/min.



5. Transfer to the standard controller.

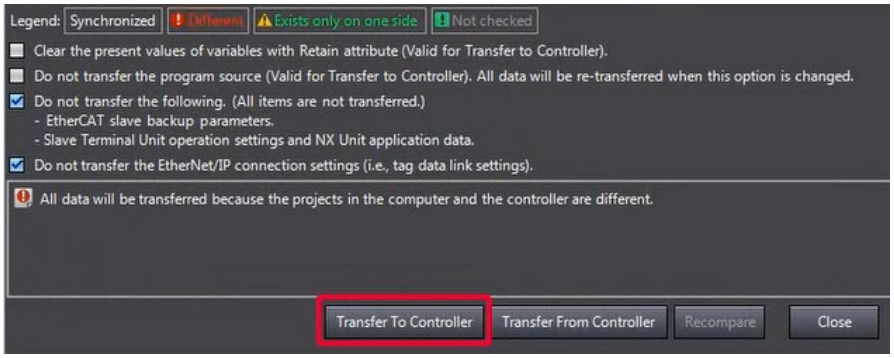
Select *new_Controller_0* from the list.



Connect to the standard controller.

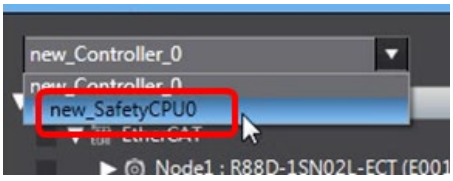
Click the Synchronization Button to synchronize with the standard controller.

Transfer to the standard controller.

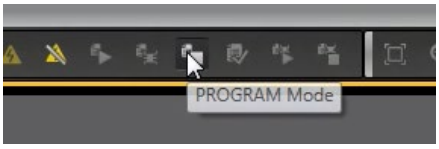


6. Download the safety application.

Select *new_SafetyCPU0* from the list.

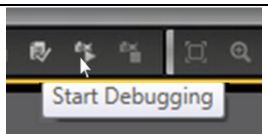


Click the PROGRAM Mode Button to switch to PROGRAM mode.

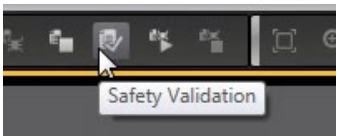


Click the DEBUG Mode Button to enter DEBUG mode.

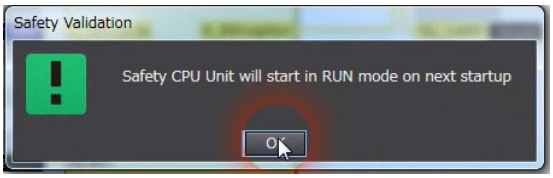
Click the Start Debugging Button to start DEBUG mode.



Click the Safety Validation Button.



The safety application is now ready to run.

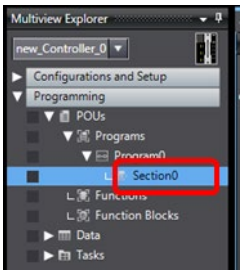
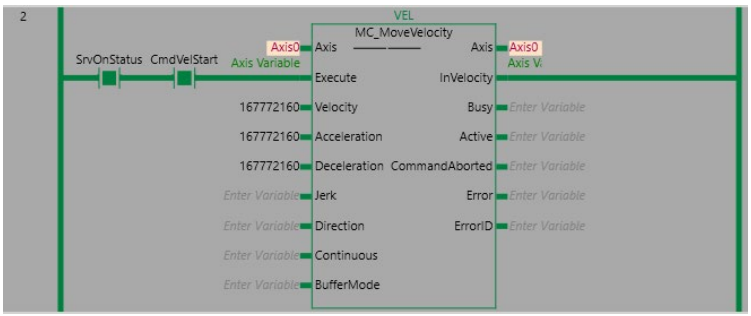


Click the Run Button.

7. The FSoE communications are now established.
The FS indicator is lit in green.

FS	Displays FSoE communications status.	Green	ON	FSoE slave connection established
			Flashing	FSoE slave connection establishment in progress
		Red	Flashing	Safety Parameter Error, Safety Communications Timeout, or other errors
		---	OFF	The safety functions are disabled by FSoE, the power is not supplied, or a fatal error including Self-diagnosis Error

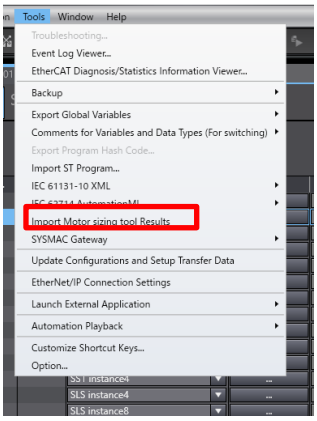
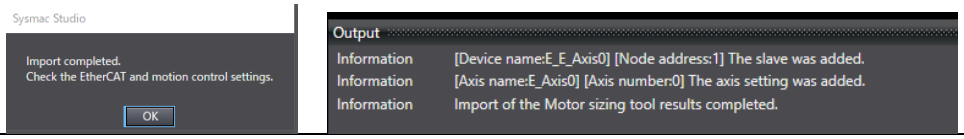
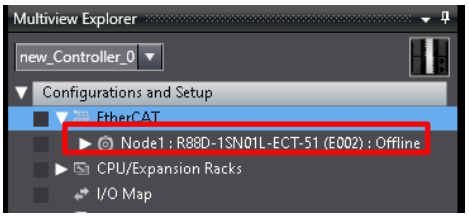
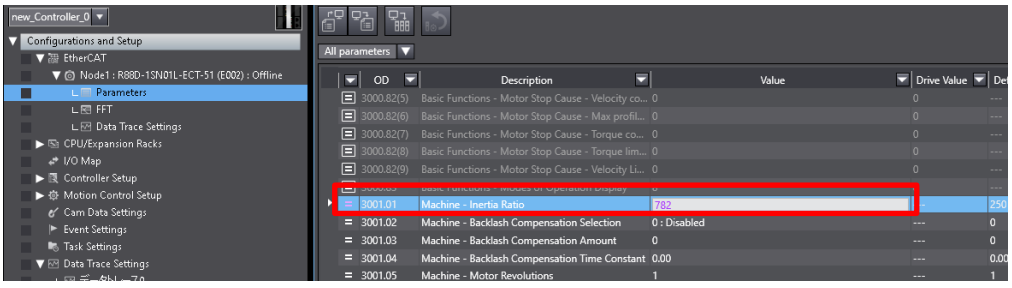
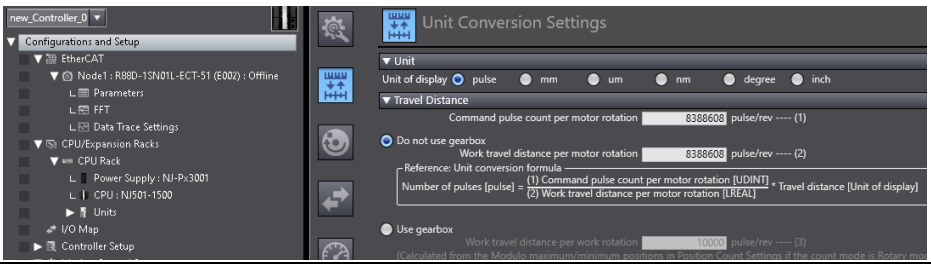
4.2.3. Checking Operation of the SLS Function

1.	Check that the Safety Key Selector Switch is in normal operating mode. 
2.	Press the safety rest button. 
3.	Double-click *Section0* to display the section. 
4.	Right-click *CmdVelStart* and select *Set/Reset − Set*.  Check that the Servomotor rotates at about 1200 r/min.
5.	Operate the Safety Key Selector Switch to switch to safety active mode.  Check that the Servomotor rotates at about 300 r/min. Check that the 7-segment LED display shows ‘SF’. 

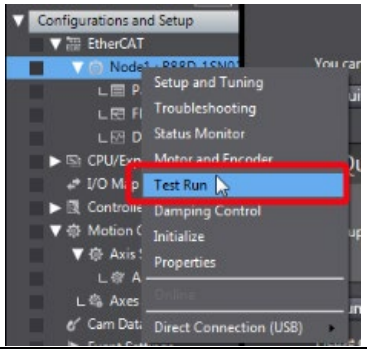
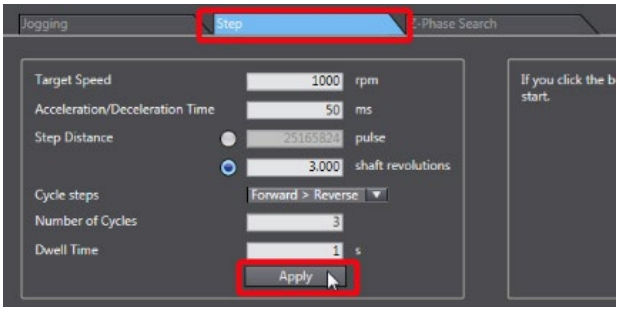
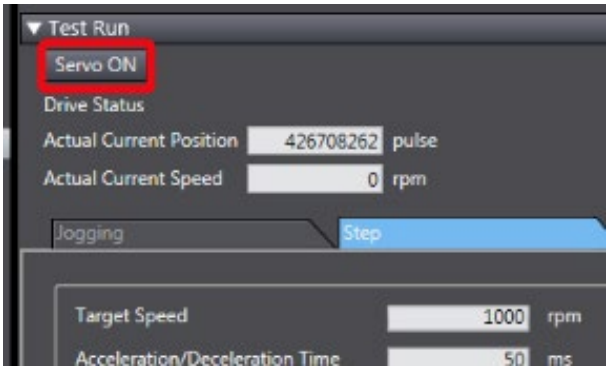
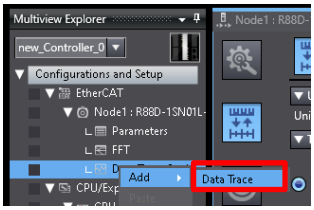
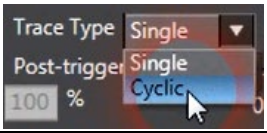
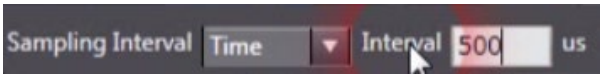
6.	Open the guard with the Safety-door Switch.  Check that the 7-segment LED display still shows ‘SF’.
7.	Close the guard and press the safety reset switch.
8.	Operate the Safety key Selector Switch to switch to normal operating mode.  Check that the Servomotor rotates at about 1200 r/min. Check that the 7-segment LED display shows ‘oE.’. 

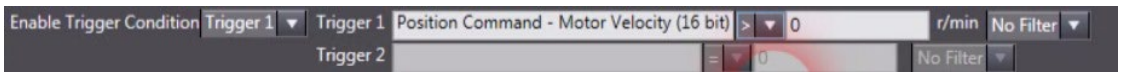
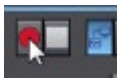
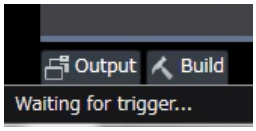
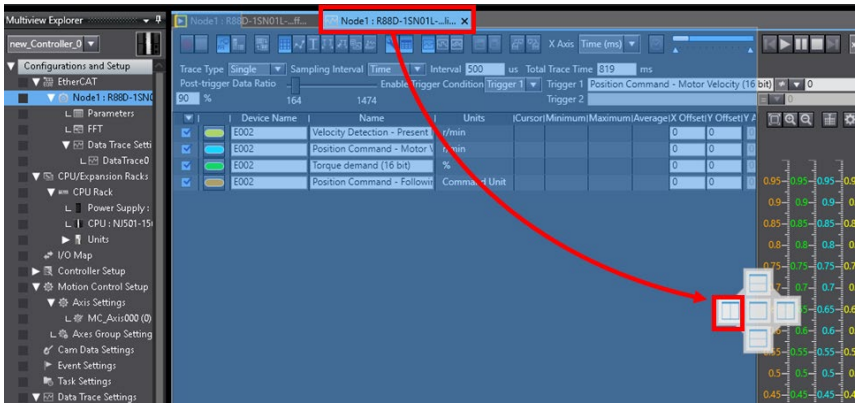
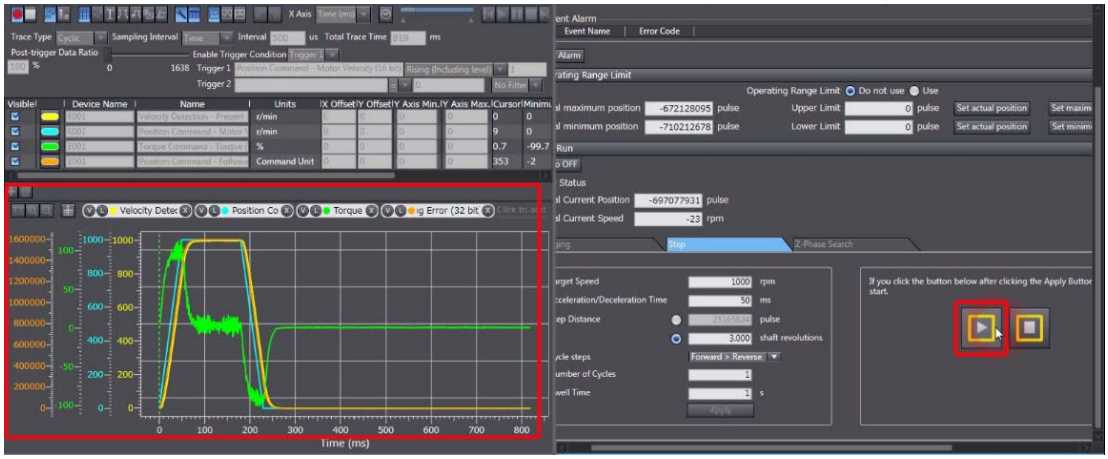
ANNEX

Adding a Servo Drive and Axis from Motor Sizing Tool Results

1.	Import the motor sizing tool results file.  Note: Refer to the *Motor Sizing Tool Startup Guide* (Cat. No. I820) for learning how to create sizing results.
2.	Devices were imported successfully. 
3.	Check that the EtherCAT configuration has been updated. 
4.	Servo Drive parameters have been updated. 
5.	Axis settings have been created and updated. 

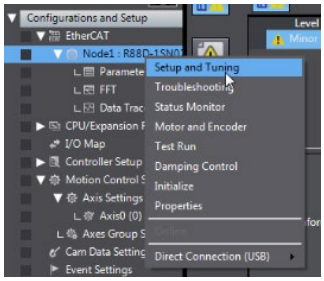
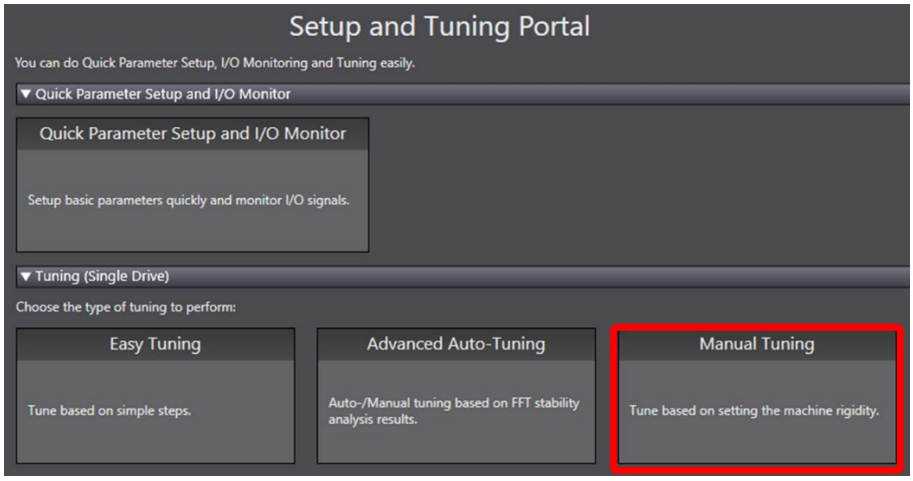
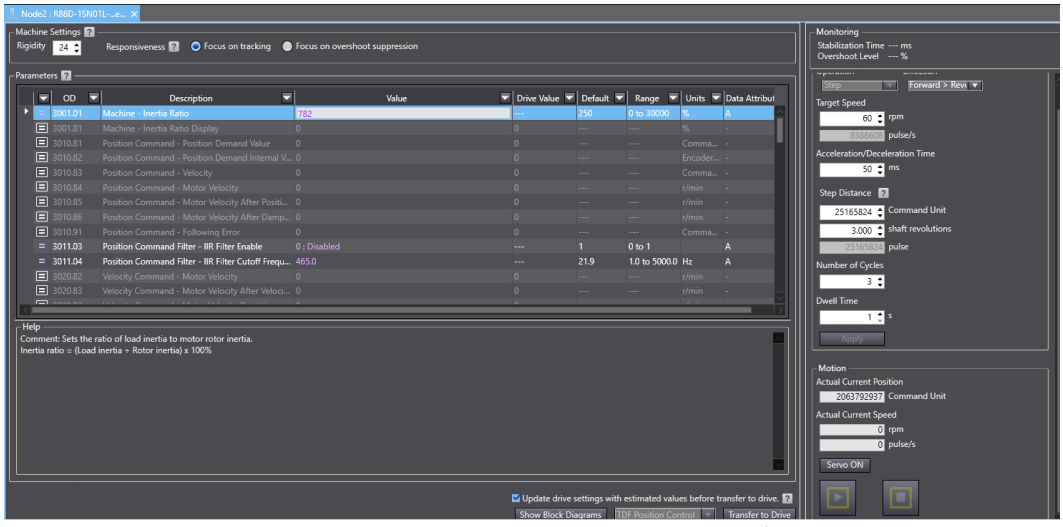
Test run and data trace

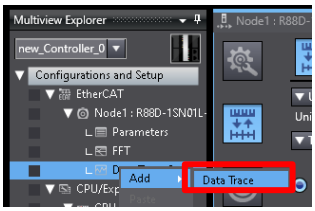
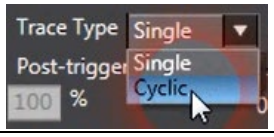
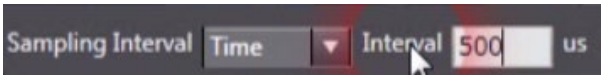
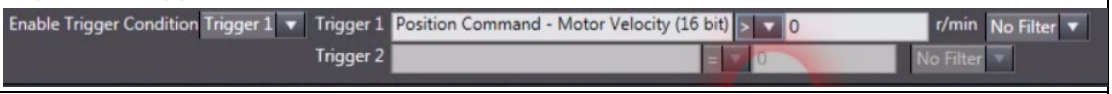
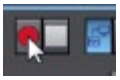
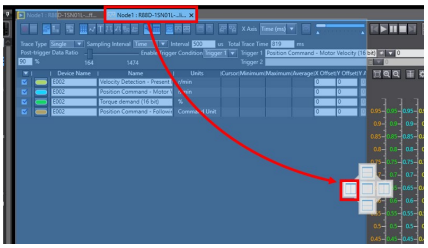
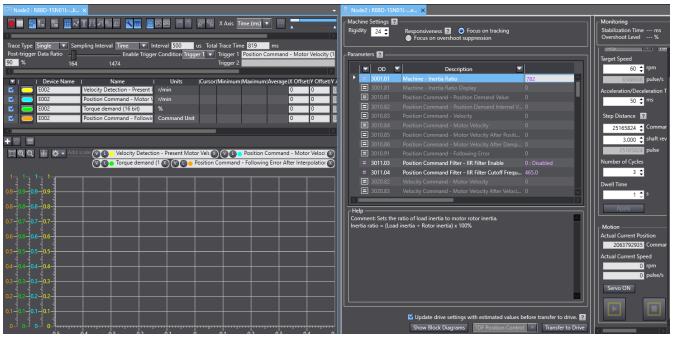
1.	**Please right click to the drive and select “test run”** 
2.	**Please click “step” tab, adjust motion profile and apply** 
3.	**Activate the servo ON** 
4.	**Please right click to the “data trace settings” and add a new trace** 
5.	**Chose cyclic mode** 
6.	**Adjust the sampling interval** 

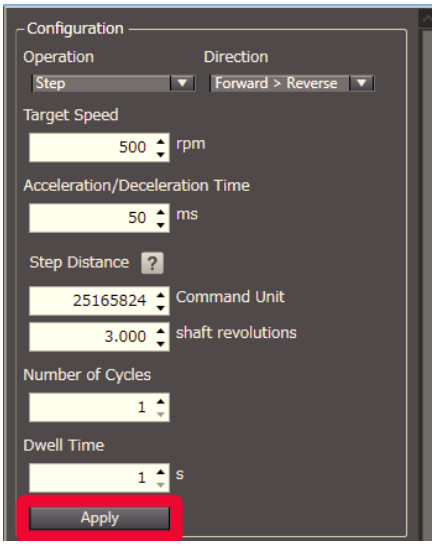
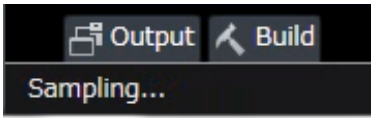
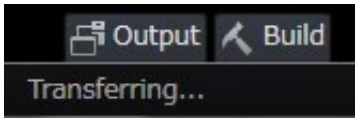
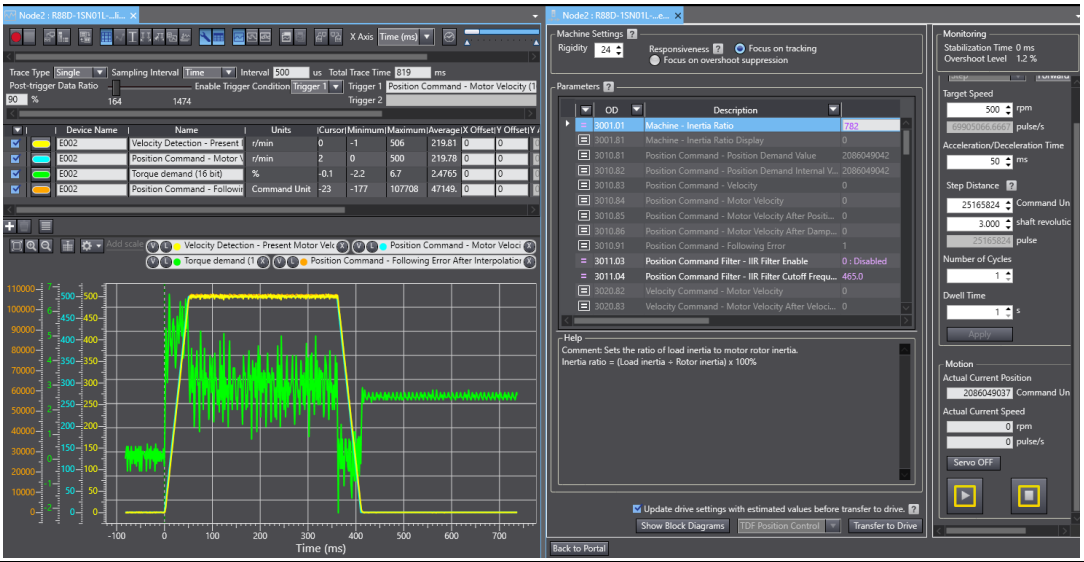
7.	**Adjust the trigger condition** 
8.	**Push record button**  Sysmac Studio is now waiting for the trigger 
9.	**Place the Test run and Data trace windows side-by-side with docking window feature**  Push start in test run, data traces will appear cyclically 

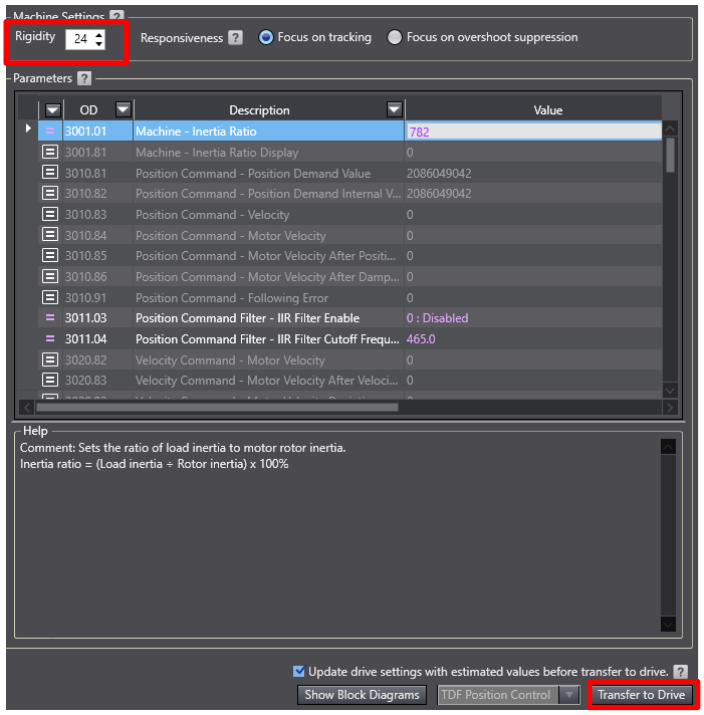
Manual tuning

■ Manual tuning guide

1.	Please right click to the drive and select “setup and tuning” 
2.	Please select Manual Tuning  Manual tuning window is displayed It includes rigidity settings, gain parameters and drive test run 

3.	In order to check the behavior of the motor, Please right click to the “data trace settings” and add a new trace 
4.	Chose cyclic mode 
5.	Adjust the sampling interval 
6.	Adjust the trigger condition 
7.	Disable parameters reading  Push record button  Sysmac Studio is now waiting for the trigger 
8.	Place the Test run and Manual tuning windows side-by-side with docking window feature  

9.	Configure the motion profile and click Apply 
10 .	Activate the Servo ON and Push Start   **Be careful, the motor will move in the forward and reverse direction.**
11.	The data trace is now triggered and result displayed.   Each time the motor will move, traces will appear cyclically. 

12.	It is possible to increase gain values by changing the rigidity settings  Push transfer to send the gain parameters to the drive.
13.	Please repeat step 10,11 and 12 until achieving the desired performance If vibrations appear, please reduce the rigidity settings. If required, it is possible to increase responsiveness by applying notch filters in Advanced Auto-Tuning mode and adjusting gains. Please refer to *3.5.2 Advanced Auto-Tuning*.

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

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