OMRON

AC Servo System 1S-series with safety functionality

Startup Guide

R88M-1AL[]/-1AM[] (AC Servomotors)
R88D-1SAN[]-ECT (AC Servo Drives)

SYSMAC
always in control

I859-E1-04

NOTE

Introduction

The *AC Servo System 1S-Series with Built-in EtherCAT Communications and Safety Functionality Startup Guide* (hereinafter, may be referred to as "this Guide") describes the procedures for installation and setup of a 1S-series Servo Drive with Built-in EtherCAT Communications and Safety Functionality (hereinafter referred to as “1S-series Servo Drive Advance Type”), where an NJ/NX-series CPU Unit is used in combination with1S-series AC Servomotors/Servo Drives Advance Type and NX-series Safety Control 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 Advance Type.
The safety circuits described in this Guide are not safety certified. The described usage examples of safety components and safety circuits may differ from your usage. 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 AC Servomotors/Drives
- Knowledge of operation procedure of Sysmac Studio

Applicable Products

This Guide covers the following products.

- Machine Automation Controller NJ/NX-series CPU Unit
- Automation Software Sysmac Studio
- 1S-series Servomotor/Servo Drive Advance Type
- NX-series EtherCAT Coupler Unit
- NX-series Safety Control Unit

Special Information

Special information in this Guide is classified as follows:

Precautions for Correct Use

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

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 http://www.fa.omron.co.jp/nj_info_e/.

Related Manuals

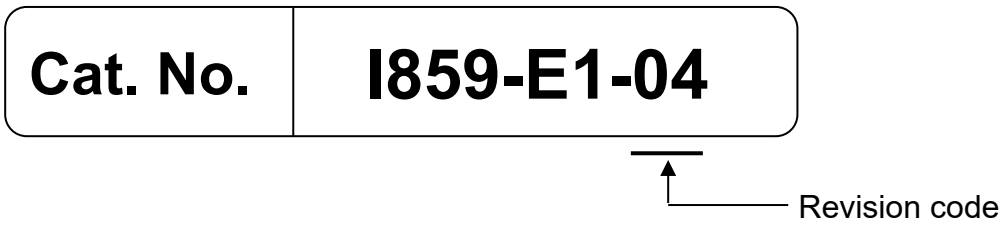
The following manuals are related. Use these manuals for reference.

Manual name	Cat. No.	Model	Application	Description
1S-Series AC Servomotors/Servo Drives with Built-in EtherCAT Communications and Safety Functionality User's Manual	I621	R88D-1SAN-ECT R88M-1A□	Learning detailed specifications of a 1S-series Servo Drive Advance Type.	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 how to set up and adjust the Servo Drives.	Describes the operating procedures of the Sysmac Studio.
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.	Provides an introduction to the entire NX-series system 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.	Provides an introduction to the entire NX102 system 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 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.	Provides an introduction to the entire NX1P2 system 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
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 • Introduction • Part names and functions • General specifications • Installation and wiring • Maintenance and inspection
NJ/NX-series CPU Unit Software User's Manual	W501	NX701-□□□□ 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-□□□□ 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-□□□□ NX102-□□□□ NX1P2-□□□□ NJ501-□□□□ NJ301-□□□□ NJ101-□□□□	Learning detailed specifications on the basic instructions of an NJ/ NX CPU Unit.	Describes the instructions in the instruction set (IEC 61131-3 specifications).
NJ/NX-series Motion Control Instructions Reference Manual	W508	NX701-□□□□ 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-□□□□ 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.
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.	Describes the hardware, setup methods and functions of the NX-series Safety Control Units.

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	December 2020	Original production
02	March 2021	Added safety functions (Sections 4.1, 4.2, 4.4, 4.6, and 4.7 added)
03	June 2021	• Added recovery procedure for SLP function. • Added Section 4.8. • Corrected mistakes.
04	September 2023	• Made changes accompanying addition of the gain tuning function (addition of Advanced Auto-Tuning)

CONTENTS

1. Servo System Configuration and Peripheral Products

1.1. Outline

The 1S-series Servo Drives Advance Type support 100-Mbps EtherCAT.
When you use the 1S-series Servo Drive Advance Type with a Machine Automation Controller NJ/NX-series CPU Unit or CJ1W-NC□8□ Position Control Unit with EtherCAT interface, you can construct a high-speed and sophisticated positioning control system.
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 tuning functions, adaptive notch filter, notch filter, and damping control, you can set up a system that provides stable operation by suppressing vibration in low-rigidity machines.
The 1S-series Servo Drives Advance Type support the FSoE (Safety over EtherCAT) protocol as the safety communications. You can build the safety system that uses safety functions from the safety CPU unit on the EtherCAT network.

Additional Information

For further details on the 1S-series Servo Drives Advance Type, refer to the *1S-Series AC Servomotors/Servo Drives with Built-in EtherCAT Communications and Safety Functionality User's Manual* (Cat. No. I621).

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 Standard and Safety Controllers
▼	
3	Sysmac Studio Project Creation
▼	
4	Motor, ABS Encoder and I/O Setup
▼	
5	Gain tuning (Easy Tuning, Advanced Auto-Tuning)
▼	
6	Creating a Motor Control Program
▼	

■ Adding a Safety Function

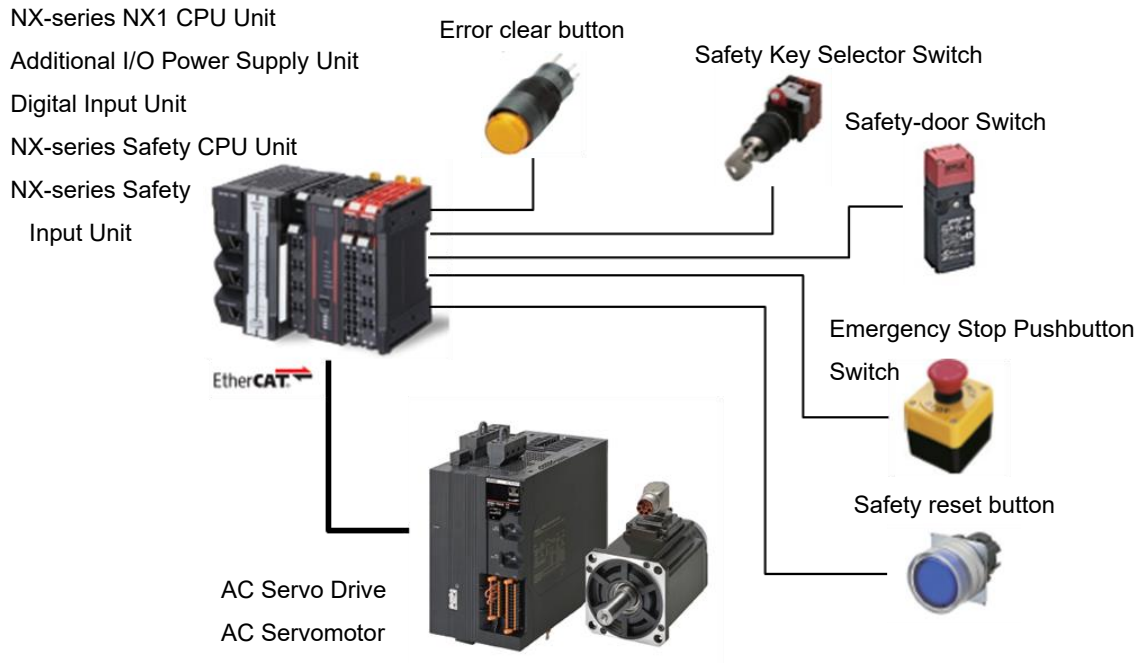
1	Select a safety function from below and add it. • Adding the Safe Brake Control (SBC) Function to the STO Function • Adding the Safe Stop 1 (SS1) Function • Adding the Safe Stop 2 (SS2) Function • Adding the Safe Operating Stop (SOS) Function • Adding the Safely-limited Speed (SLS) Function • Adding the Safely-limited Position (SLP) Function • Adding the Safe Direction (SDI) Function • Adding Multiple Safety Functions (SS2 + SLS)

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
NX-series NX1 CPU Unit (Standard controller)	NX102-[]	NX-series NX102 CPU Unit Hardware User's Manual (W593)
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-SL3300	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-1SAN[]	1S-series AC Servomotors/Servo Drives with Built-in EtherCAT Communications and Safety Functionality User's Manual (I621)
AC Servomotor	R88M-1A[]	
Integrated Cable	R88A-CX1[]	
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 1.27	None (DVD only)	SYSMAC-SE200D
	From 1 license to site license	SYSMAC-SE[]

2. Before You Begin

■ Unpacking

1.	**Unpack the motor package.** The package includes only one Servomotor and the instruction sheet. Cables are provided separately.
2.	**Unpack the drive package.** The Servo Drive comes with the following accessories. • INSTRUCTION MANUAL × 1 copy • Warning label × 1 sheet • General Compliance Information and instructions for EU × 1 copy • Attached connector

■ Installing the Sysmac Studio Standard Edition Version 1.27 or higher

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

Additional Information

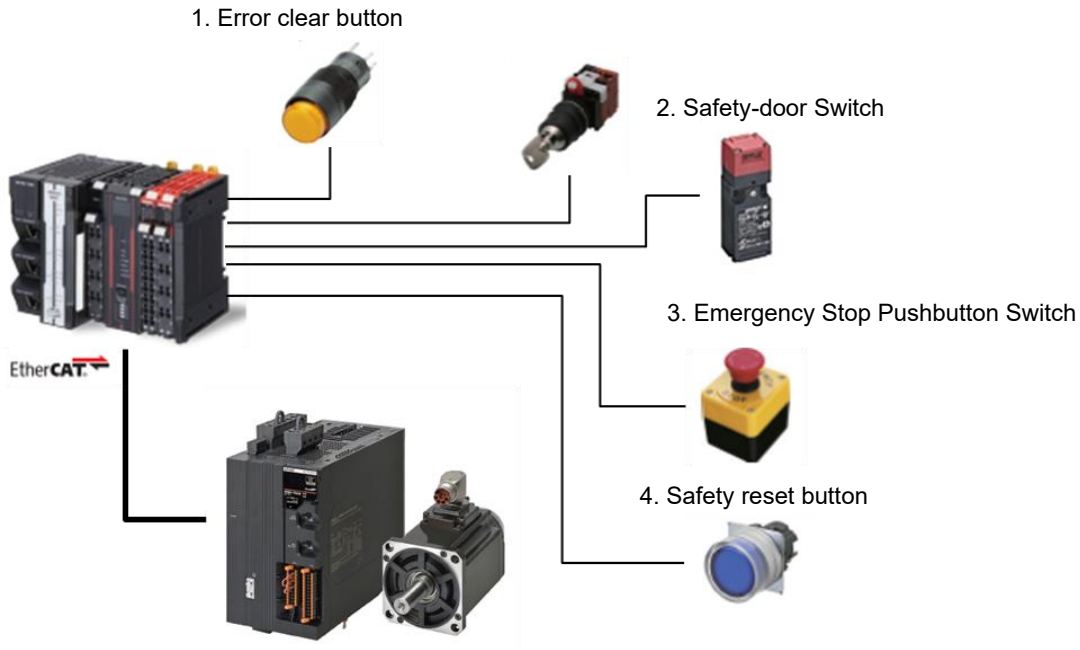
For further details on how to handle the drive and motor packages, refer to the *Items to Check After Unpacking* in the *1S-Series AC Servomotors/Servo Drives with Built-in EtherCAT Communications and Safety Functionality User's Manual* (Cat. No. I621).

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.

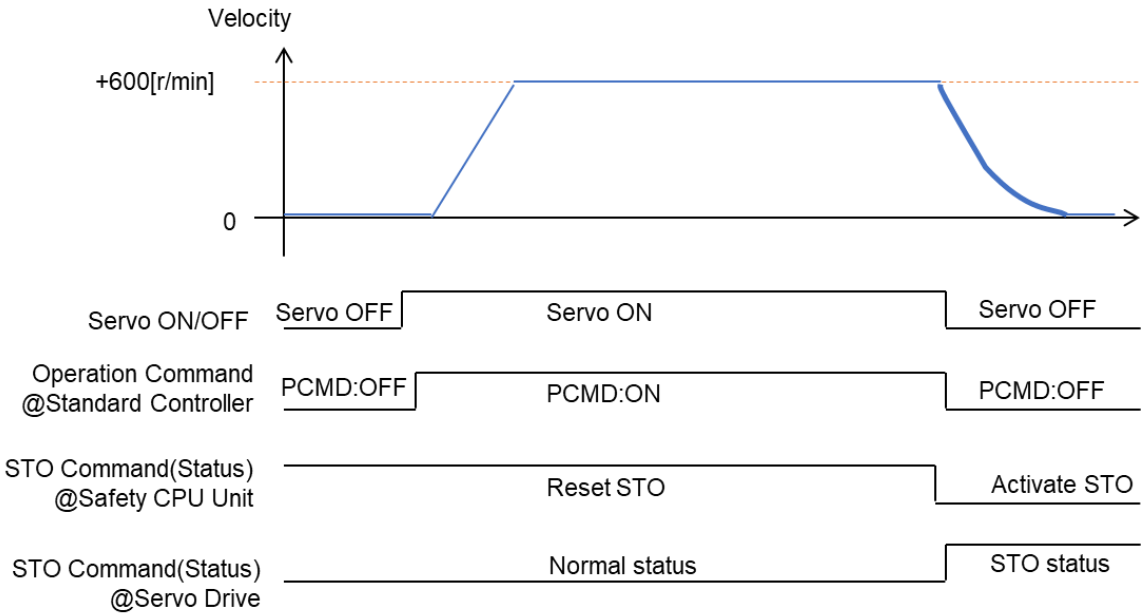
1. When the error clear button is pressed, the errors of the standard controller and Servo Drive are reset.
2. When the guard with the Safety-door Switch is opened, the motor torque is turned OFF.
3. When the Emergency Stop Pushbutton Switch is pressed, the motor torque is turned OFF.
4. When the safety 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-door Switch	Open	Enable STO command
	Close	Disable STO command
3. Emergency Stop Pushbutton Switch	ON	Enable STO command
	OFF	Disable STO command
4. 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 600 r/min.

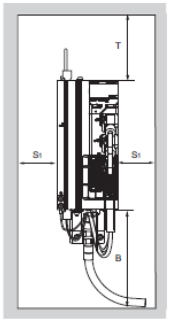


3.1. Installation and Wiring

■ Space Conditions around Servo Drives

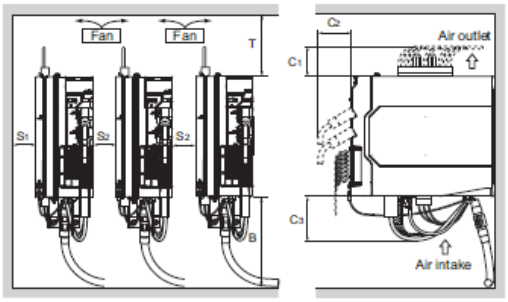
Install the Servo Drive according to the following instructions.

● Single-unit Installation



Front view　　Side view

● Side-by-side Installation

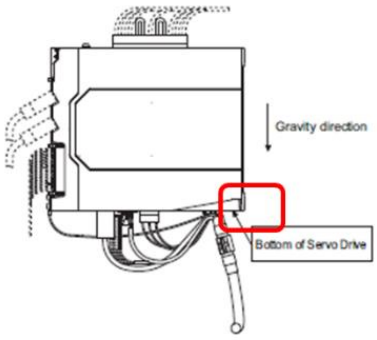
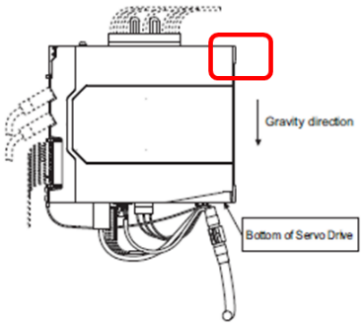
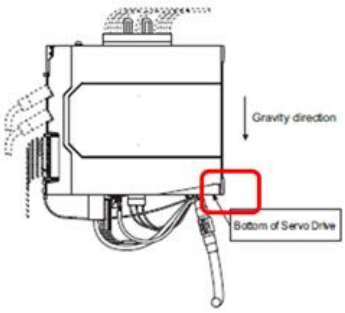
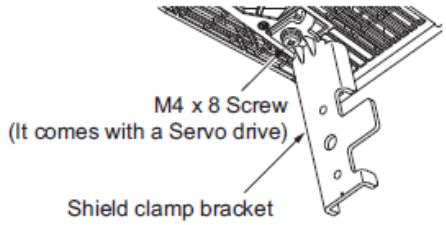


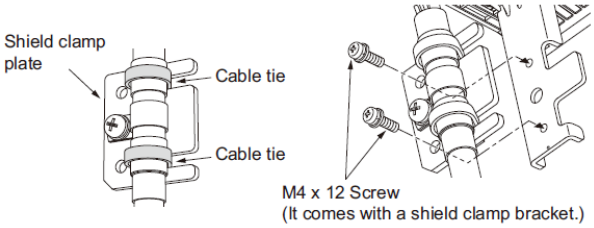
Front view　　Side view

Dimension	Distance	
T	100 mm min.	
B	R88D-1SAN02H-ECT/-1SAN04H-ECT/-1SAN08H-ECT	150 mm min.
	R88D-1SAN10H-ECT/-1SAN15H-ECT/-1SAN20H-ECT/-1SAN30H-ECT/ -1SAN10F-ECT/-1SAN15F-ECT/-1SAN20F-ECT/-1SAN30F-ECT	180 mm min.
S_1	40 mm min.	
S_2	10 mm min.	
C_1	R88D-1SAN02H-ECT/-1SAN04H-ECT/-1SAN08H-ECT/-1SAN10H-ECT	45 mm min.
	R88D-1SAN15H-ECT/-1SAN20H-ECT/-1SAN30H-ECT/-1SAN10F-ECT/ -1SAN15F-ECT/-1SAN20F-ECT/-1SAN30F-ECT	60 mm min.
C_2	50 mm min.	
C_3	80 mm min.	

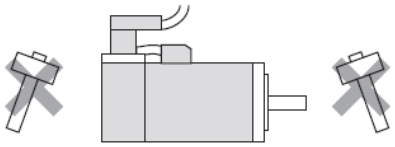
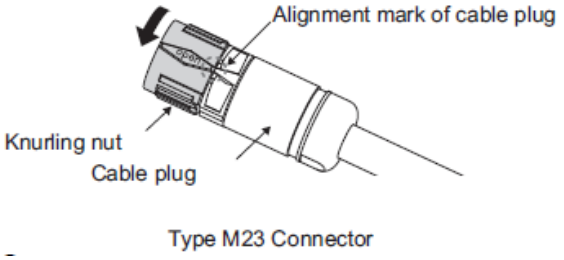
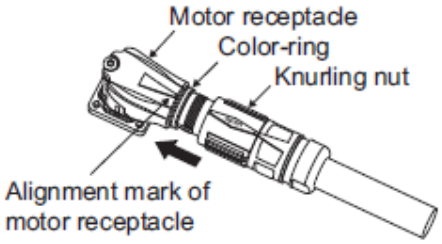
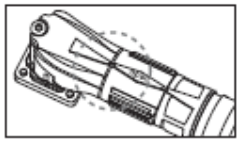
- Install the Servo Drive on the vertical metal surface.
- To provide electrical conduction, remove any paint from the surface on which you install the Servo Drives. Also, it is recommended that you apply conductive plating if you make the mounting bracket by yourself.
- The recommended tightening torque 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.
- You can install Servo Drives without the clearance of S_2 if the operating ambient temperature is from 0 to 45°C.
- When mounting the shield clamp, use the threads included in the Servo Drive or specified standard threads.
- Before installing the Servo Drive on the control panel, mount the shield clamp to the Servo Drive. Then connect the cable and fix the cable to the shield clamp.
- When you connect PC to the USB connector of the Servo Drive, separate the USB cable from other cables such as the main circuit power supply cable.

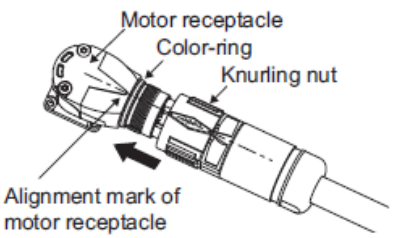
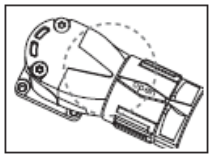
■ **Mounting the Servo Drive**

1.	**Put the Servo Drive in place and secure the top first and then the bottom.** Temporarily tighten the screw to attach the lower part of the Servo Drive and slide the Servo Drive from top to bottom to put the U-groove of the Servo Drive on the screw. 
2.	**Tighten the screw at the upper part.** 
3.	**Tighten the screw at the lower part.** 
4.	**Mount a shield clamp bracket to the Servo Drive.** Tightening torque: 1.5 N•m 

5.	**Mount the shield clamp plate to the shield clamp bracket.** Tightening torque: 1.5 N•m • Do not cut cable ties. 

■ **Mounting the Servomotor** (The order of step 2 and step 3 depends on your mechanical implementation.)

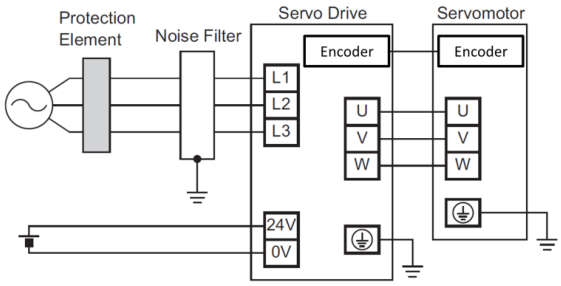
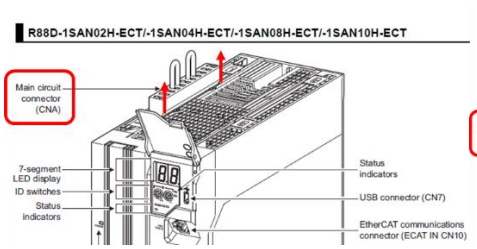
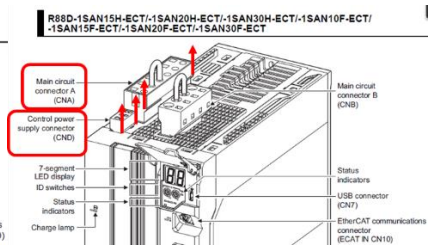
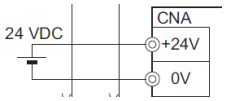
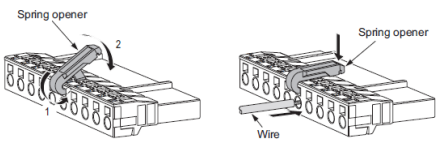
1.	**Handle the Servomotor carefully and do not apply heavy impacts or loads during transport, installation, or removal of the Servomotor.** 
2.	**Fix and connect the Servomotor to the mechanical system.** First, check motor operation without any load.
3.	**Connect the integrated cable.** Turn the knurling nut of a cable plug to counterclockwise direction.  Type M23 Connector Align a mark of the motor receptacle with the printed “open” on the knurling nut. Insert the knurling nut into the receptacle as far as it goes. • Type M17 Connector   State of a knurling nut inserted to a motor receptacle firmly

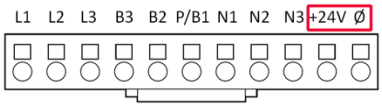
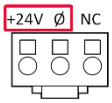
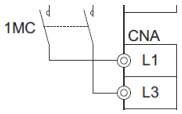
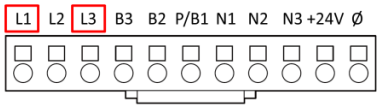
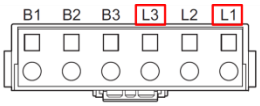
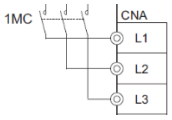
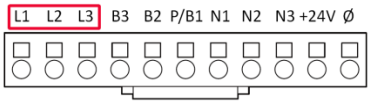
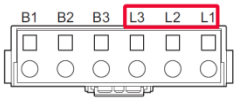
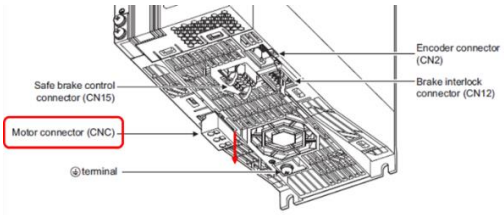
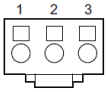
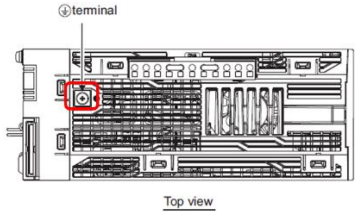
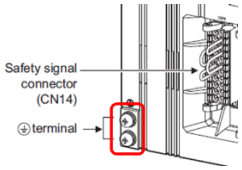
	• Type M23 Connector   State of a knurling nut inserted to a motor receptacle firmly Turn the knurling nut to clockwise direction until it stops.

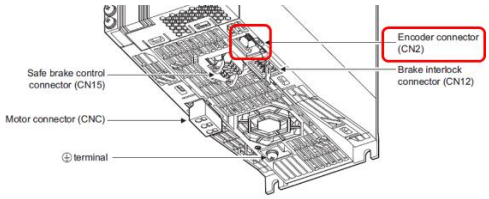
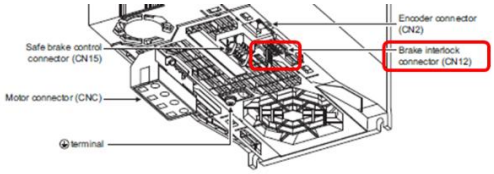
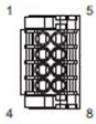
Additional Information

For further details on how to mount the Servomotor, refer to the *1S-series AC Servomotors/Servo Drives with Built-in EtherCAT Communications and Safety Functionality User's Manual* (Cat. No. I621).

■ Wiring

1.	**Overview** **■ Wiring Diagram** 
2.	**Remove the main circuit connector (CNA), or the main circuit connector A (CNA) and control power supply connector (CND) from the Servo Drive.** **200 V (up to 1 kW)** **200 V (1.5 - 3 kW) and 400 V (1 - 3 kW)**  
3.	**Wire the 24 V control power supply.**  **Connect wires with the spring opener.**  **Check the connector corresponding to your Servo Drive and AC power supply.**

	CNA for 200 V (up to 1 kW)  **CND for 200 V (1.5 - 3 kW) and 400 V (1 - 3 kW)** 
4.	**Wire the main circuit power supply.** **Check the connector corresponding to your Servo Drive and AC power supply.** **Single-phase** **200 V (up to 1 kW)** **200 V (1.5 kW)**    **3-phase** **200 V (up to 1 kW)** **200 V (1.5 - 3 kW) and 400 V (1 - 3 kW)**     **Example**: CNA for 200 V (up to 1 kW)
5.	**Remove the motor connector (CNC) from the Servo Drive.** 
6.	**Connect the power line to the phase U, V, and W of the Servomotor.** **Pin No.** **Name** 1 U 2 V 3 W 
7.	**Screw the PE wire of the main circuit power supply cable to the Servo Drive.** 
8.	**Plug back the above connectors to the Servo Drive. (Power and motor)**
9.	**Screw the FG wire of the motor cable to the Servo Drive.** 

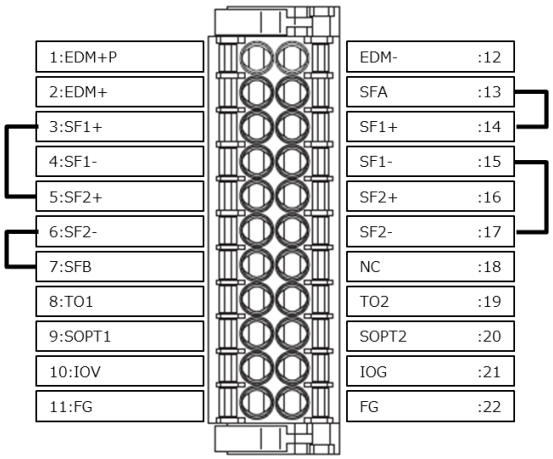
10.	**Plug the encoder cable into the Servo Drive. (CN2)** 
11.	**When you use a motor with a brake, plug the brake cable into the Servo Drive. (CN12)**  **Pin No. / Symbol / Signal name / Pin No. / Symbol / Signal name** 1 / SBC PS / 24-V power supply for SBC (+) / 5 / SBC CM / 24-V power supply for SBC (-) 2 / SBC PS / 24-V power supply for SBC (+) / 6 / SBC RFB / SBC relay feedback input 3 / S1+ / SBC1+ / 7 / S1- / SBC1- 4 / S2+ / SBC2+ / 8 / S2- / SBC2- ● Connector for CN15 (8 Pins) **Model / Manufacturer / Omron model** DFMC1,5/4-ST-3,5-LRBK / PHOENIX CONTACT / R88A-CN102S Applicable wire: AWG 24 to 16 (0.2 to 1.5 mm²) (Strip length of the wire insulating cover: 10 mm) 

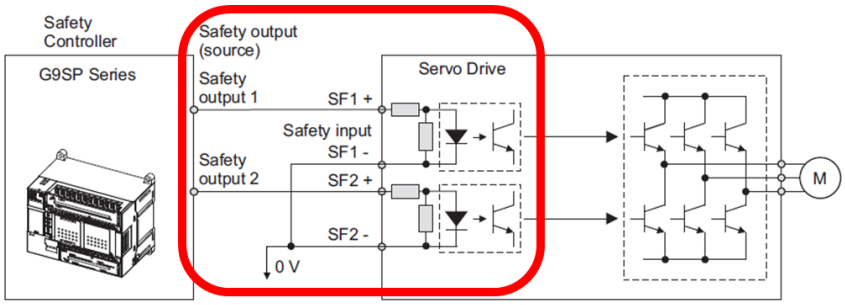
Additional Information

For further details on wiring, refer to the *1S-series AC Servomotors/Servo Drives with Built-in EtherCAT Communications and Safety Functionality User's Manual* (Cat. No. I621).

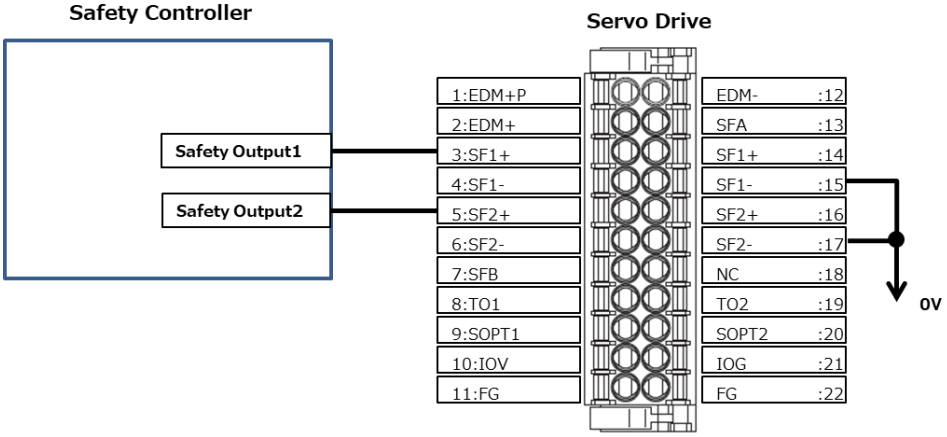
■ Safety Wiring

1.	**By default, hard-wired STO is disabled and bypassed with jumpers.**
2.	**When using hard-wired STO, make the wiring between the Safety CPU Unit and the Servo Drive as shown below.**

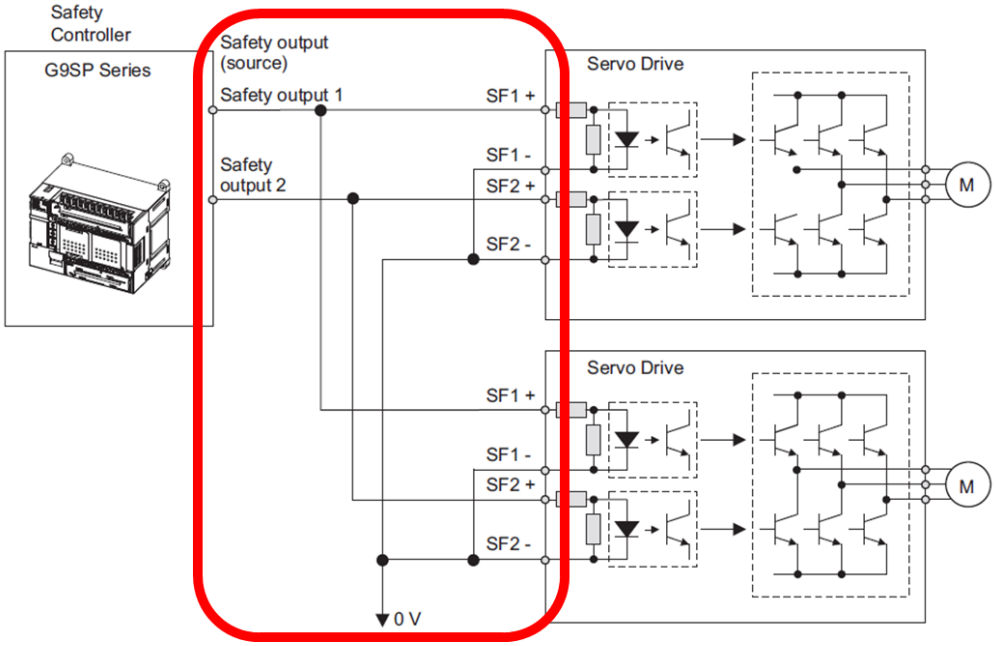


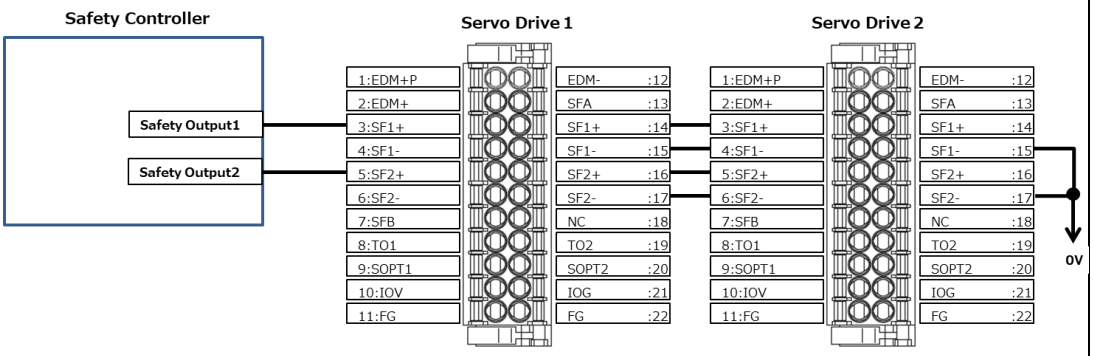


Wire SF1 and SF2 to different safety outputs.



3.	**When using hard-wired STO for multiple Servo Drives, make the wiring between the Safety CPU Unit and the Servo Drives as shown below.**



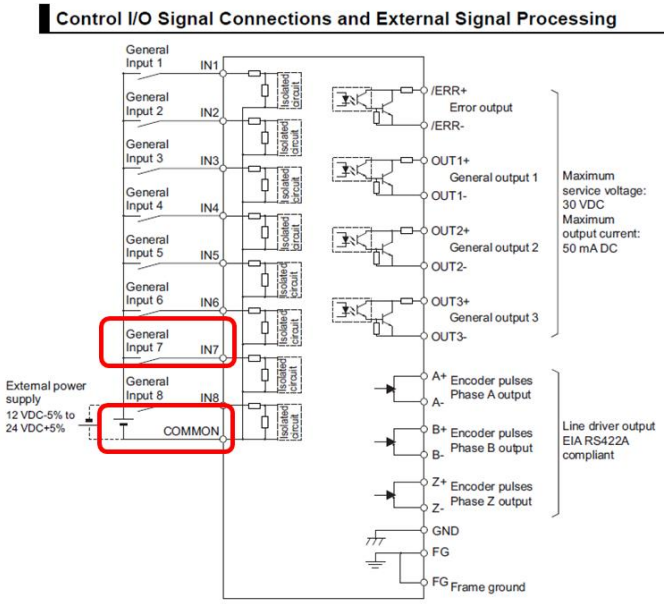


Note: When using a G9SP-series Safety Controller, you can connect up to four 1S-series Servo Drives.

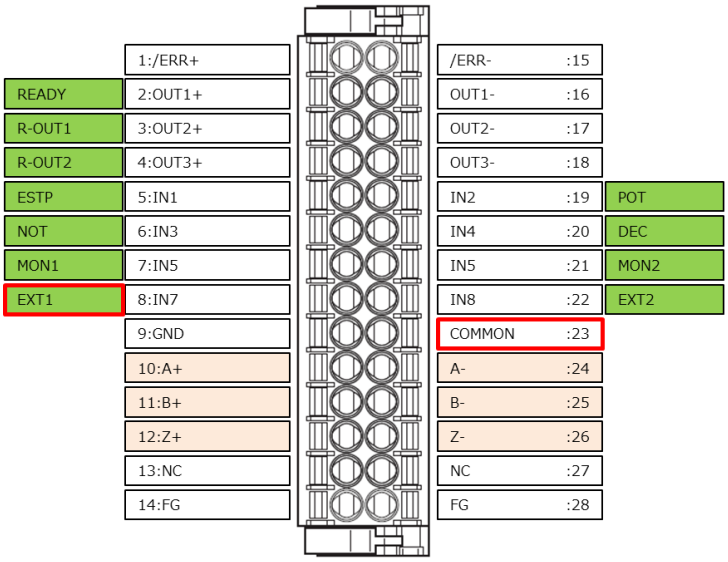
■ I/O Wiring

When using general-purpose I/O, make the wiring as shown below.

Example of Latch Input 1:



Servo Drive connector view:

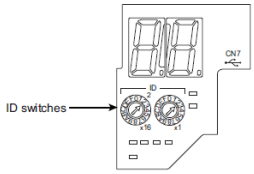
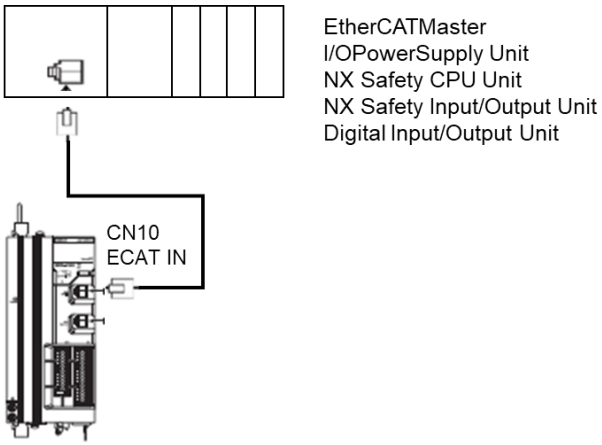


Additional Information

For further details on wiring, refer to the *1S-series AC Servomotors/Servo Drives with Built-in EtherCAT Communications and Safety Functionality User's Manual* (Cat. No. I621).

3.2. System Configuration with Standard and Safety Controllers

■ EtherCAT Node Address Configuration

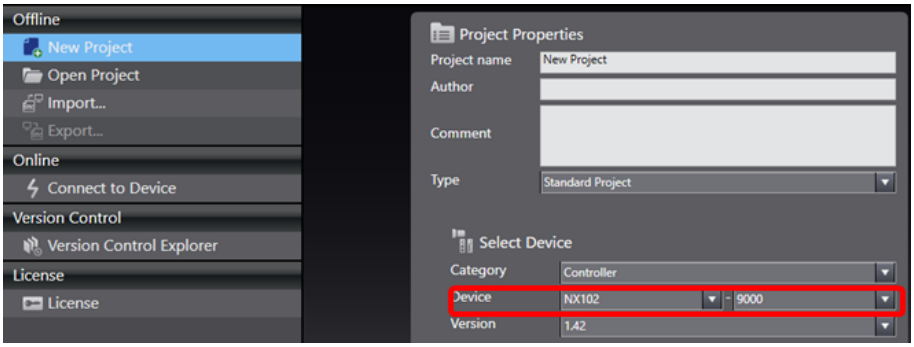
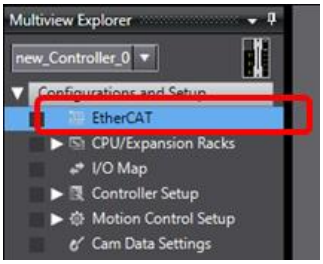
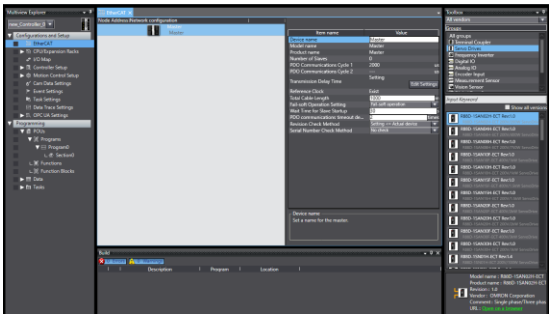
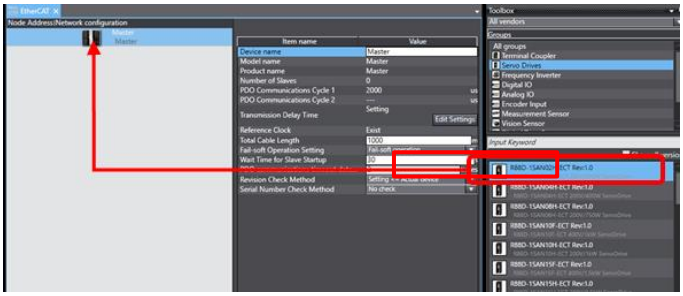
1.	**Use the ID switches to set the EtherCAT node address of the Servo Drive to 1.** 
2.	**Connect an EtherCAT communications cable to the device.** **ECAT IN CN10: EtherCAT cable from NX102 CPU Unit** 

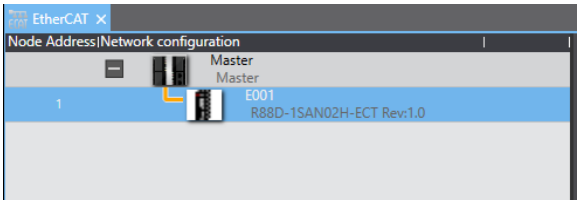
Additional Information

For further details on the Safety Control Unit, refer to the *NX-series Safety Control Unit User's Manual* (Cat. No. Z930).

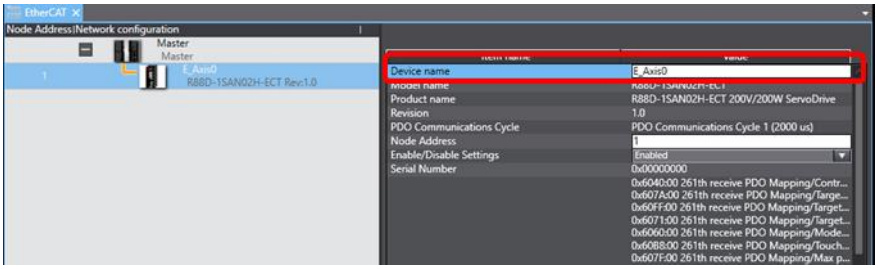
3.3. Sysmac Studio Project Creation

■ Creating a Network Configuration

1.	**Select the NX102-9000 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*.**



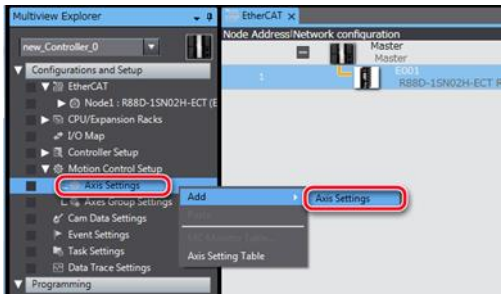
Additional Information

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.

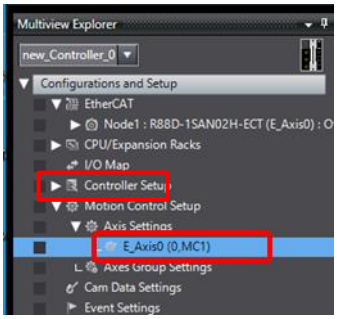
■ Setting an Axis

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.

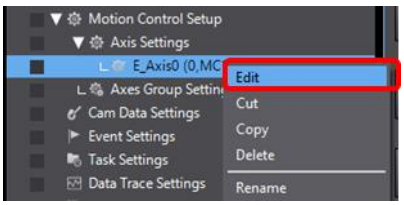
1. **Right-click *Axis Settings* in the Multiview Explorer and select *Add - Motion Control Axis* from the menu.**



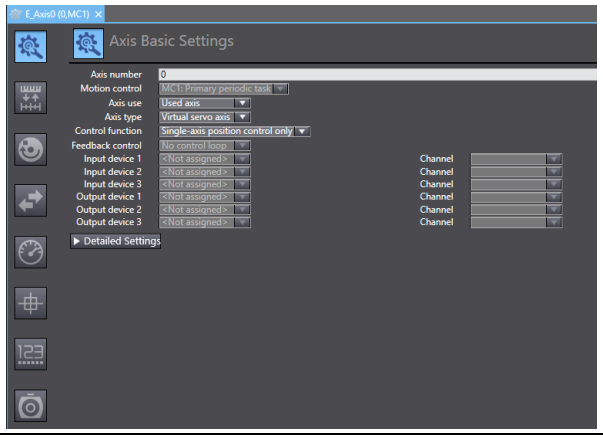
The axis *Axis0* is added to the Multiview Explorer.
This added axis is called the axis 0.



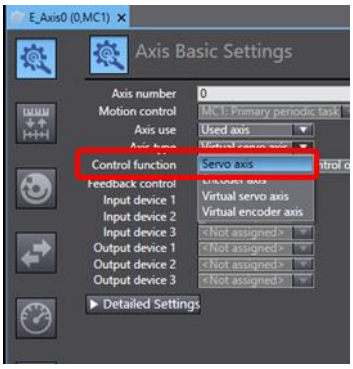
2. **Right-click *Axis0* (axis 0) in the Multiview Explorer and select *Edit* from the menu.**



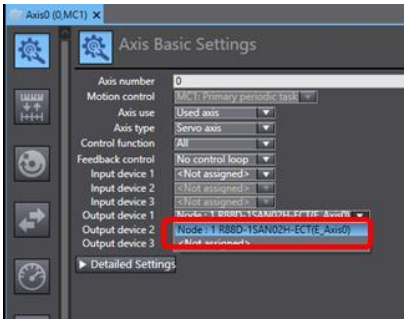
The Axis Basic Settings view is displayed on the Axis Parameter Settings Tab Page in the Edit Pane.



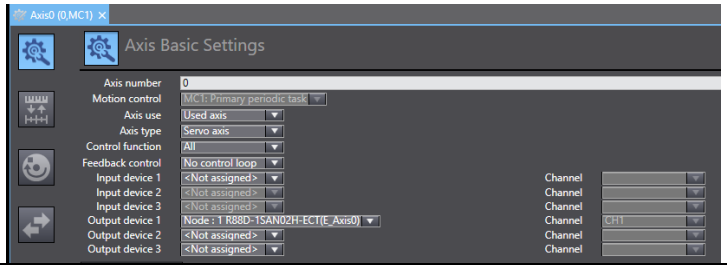
3. **Select *Servo axis* for the *Axis type* setting.**



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.



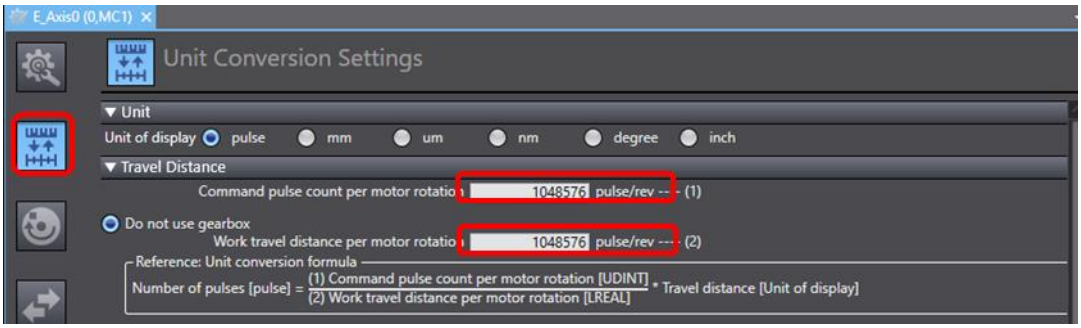
5. **Set the parameters on the Axis Parameter Settings Tab Page.**

The following figure shows the axis parameters for the unit conversion settings.

Unit of display: pulse

Command pulse count per motor rotation: 1,048,576 pulse/rev

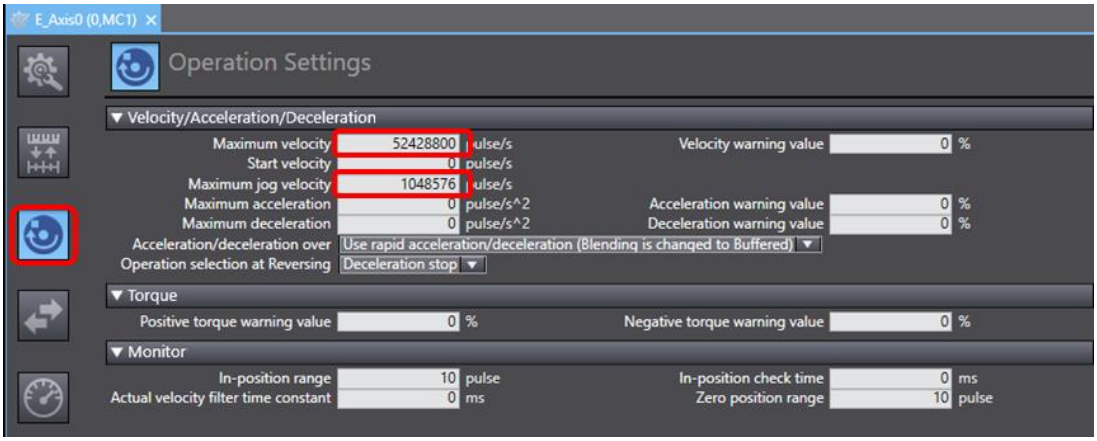
Work travel distance per motor rotation: 1,048,576 pulse/rev



6. **Operation Settings**

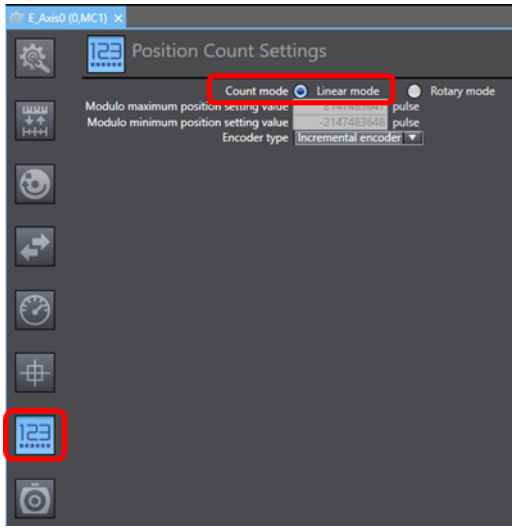
Maximum velocity: 52,428,800 pulse/s (3,000 r/min)

Maximum jog velocity: 1,048,576 pulse/s (60 r/min)

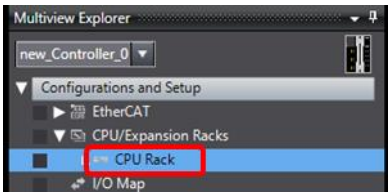
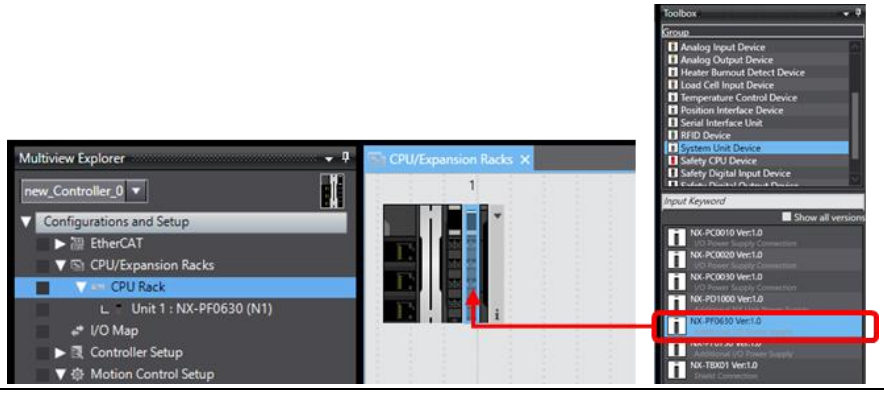
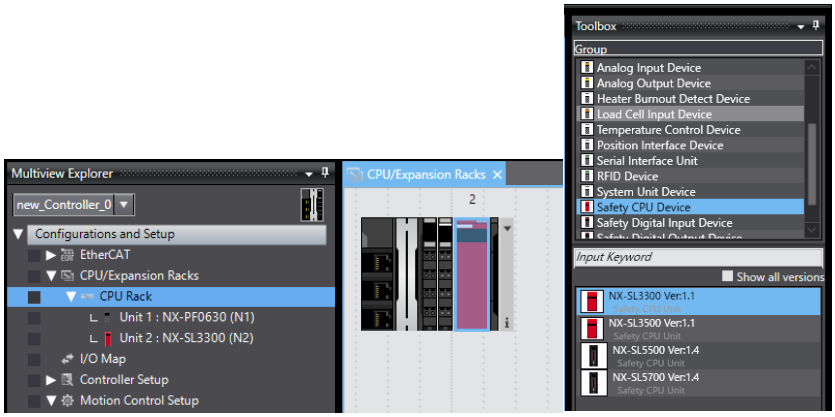


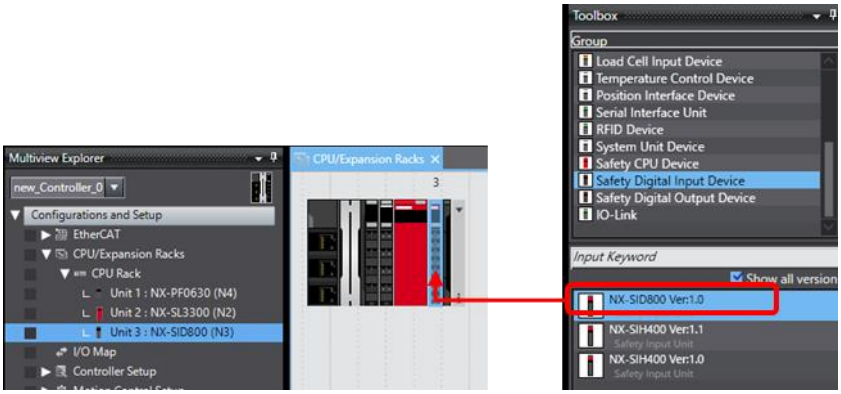
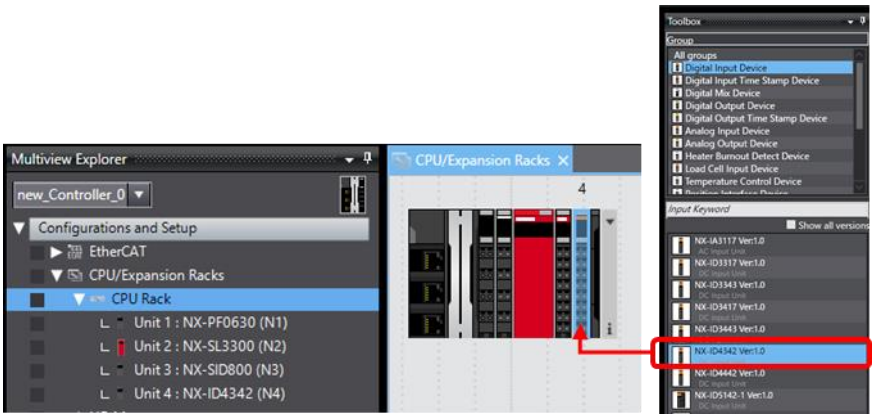
7. **Position Count Settings**

Count mode: Linear mode

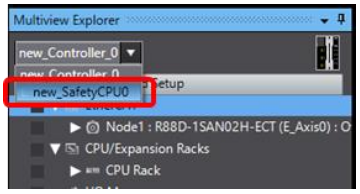
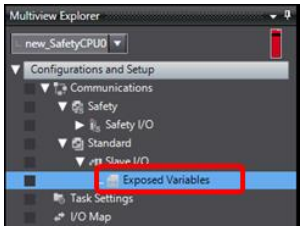


■ Setting the Network Configuration

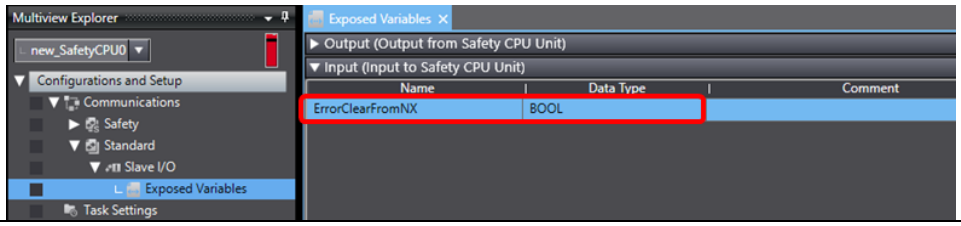
1.	**Double-click *CPU Rack*.** 
2.	**Drag a system unit device to the location where you want to add it in the CPU and Expansion Racks Tab Page.** In this example, drag the NX-PF0630 Additional I/O Power Supply Unit. 
3.	**Drag a safety CPU device to the location where you want to add it in the CPU and Expansion Racks Tab Page.** In this example, drag the NX-SL3300 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.**

■ **Setting to Transfer Data from the Standard Controller to the Safety Controller**

1.	**Select *new_SafetyCPU0* from the list.** 
2.	**Double-click *Exposed Variables*.** 

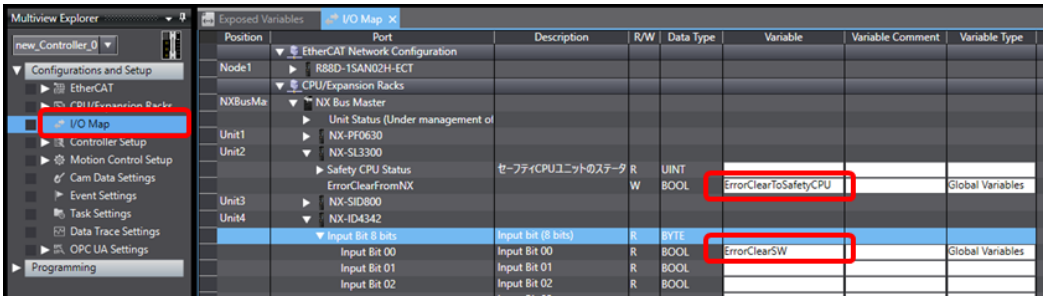
3. **Add the *ErrorClearFromNX* BOOL variable to Input (Input to the Safety CPU Unit).**



4. **Select *new_Controller_0* from the list.**

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

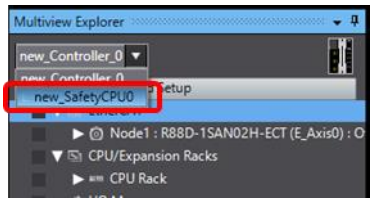
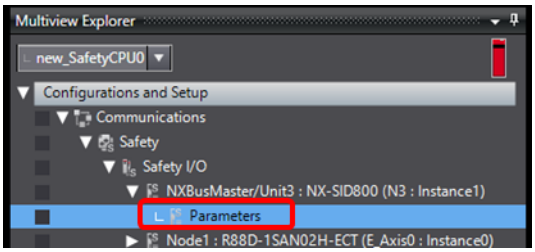
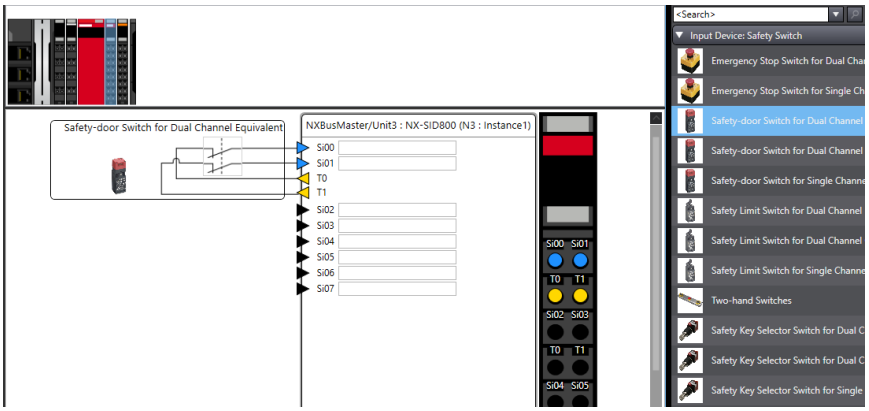
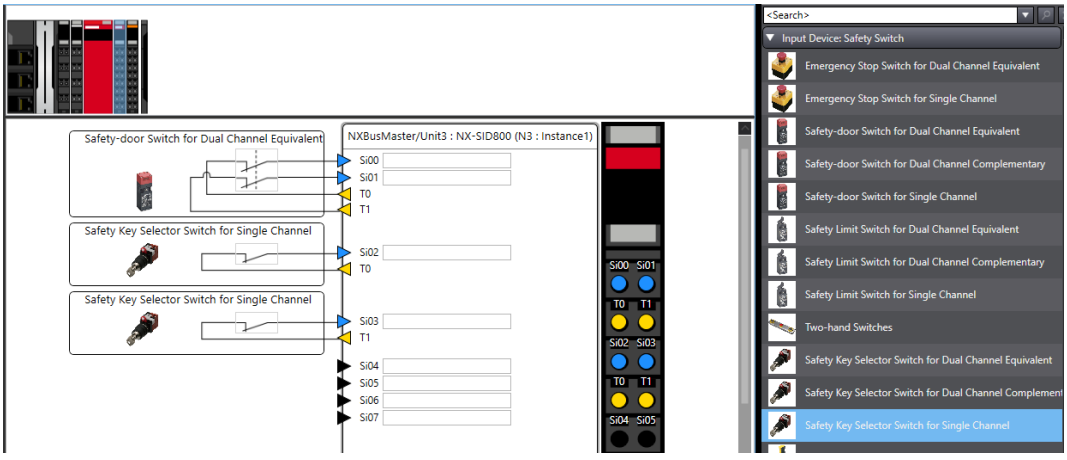
Port	Variable name
ErrorClearFromNX	ErrorClearToSafetyCPU
Input Bit 00	ErrorClearSW



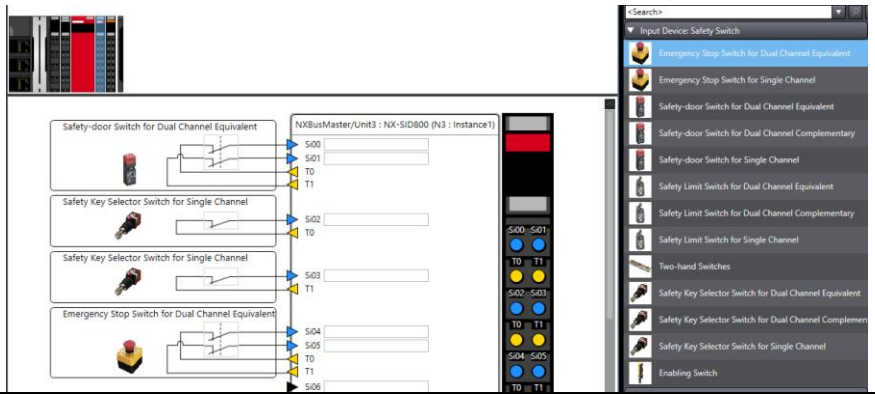
6. **Double-click *Section0* to create a ladder program that transfers *ErrorClearSW* to the safety controller.**

■ Setting the Safety Controller

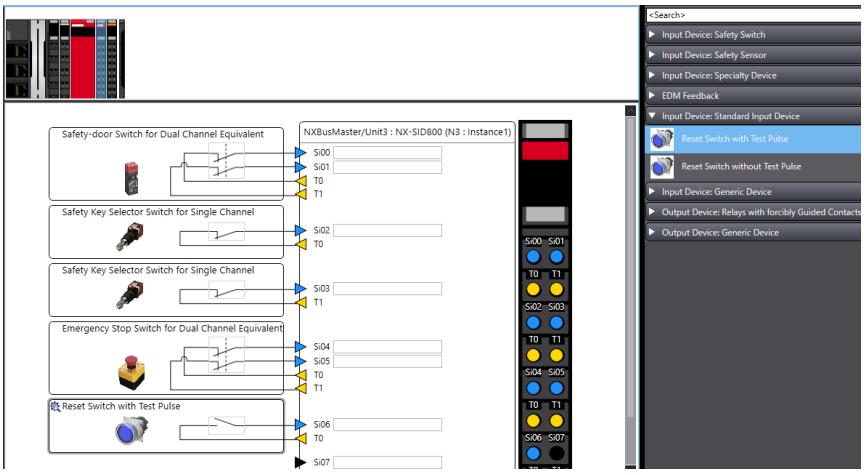
This section describes how to set safety input devices.

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.** 

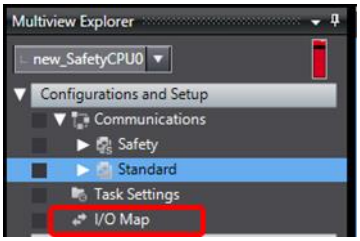
5. **Drag an emergency stop pushbutton switch to the desired I/O terminal.**



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

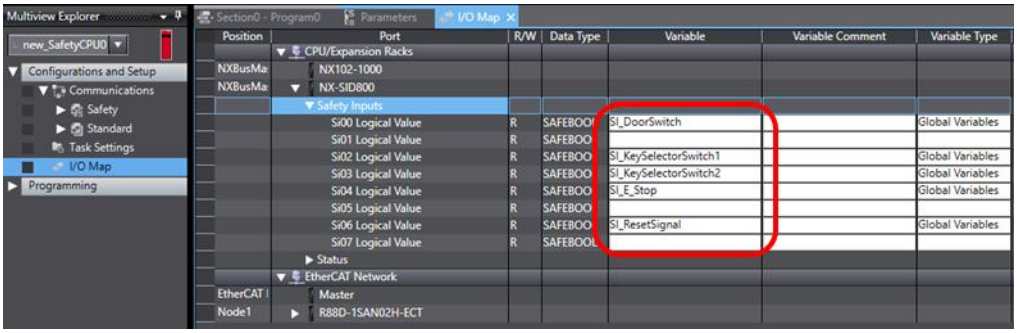


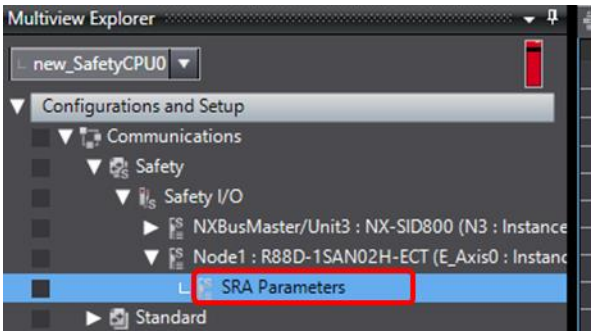
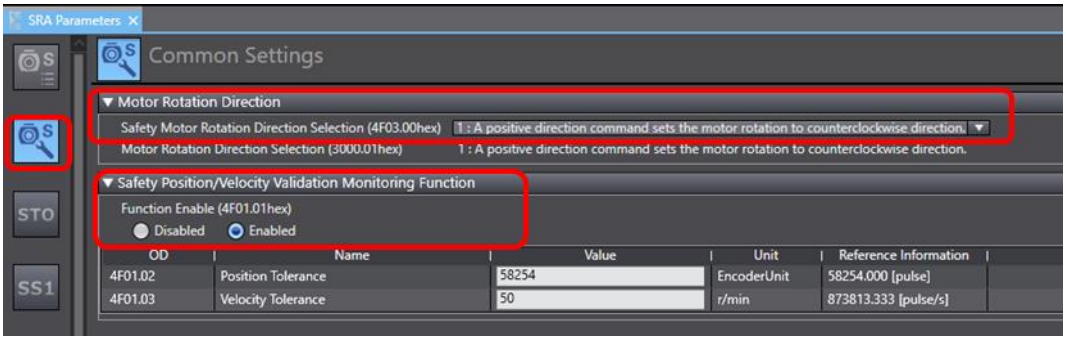
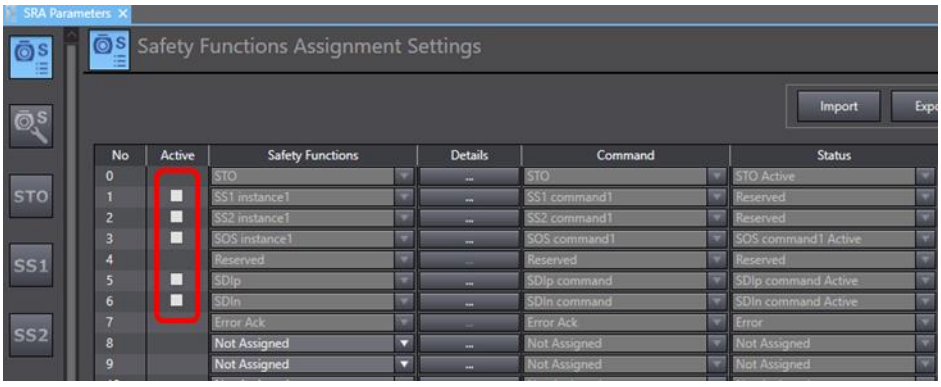
7. **Double-click *I/O Map*.**



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.	**Click the *Common Settings* Button and set the *Motor Rotation Direction* Field and the *Safety Position/Velocity Validation Monitoring Function* Field.** Set *Safety Motor Rotation Direction Selection (4F03.00hex)* and *Motor Rotation Direction Selection (3000.01hex)* to the same value. Make sure that *Safety Position/Velocity Validation Monitoring Function* is set to *Enabled*. 
11.	**Deactivate safety functions except for the STO function.** Clear the selections of the *Active* Check Boxes for SS1 instance1, SS2 instance1, SOS instance1, SDIp, and SDIn to deactivate the unused safety functions. 

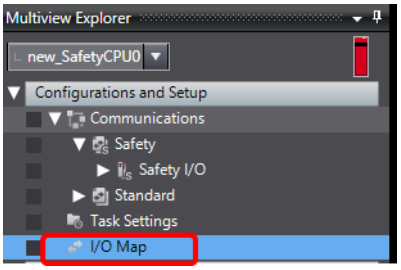
■ Creating a Safety Program

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.

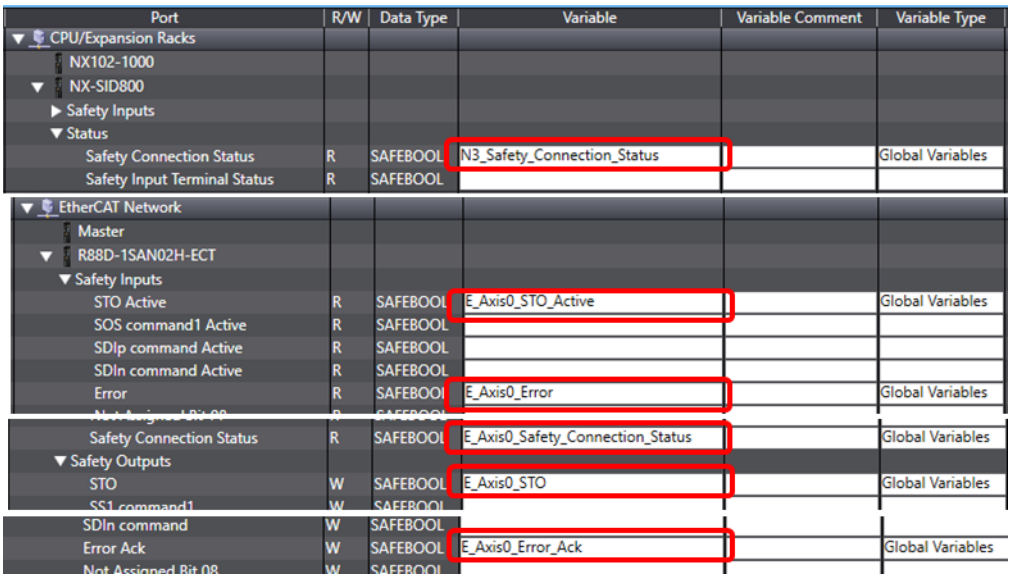
1. Create device variables.

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

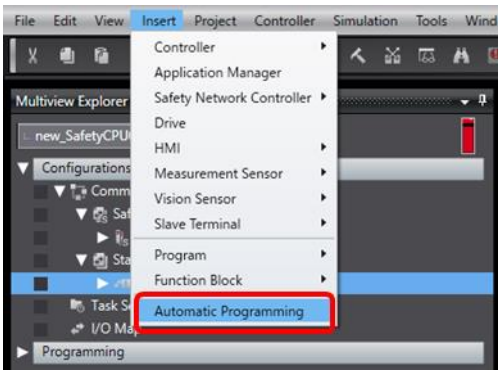
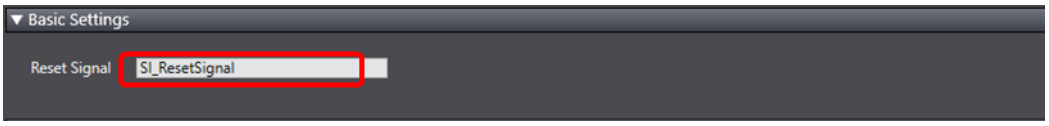
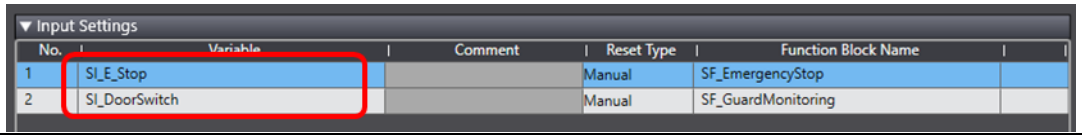
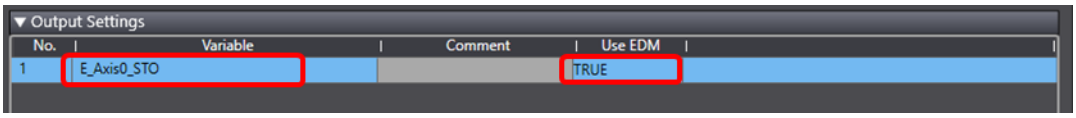
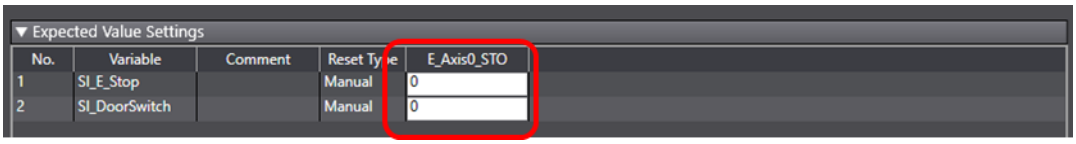
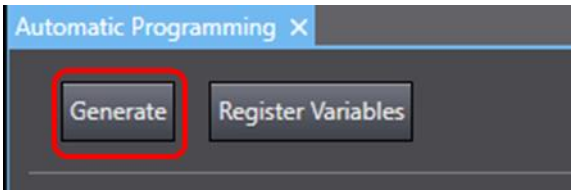
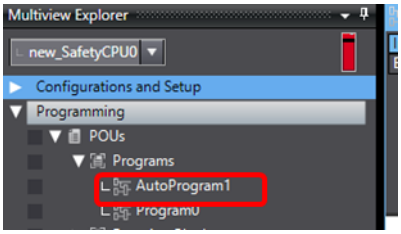


2. **Create device variables.**

Port	Variable name
Safety Connection Status for NX-SID800	**N3_Safety_Connection_Status**
STO Active for R88D-1SAN02H-ECT	**E_Axis0_STO_Active**
Error for R88D-1SAN02H-ECT	**E_Axis0_Error**
Safety Connection Status for R88D-1SAN02H-ECT	**E_Axis0_Safety_Connection_Status**
STO for R88D-1SAN02H-ECT	**E_Axis0_STO**
Error Ack for R88D-1SAN02H-ECT	**E_Axis0_Error_Ack**

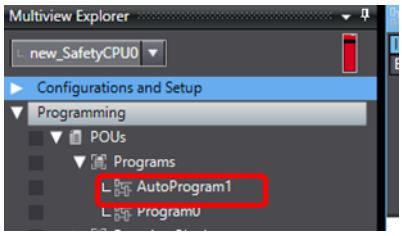


2. Create a safety program using the Automatic Programming function.

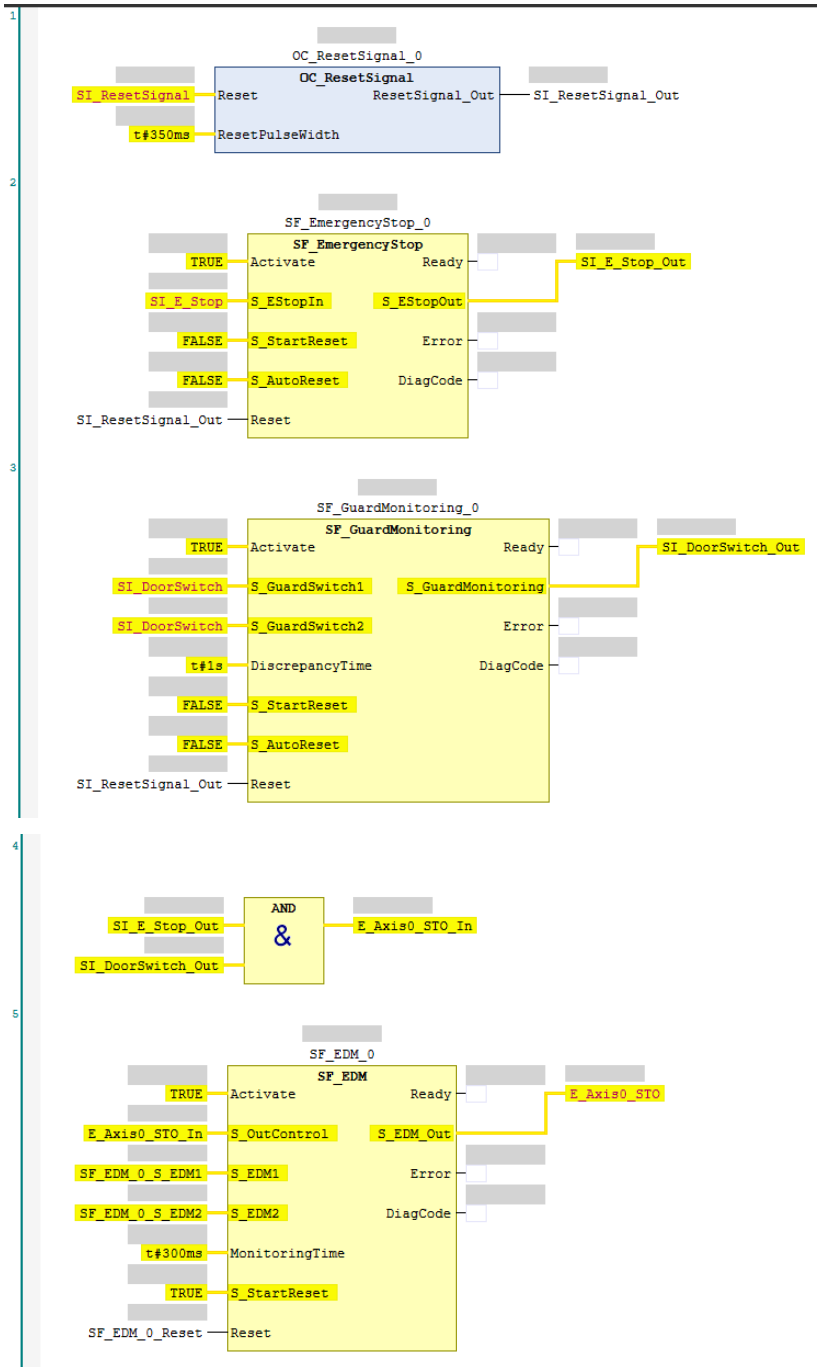
1.	**Click *Automatic Programming* from the Insert Menu.** 
2.	**Set the reset signal to *SI_ResetSignal* in the Basic Settings Field.** 
3.	**Set *SI_E-Stop* and *SI_DoorSwitch* in the Input Settings Field.** 
4.	**Set *E_Axis0_STO* in the Output Settings Field.** **Set the *Use EDM* Column to *TRUE*.** 
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.** 

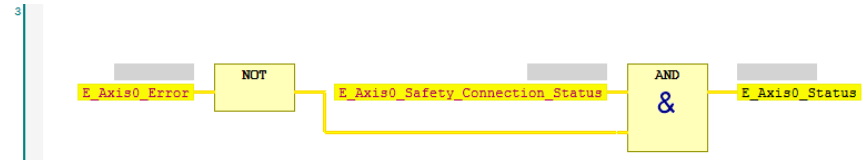
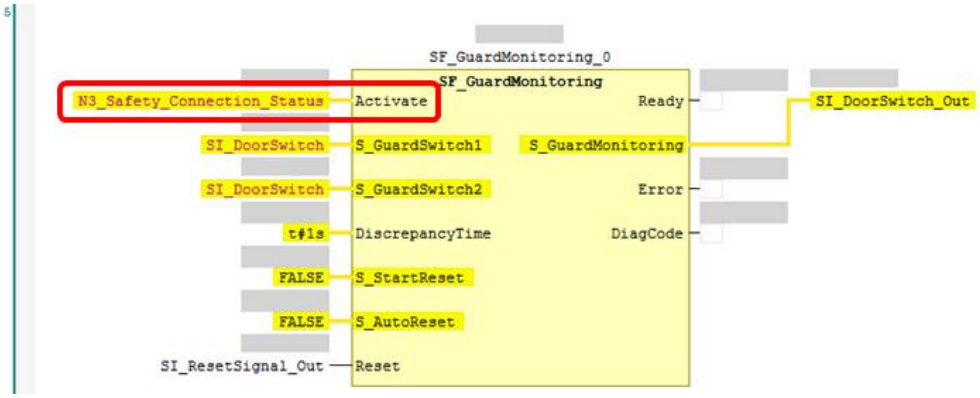
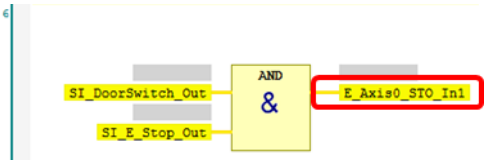
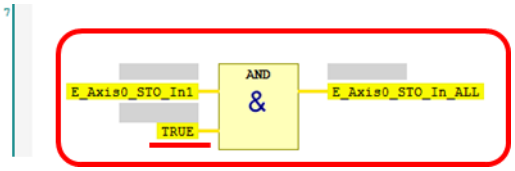
3. Modify the created safety program.

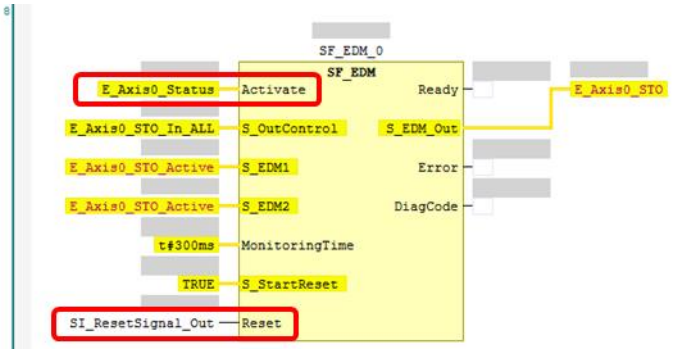
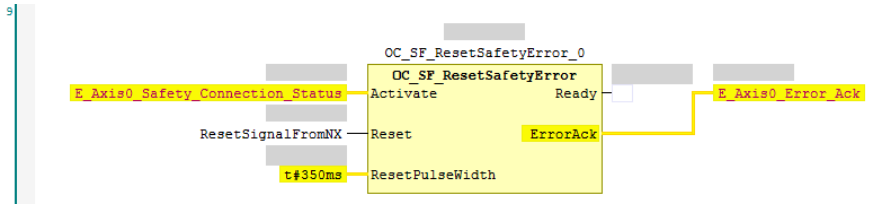
1. **Double-click *AutoProgram1*.**



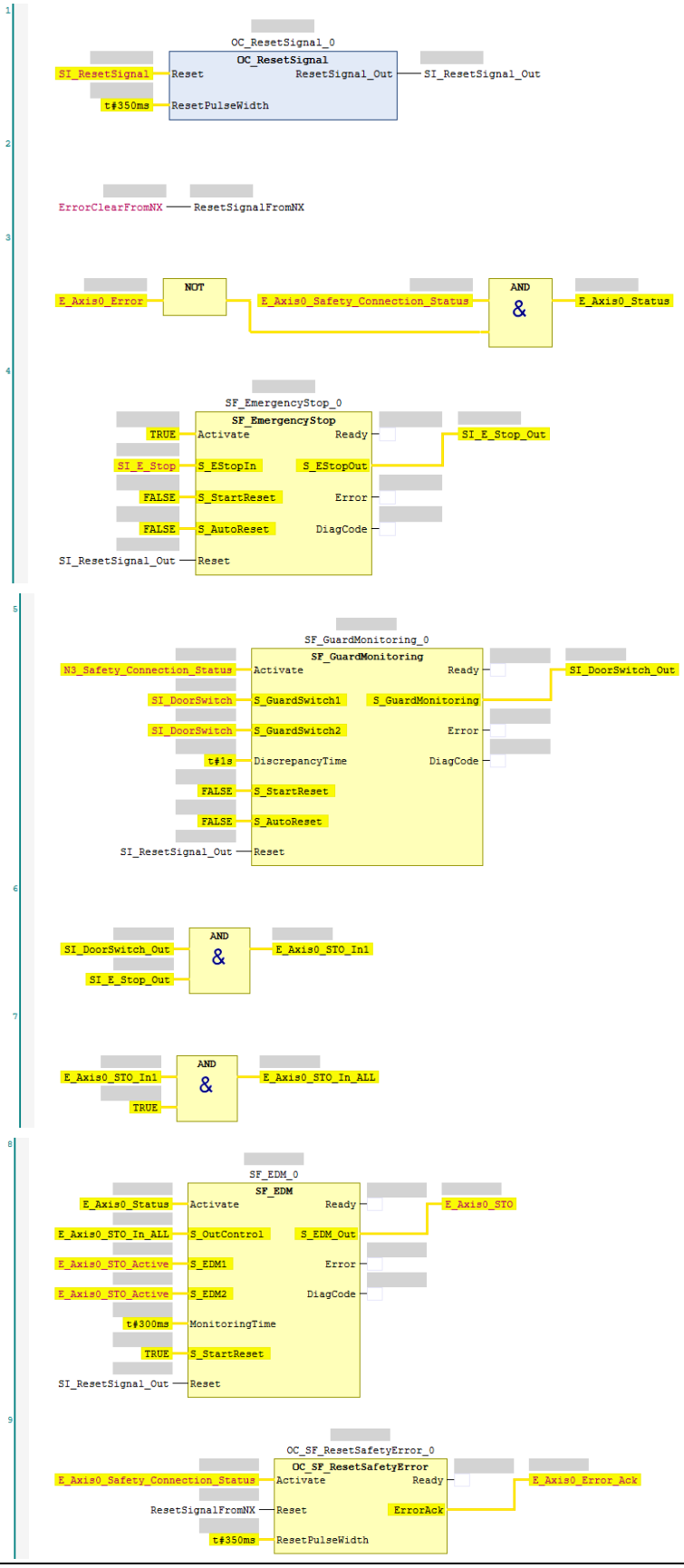
The program shown below appears.

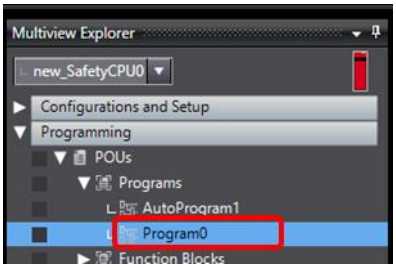
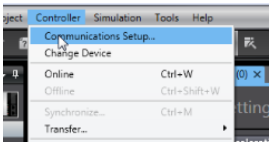
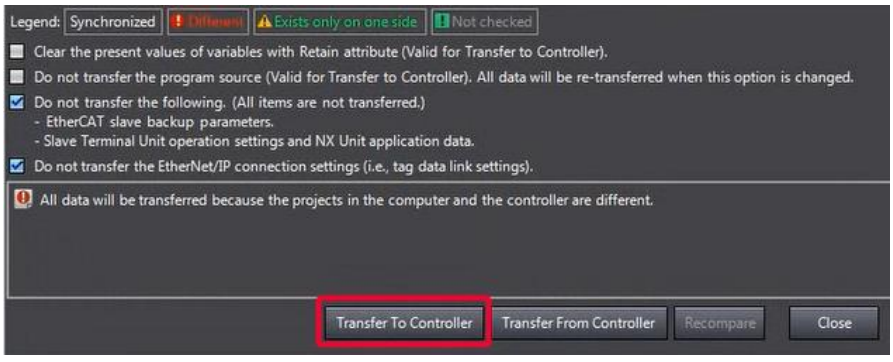


2.	**Add the code to assign *ErrorClearFromNX* to the *ResetSignalFromNX* local variable.** 
3.	**Add the following code.** This is used to enable the function block that uses safety functions of the Servo Drive. 
4.	**Set the input parameter to the *Activate* input variable to *N3_Safety_Connection_Status* 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* 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. 

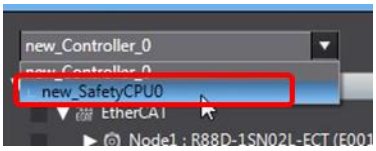
9. **Check that the created program is the same as shown below.**



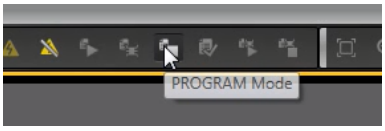
10.	**Delete *Program0*.** 
11.	**Connect to the standard controller.** Change the connection method  Test the connection.  Confirm that *Test OK* is displayed and connect to the standard controller. 
12.	**Transfer to the standard controller.** Click the **Synchronization** Button to synchronize with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

13. **Download the safety application.**

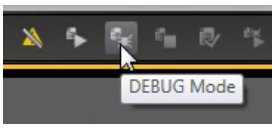
Select *new_SafetyCPU0* from the list.



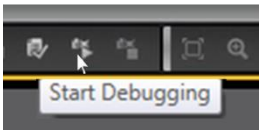
Click the **PROGRAM Mode** Button to switch to PROGRAM mode.



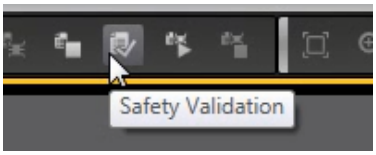
Click the **DEBUG Mode** Button to enter DEBUG mode.



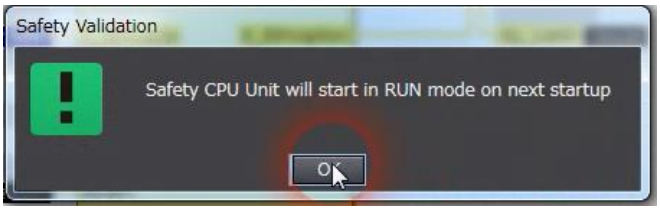
Click the **Start Debugging** Button to start DEBUG mode.



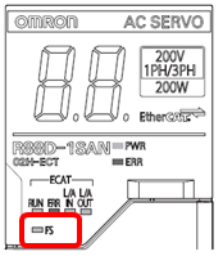
Click the **Safety Validation** Button.



The safety application is now ready to run.

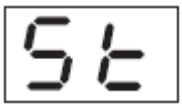
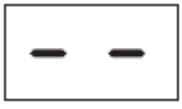


Click the **Run** Button.

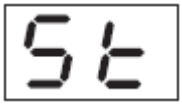
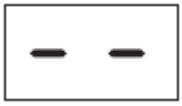
14.	**The FSoE communications are now established.** The FS indicator is lit in green.  FS | Displays FSoE communications status. | Green | ON | FSoE slave connection established Flashing | FSoE slave connection establishment in progress Red | Flashing | Safety Parameter Error, Safety Communications 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

■ Checking Operation of the STO Function

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

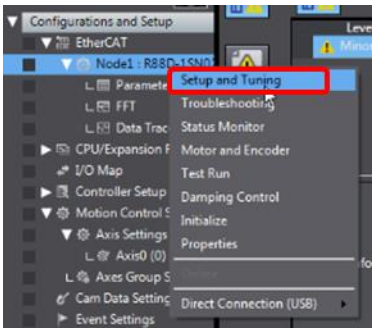
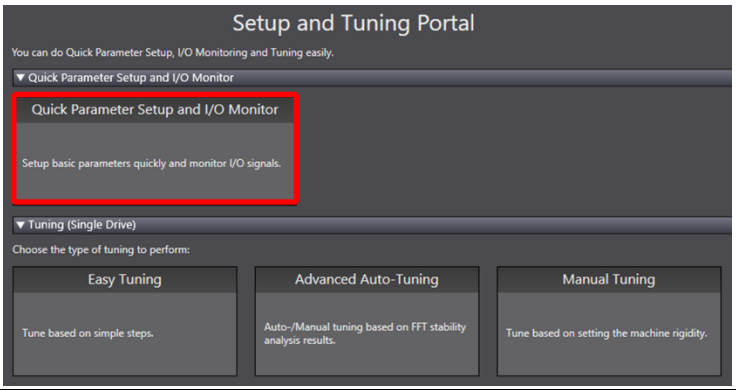
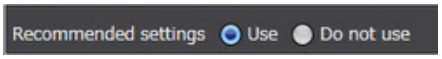
1.	**Press the safety rest button.** 
2.	**Press the Emergency Stop Pushbutton Switch.**  Check that the 7-segment LED display shows ‘st’. 
3.	**Release the Emergency Stop Pushbutton Switch and press the safety rest button.**  Check that STO is released and the 7-segment LED display shows ‘--’. 

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

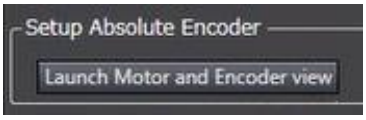
1.	**Press the safety rest button.** 
2.	**Open the guard with the Safety-door Switch.**  Check that the 7-segment LED display shows ‘st’. 
3.	**Close the guard and press the safety reset switch.**  Check that STO is released and the 7-segment LED display shows ‘--’. 

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 Sysmac 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.	**Selects the operating method for the absolute encoder.**  All 1S-series Servomotors have an absolute encoder, and it can be used as an incremental encoder if needed. When the Sysmac Controller is used, it is recommended to keep the default value (as described in step 3).

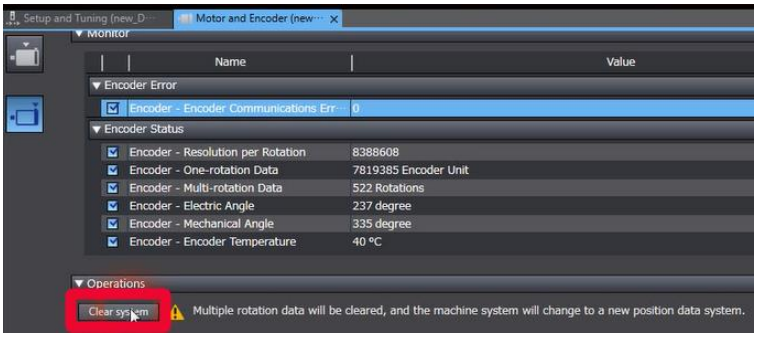
5. **Set up the absolute encoder (if required).**



Use this function when clearing the multiple rotation data or when replacing a Servomotor in the actual machine.

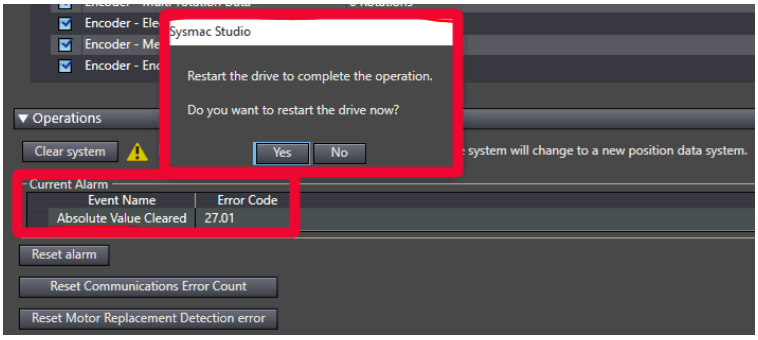
Resetting multiple rotation data

Click the **Clear system** Button.

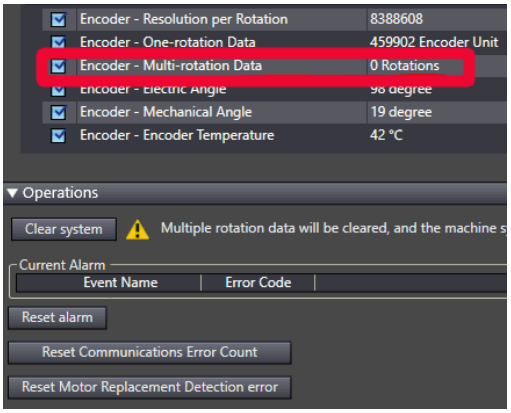


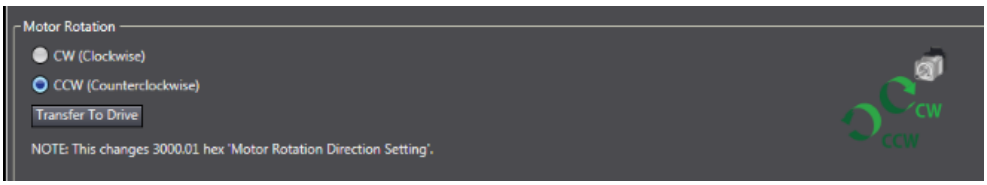
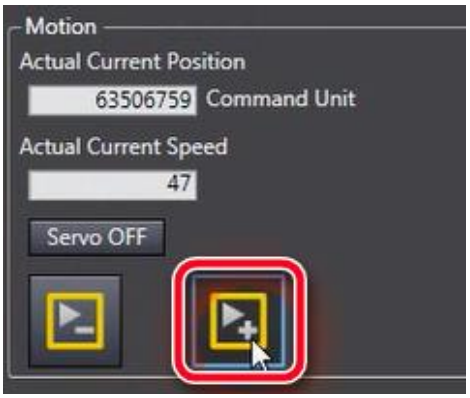
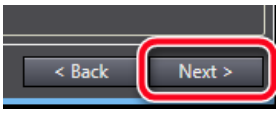
The following message appears: *Restart the drive to complete the operation.*

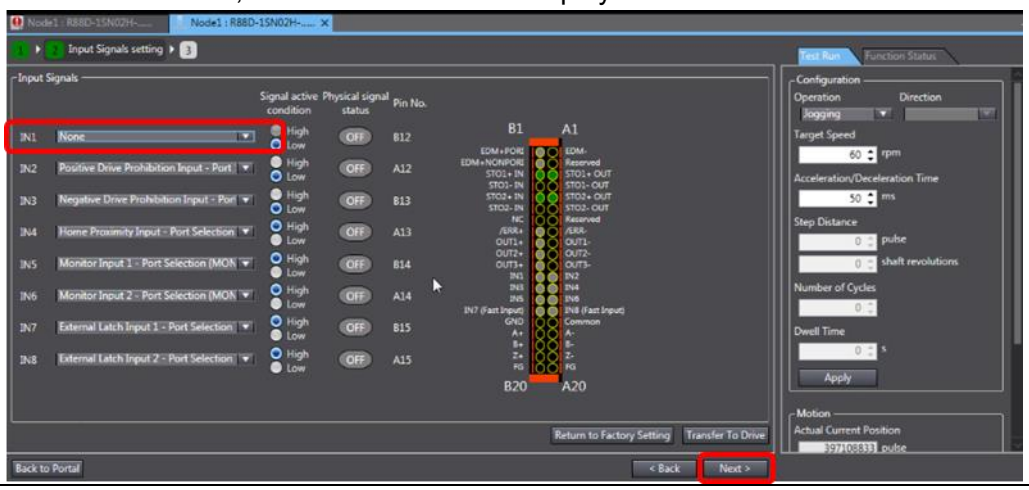
Click the **Yes** Button.



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.

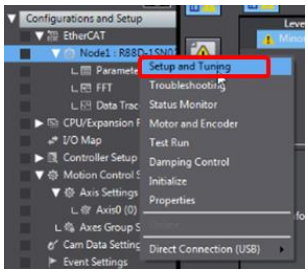
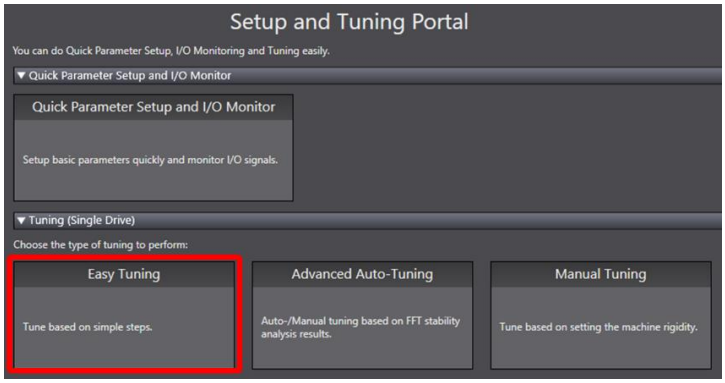
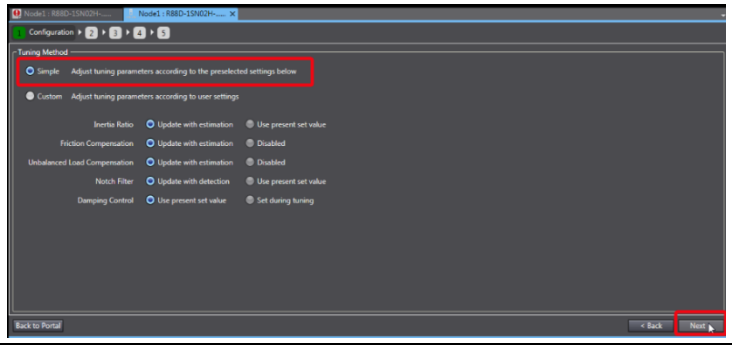
8.	**Set input signals and transfer the settings to the Servo Drive. Perform a test run to confirm that the settings are correct.** The Error Stop Input (ESTP) is ON by default. Turn it OFF as follows if necessary. When ESTP is ON, the Error No. 87.00 is displayed on the Servo Drive. 
9.	**Set output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

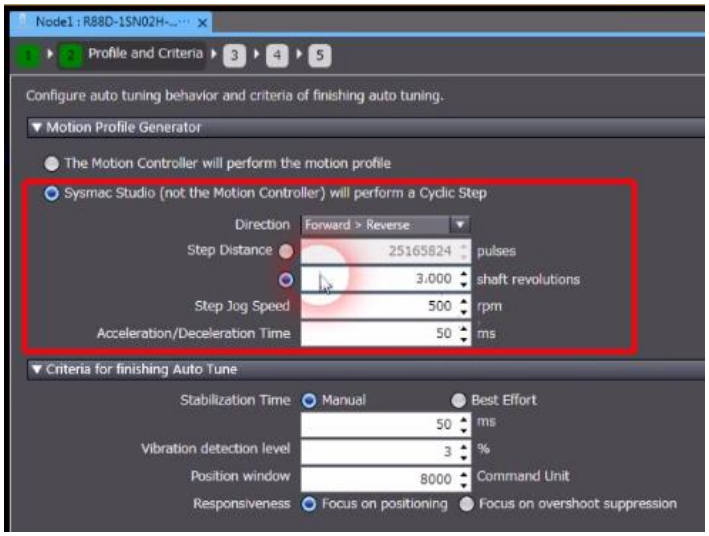
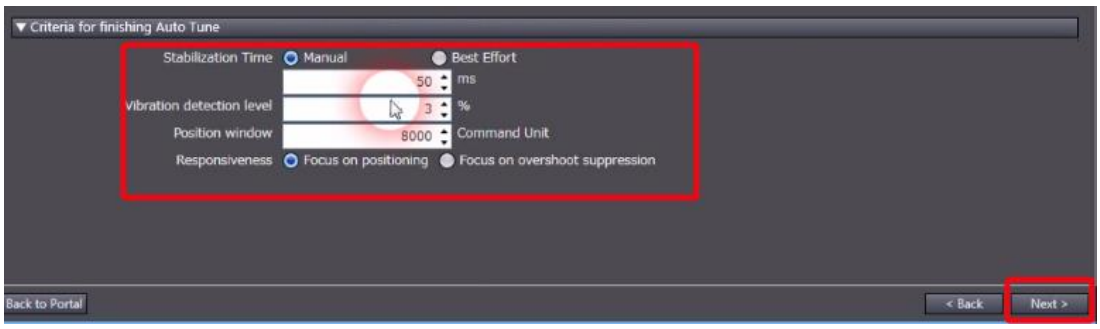
3.5. Gain tuning

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

■ Easy Tuning

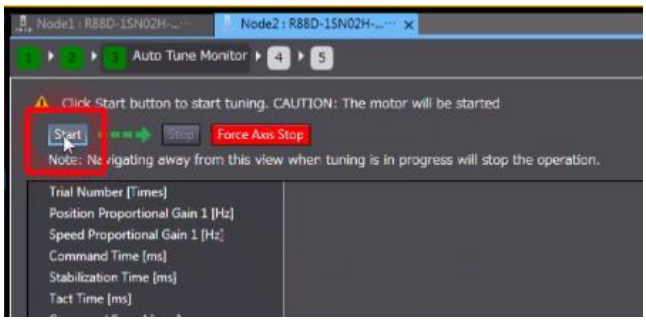
This function adjusts the gain automatically while the Servomotor is actually operated based on commands from the Controller or operation conditions that are set on the Sysmac Studio. It is possible to select the single drive or multiple drives tuning method. In the system with the synchronized axes, 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.** 

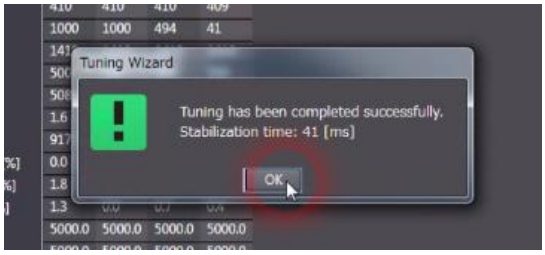
4.	**Profile and Criteria** Set the motion profile generator. 
5.	**Set the criteria for finishing auto tuning.** Click the **Next** Button.  • When you select *Manual* for stabilization time, gain will be increased gradually until the stabilization time reaches the specified time. Specify the following 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.**

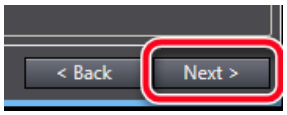
Be careful because the Servomotor will start running.



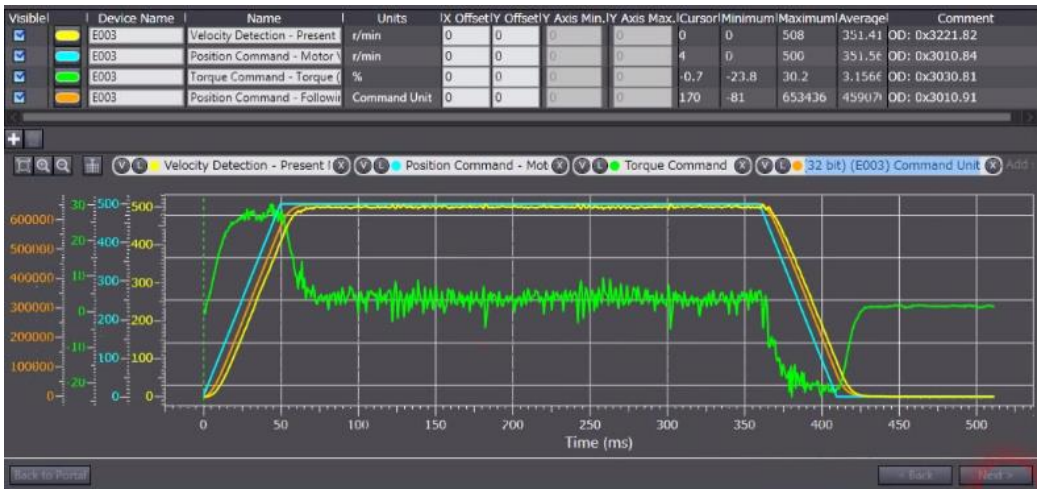
Easy Tuning has been completed.



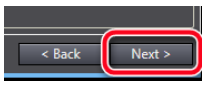
Click the **Next** Button.

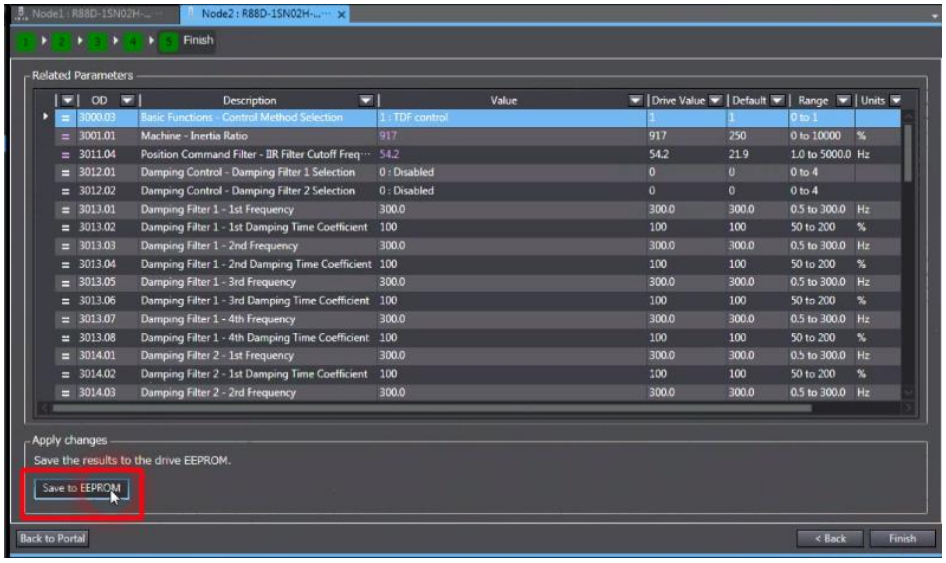
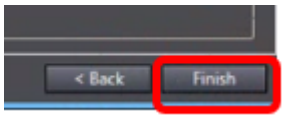


7. **Click the *Start Trace* Button. The Servomotor will run, and the traced data will be displayed in the graph area.**



Click the **Next** Button.

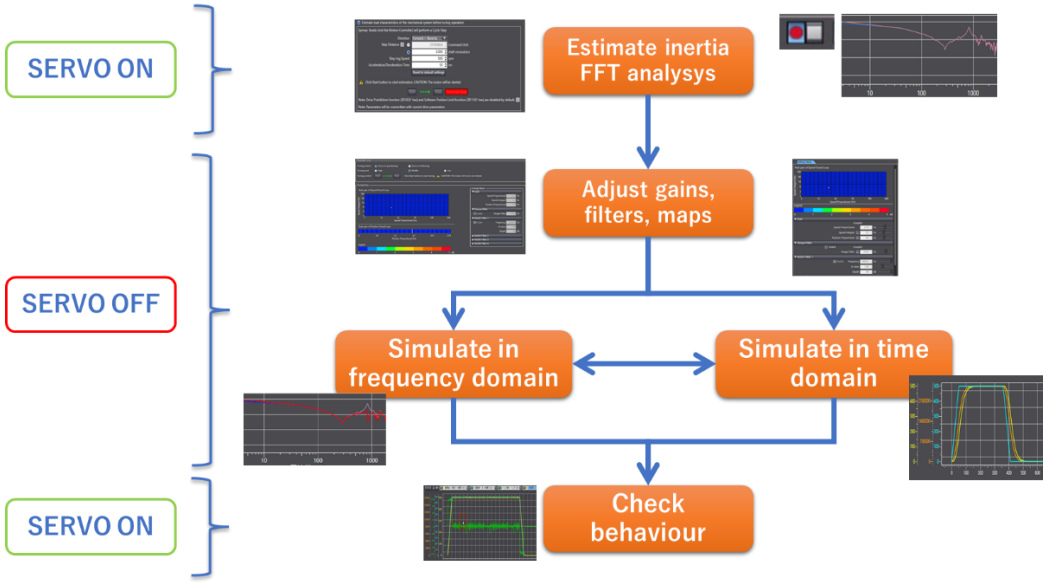
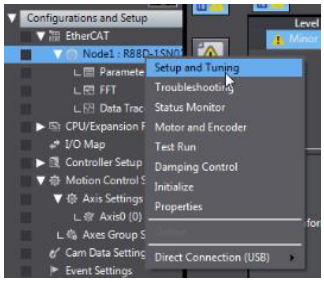
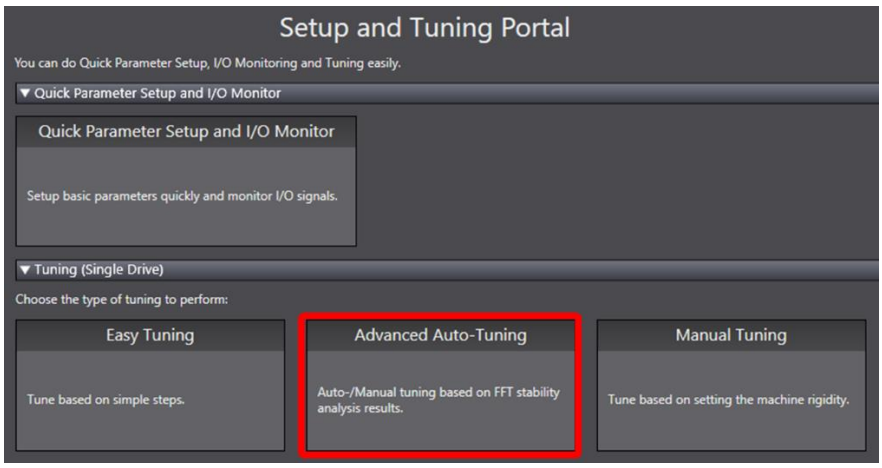


8.	**Check the tuning results of the gain parameters.** **Click the *Save to EEPROM* Button to save the gain parameters.**  Click the **Finish** Button. 

■ Advanced Auto-Tuning

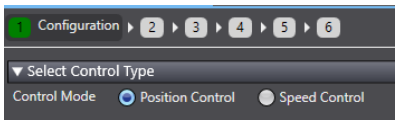
This function uses FFT measurement data-based simulation to adjust the gain and filter settings automatically. Repeating actual Servomotor operation is not necessary, and a fine adjustment is possible in a short period of time.

■ How to Perform Advanced Auto-Tuning

	Overview  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** 

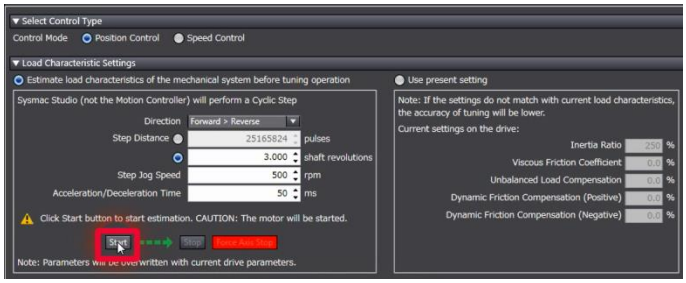
3. **<u>Configuration</u> (Wizard Step 1)**

Please select your control mode

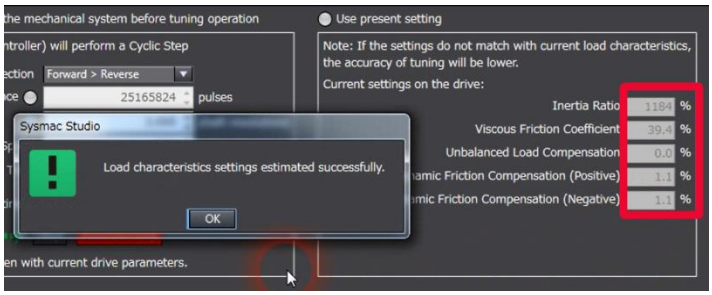


Please estimate the load characteristics by pushing start (the motor will move)

If Easy Tuning has been performed already, please select “use present setting”



Load characteristics have been updated



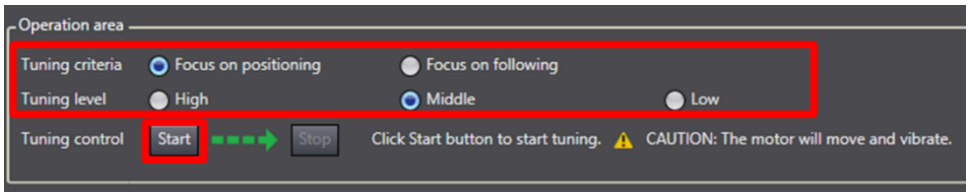
Click Next

4. **<u>Advanced Auto-Tuning</u> (Wizard Step 2)**

Set the tuning finish criteria and the tuning level.

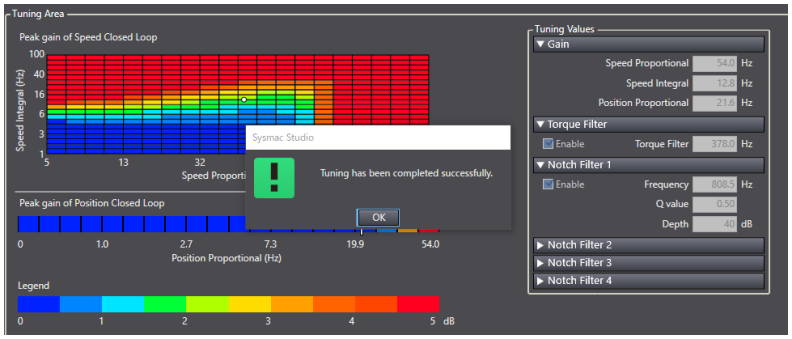
Click Start to start auto tuning.

(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.

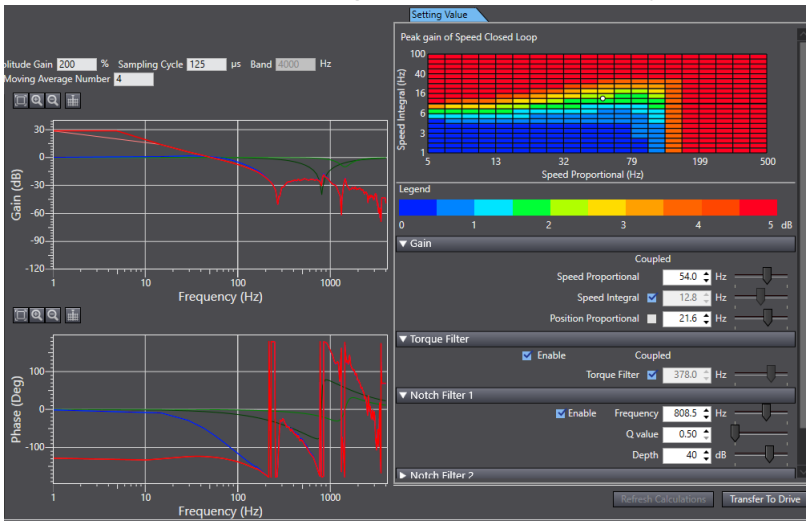
Advanced Auto-Tuning has been completed.



Click Next

5. **<u>Frequency response simulation</u> (Wizard Step 3)**

The Advanced Auto-Tuning results will be displayed in Bode diagrams.

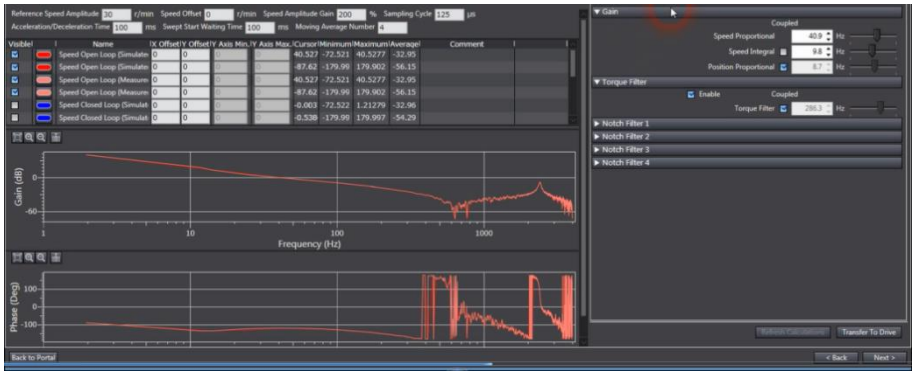


Check the result. If you are satisfied with it, proceed to step 12 (Wizard step 5). If you need more tuning, perform step 6.

6. **<u>FFT measurement</u>**

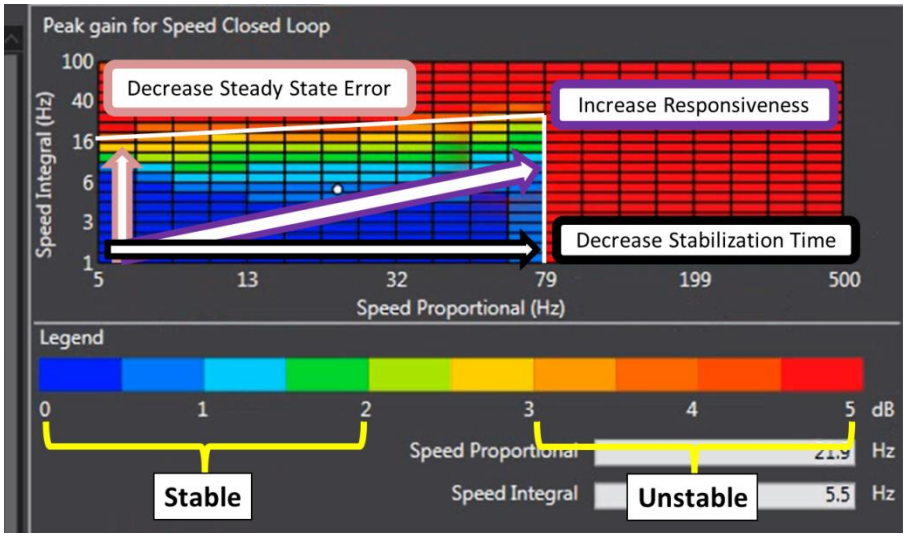
Please start the trace (FFT measurement will be performed, the motor will move slightly)

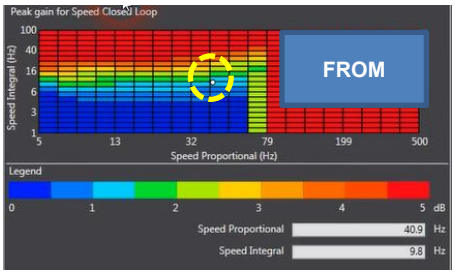
FFT measurement and simulated values are displayed (Gain and Phase)

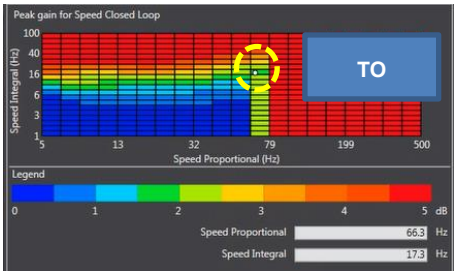


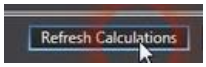
7. **Adjust gain and simulate**

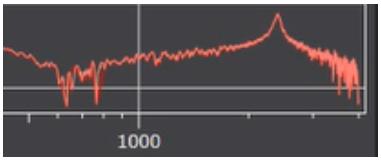
Adjust the gain to a proper value and push “refresh simulation”

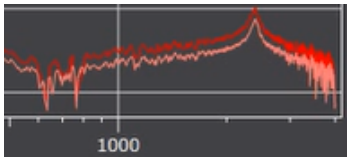






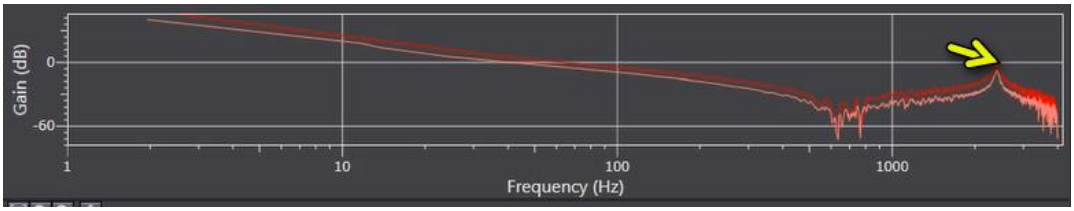
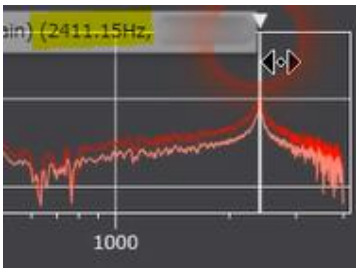
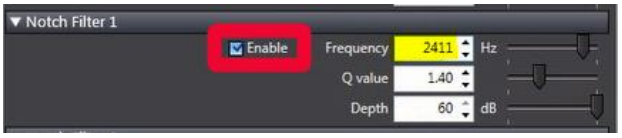
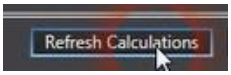
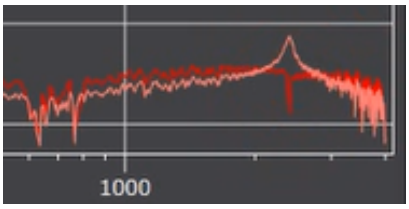


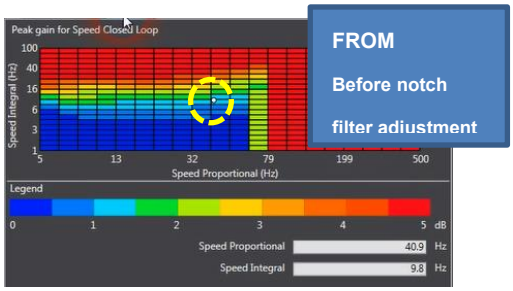
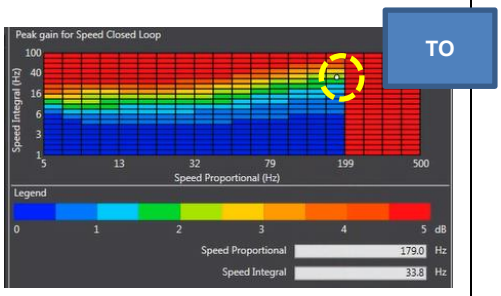
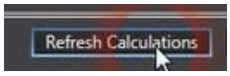
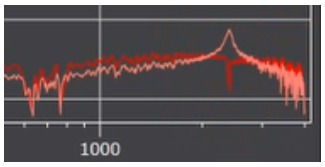
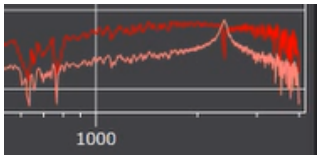
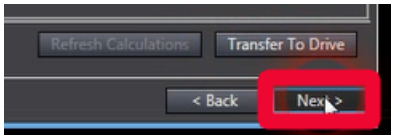
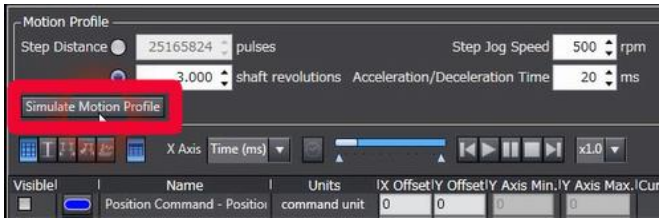
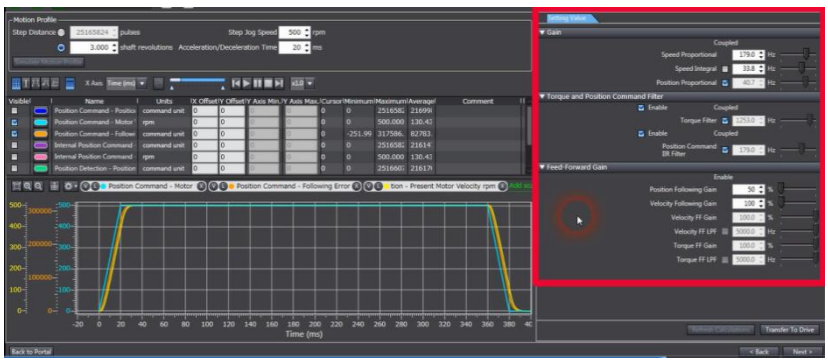




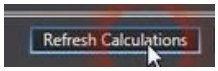
Pink curve is the measured value

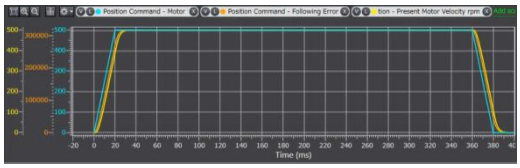
Red curve is the simulated value

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:** 

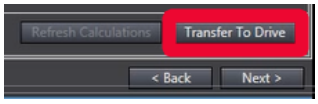
If your application required a small tracking error, here is an example of position following gain adjustment:



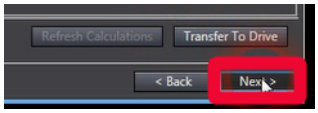


Following error has been reduced.

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

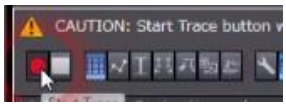


Click Next



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

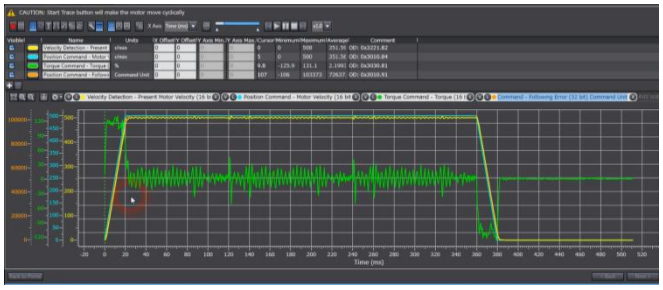
Push start trace (the motor will move following the previous configuration in Wizard step 3)



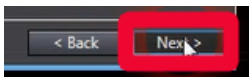
(motion profile in Wizard step 3)

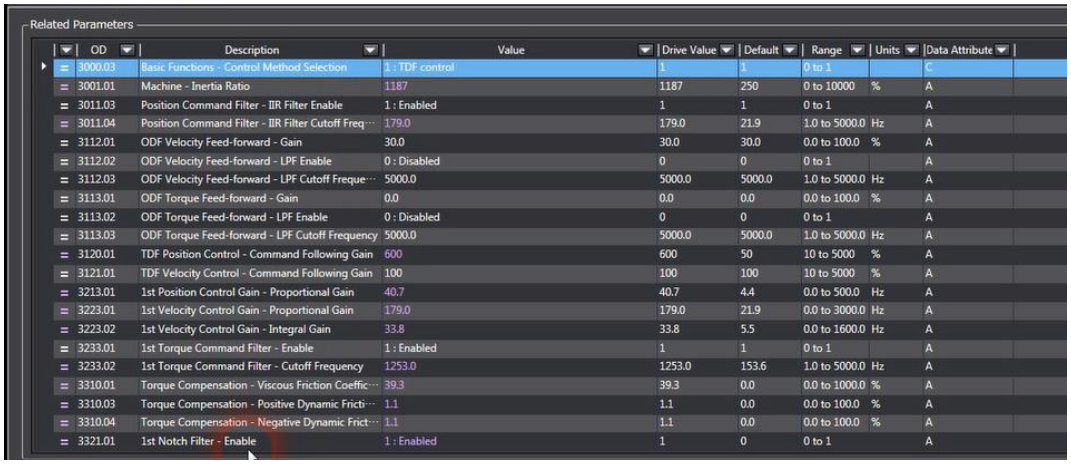
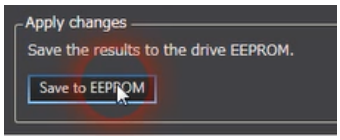
The chart is updated and shows:

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



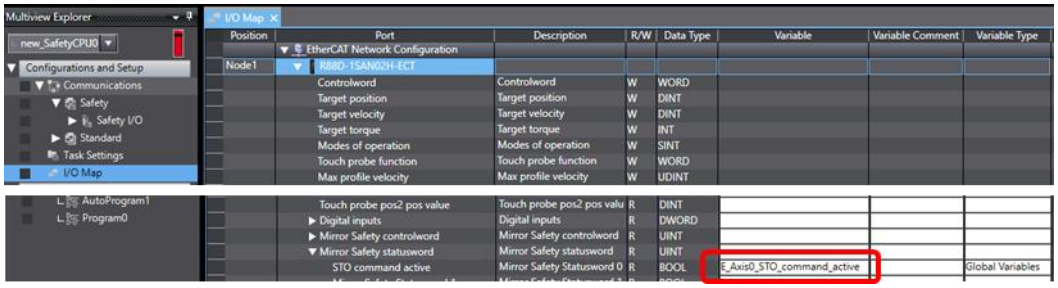
If satisfied, please click next



13.	**Results (Wizard step 5)**  Related Parameters 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 C 3001.01 Machine - Inertia Ratio 1187 1187 250 0 to 10000 % A 3011.03 Position Command Filter - IIR Filter Enable 1 : Enabled 1 1 0 to 1 A 3011.04 Position Command Filter - IIR Filter Cutoff Freq··· 179.0 179.0 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 Freque··· 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 600 600 50 10 to 5000 % A 3121.01 TDF Velocity Control - Command Following Gain 100 100 100 10 to 5000 % A 3213.01 1st Position Control Gain - Proportional Gain 40.7 40.7 4.4 0.0 to 500.0 Hz A 3223.01 1st Velocity Control Gain - Proportional Gain 179.0 179.0 21.9 0.0 to 3000.0 Hz A 3223.02 1st Velocity Control Gain - Integral Gain 33.8 33.8 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 1253.0 1253.0 153.6 1.0 to 5000.0 Hz A 3310.01 Torque Compensation - Viscous Friction Coeffic··· 39.3 39.3 0.0 0.0 to 1000.0 % A 3310.03 Torque Compensation - Positive Dynamic Fricti··· 1.1 1.1 0.0 0.0 to 100.0 % A 3310.04 Torque Compensation - Negative Dynamic Frict··· 1.1 1.1 0.0 0.0 to 100.0 % A 3321.01 1st Notch Filter - Enable 1 : Enabled 1 0 0 to 1 A **Save to EEPROM**  Apply changes Save the results to the drive EEPROM. Save to EEPROM  Sysmac Studio Changes successfully saved in non-volatile memory. OK **Finish**  < Back Finish

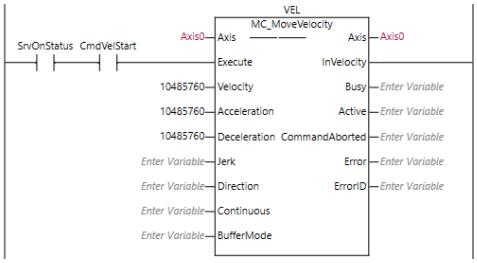
3.6. Creating a Motor Control Program

■ Creating a Standard Program

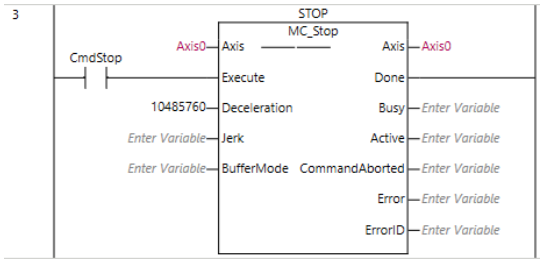
1.	**Open the I/O Map and create a device variable.** **Port** / **Variable name** **STO command active** for R88D-1SAN02H-ECT / **E_Axis0_STO_command_active**  Multiview Explorer new_SafetyCPU0 Configurations and Setup Communications Safety Safety I/O Standard Task Settings I/O Map AutoProgram1 Program0 I/O Map Position / Port / Description / R/W / Data Type / Variable / Variable Comment / Variable Type EtherCAT Network Configuration Node1 R88D-1SAN02H-ECT Controlword W WORD Target position W DINT Target velocity W DINT Target torque W INT Modes of operation W SINT Touch probe function W WORD Max profile velocity W UDINT Touch probe pos2 pos value R DINT Digital inputs R DWORD Mirror Safety controlword R UINT Mirror Safety statusword R UINT STO command active Mirror Safety Statusword 0 R BOOL E_Axis0_STO_command_active Global Variables
2.	**Create the following code:** 1. The Servo is turned ON or OFF.

2. The Servomotor is run.

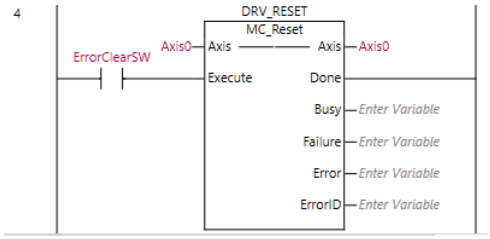
Set the velocity in the command unit specified in the *Setting an Axis*.



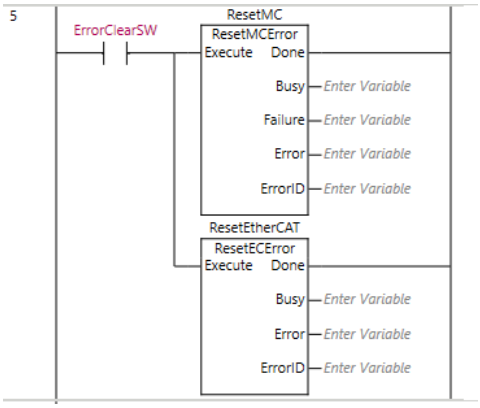
3. The Servomotor is stopped.



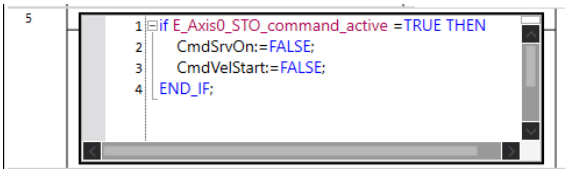
4. The errors of the Servo Drive are reset.

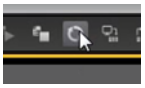
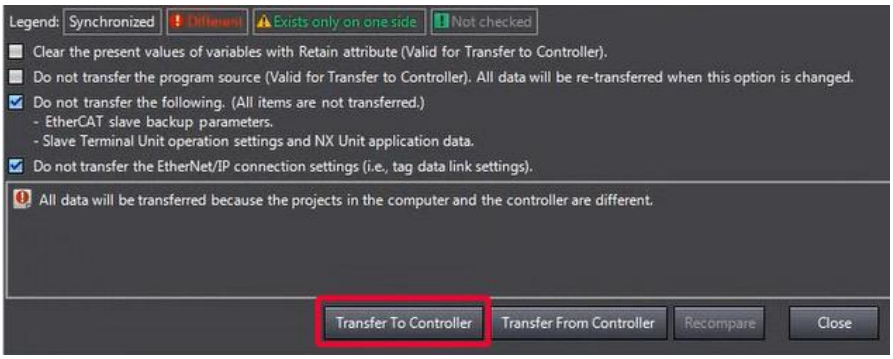


5. The errors of the standard controller are reset.

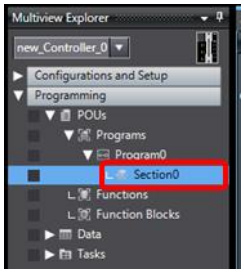
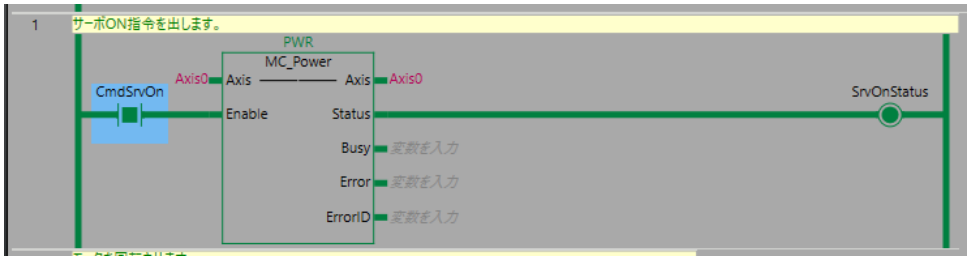
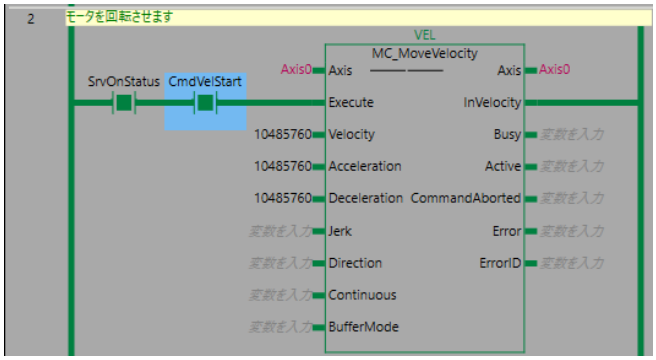


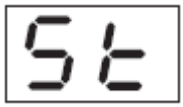
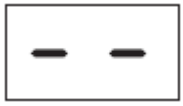
6. When the Servo Drive goes into the STO state, the Servo ON command and the motor start command are turned OFF.



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 600 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

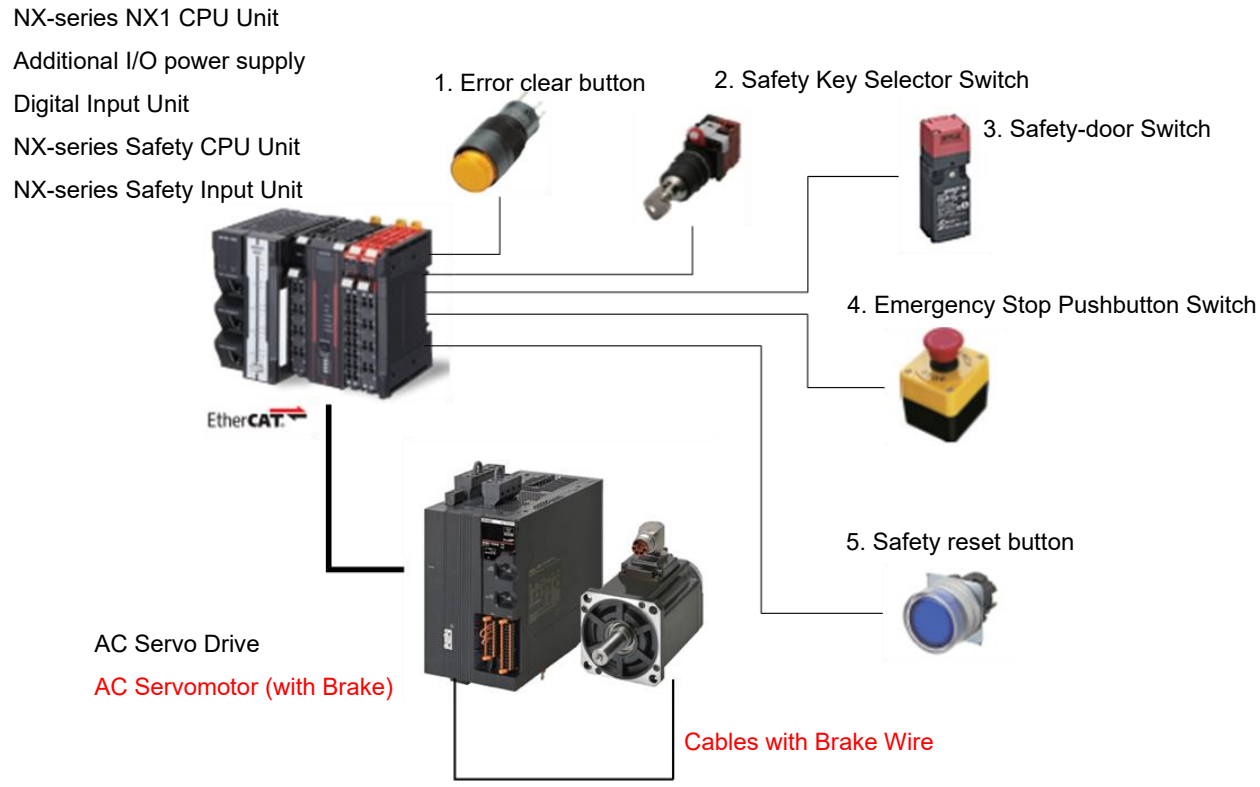
This section describes how to add a safety function to the servo system built in *3. Performing Setup*. Refer to the section of the safety function to add.

4.1. Adding the Safe Brake Control (SBC) Function to the STO Function

This section describes how to add the SBC function to the project created in *3. Performing Setup*. The SBC function is used to interlock it with the Brake Interlock Output (BKIR).

■ Changes in System Configuration

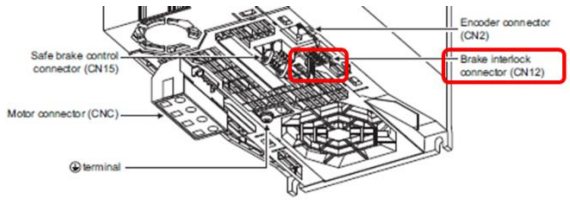
Change the Servomotor to a motor with a brake.

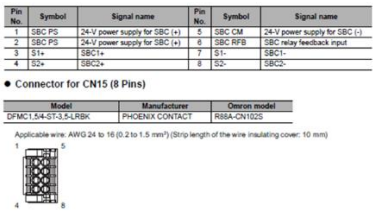


Device name	Model	Manual name
AC Servomotor (with Brake)	R88M-1A[]-B[]	1S-series with Built-in EtherCAT Communications and Safety Functionality User's Manual (Cat. No. I621)

■ Changes in Wiring

1. **When you use the SBC function, plug the brake cable into the Servo Drive. (CN15)**





Pin No.	Symbol	Signal name	Pin No.	Symbol	Signal name
1	SBC PS	24-V power supply for SBC (+)	5	SBC CM	24-V power supply for SBC (-)
2	SBC PS	24-V power supply for SBC (+)	6	SBC RFB	SBC relay feedback input
3	S1+	SBC1+	7	S1-	SBC1-
4	S2+	SBC2+	8	S2-	SBC2-

● Connector for CN15 (8 Pins)

Model	Manufacturer	Omron model
DFMC1,5/4-ST-3,5-LRBK	PHOENIX CONTACT	R88A-CN102S

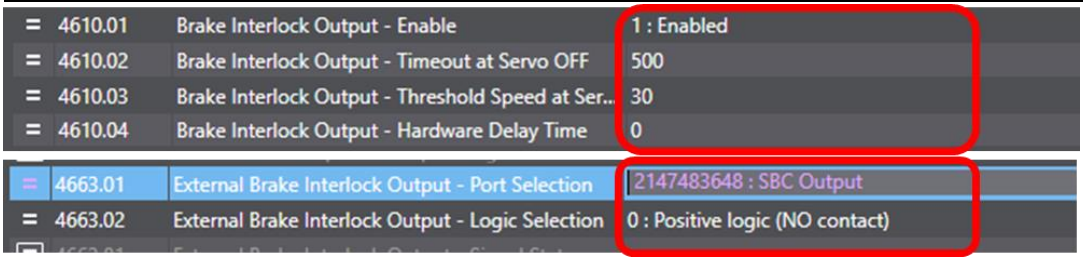
Applicable wire: AWG 24 to 16 (0.2 to 1.5 mm²) (Strip length of the wire insulating cover: 10 mm)

■ Changes in Drive Parameters

1. **Set Drive parameters.**

In this guide, set them as follows.

Name	Object	Value	Unit
Brake Interlock Output	**4610-01 hex**	**1: Enabled**	**-**
Timeout at Servo OFF	**4610-02 hex**	**500**	**ms**
Threshold Speed at Servo OFF	**4610-03 hex**	**30**	**r/min**
Hardware Delay Time	**4610-04 hex**	**0**	**ms**
External Brake Interlock Output	**4663-01 hex**	**SBC Output**	**-**



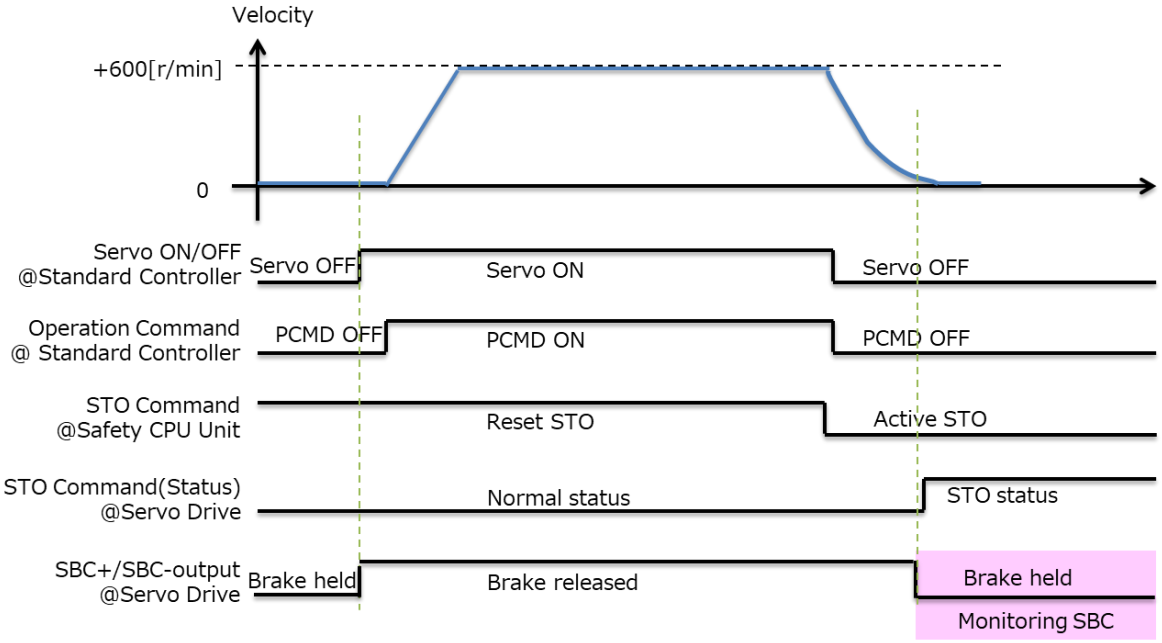
The operation of the servo system set up in this section is explained below.

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. After the torque is turned OFF, the Servo Drive activates the SBC function to monitor the brake signal.
3. When the Emergency Stop Pushbutton Switch is pressed, the motor torque is turned OFF. After the torque is turned OFF, the Servo Drive activates the SBC function to monitor the brake signal.
4. When the safety reset button is pressed, the STO status is reset.

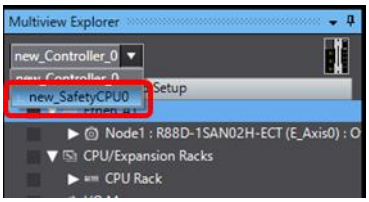
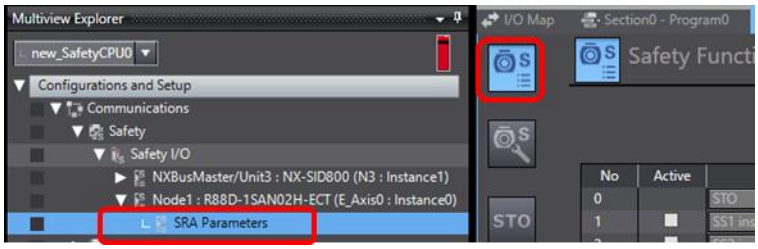
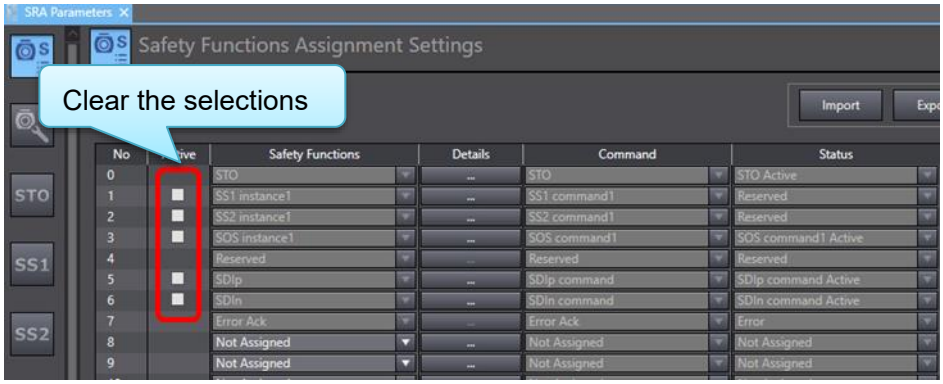
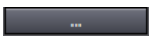
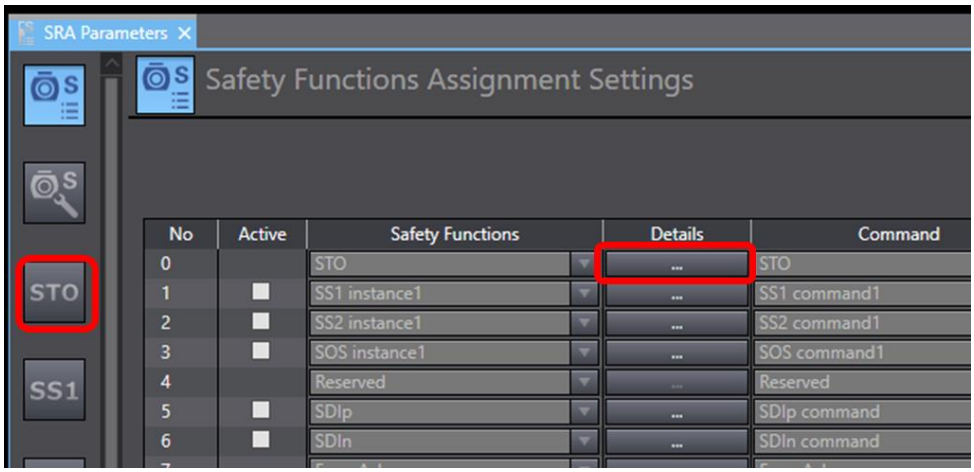
Input device	State	Operation
1. Error clear button	ON	Enable error reset command
	OFF	Disable error reset command
2. Safety-door Switch	Open	Enable STO command
	Close	Disable STO command
3. Emergency Stop Pushbutton Switch	ON	Enable STO command
	OFF	Disable STO command
4. Safety reset button	ON	Enable reset STO status command
	OFF	Disable reset STO status command

■ **Operation of SBC Function Interlocked with Motion Control and STO Function**

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 600 r/min.
3. When the STO function is executed, the Servo Drive shifts to the STO state and turns OFF torque. After the torque is turned OFF, the Servo Drive activates the SBC function.



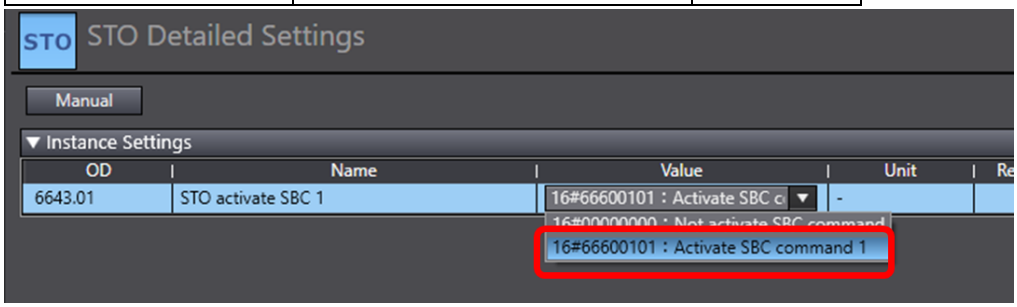
■ Setting the Safety Controller

1.	**Select *new_SafetyCPU0* from the list.** 
2.	**Double-click *SRA Parameters* and click the *Safety Function Assignment Settings* Button.** 
3.	**Deactivate safety functions except for the STO function.** Clear the selections of the *Active* Check Boxes for SS1 instance1, SS2 instance1, SOS instance1, SDIp, and SDIn to deactivate the unused safety functions. 
4.	Click the  **Button to display the STO Detailed Settings view.** You can also use  the Button to display the STO Detailed Settings view. 

5. **Set STO parameters.**

In this guide, set them as follows.

Name	Value	Unit
STO activate SBC 1	**Activate SBC command 1**	**-**

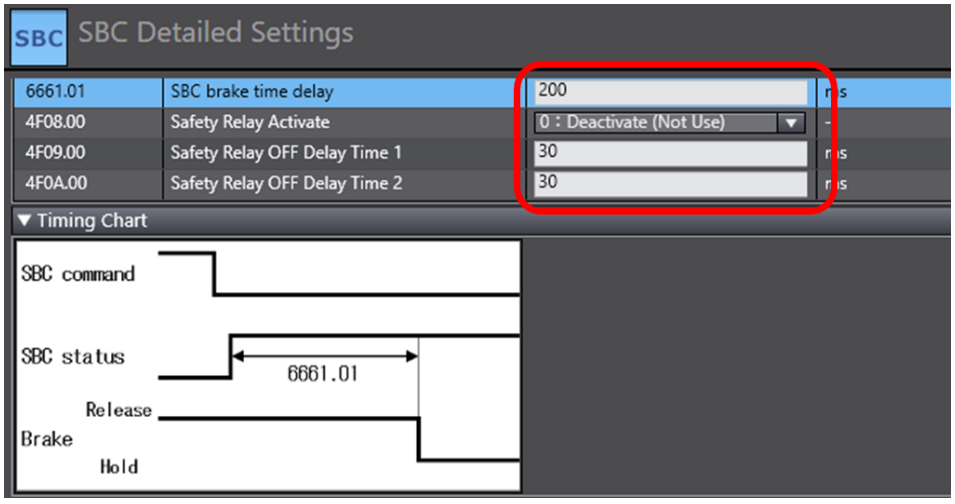


6. Click the SBC **Button to display the SBC Detailed Settings view.**

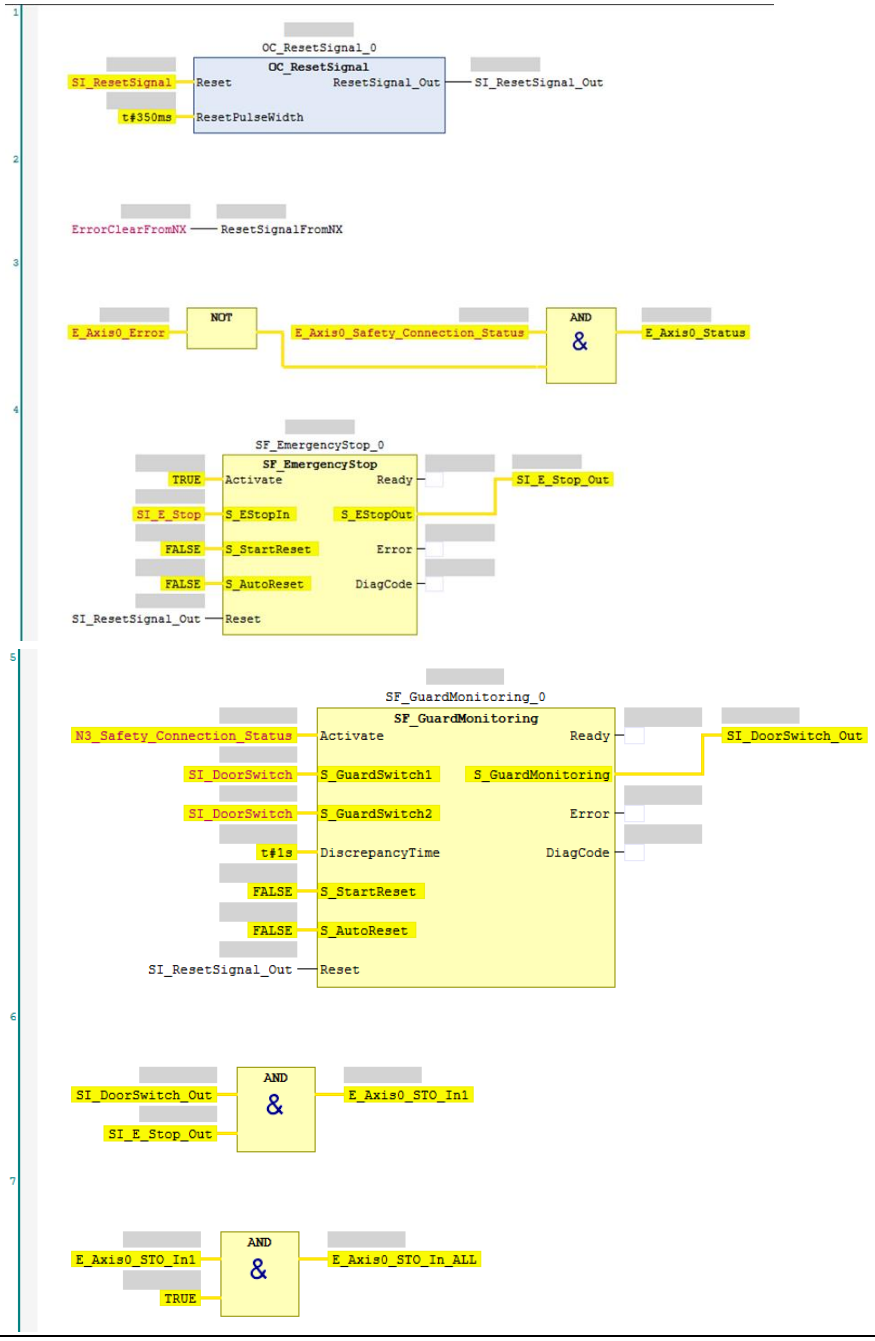
7. **Set SBC parameters.**

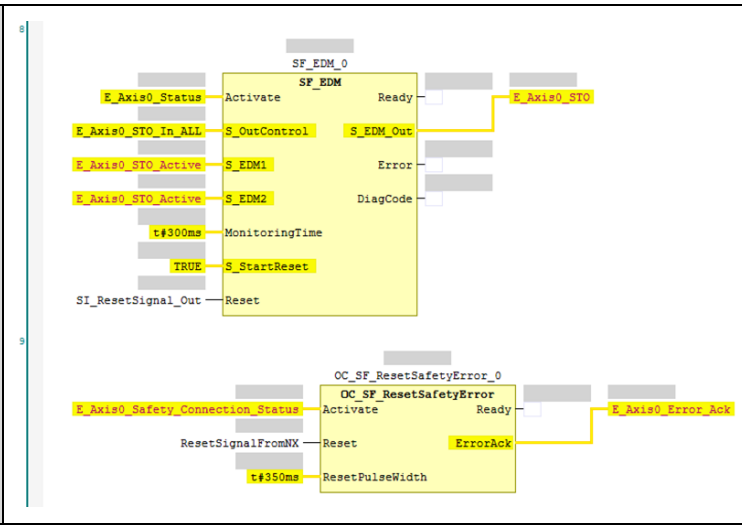
In this guide, set them as follows.

Name	Value	Unit
SBC brake time delay	**200**	**ms**
Safety Relay Activate	**0: Deactivate (Not Use)**	**-**
Safety Relay OFF Delay Time 1	**30**	**ms**
Safety Relay OFF Delay Time 2	**30**	**ms**



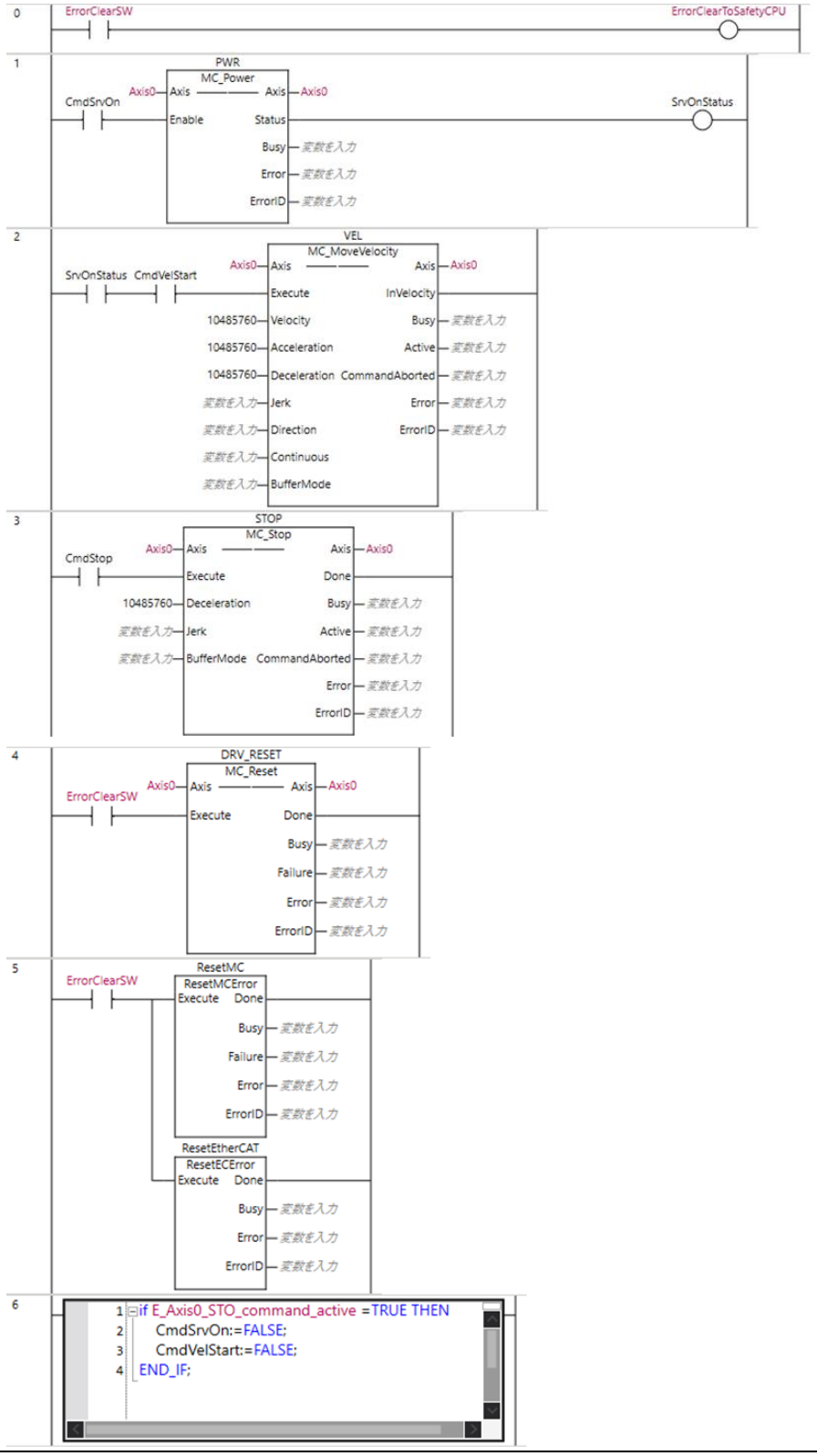
8.	**Check that the created program is the same as shown below.** **Device variables and safety programs are the same as those of the STO function.** *** For further details, refer to *Creating a Safety Program* in *3.3 Sysmac Studio Project Creation*.**

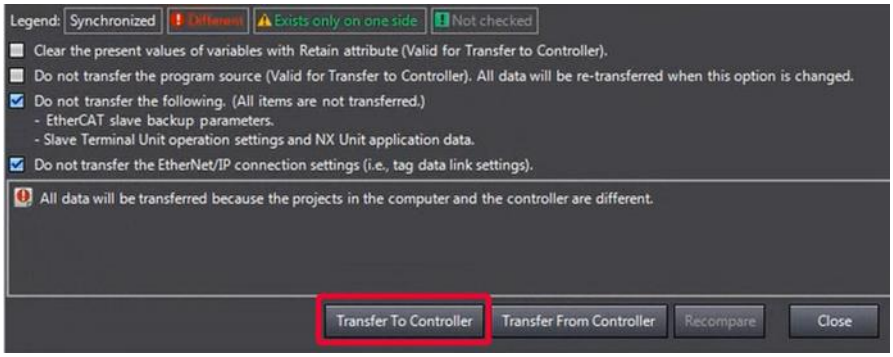
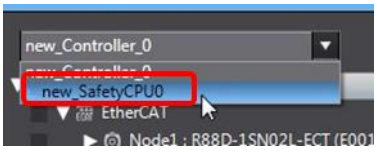
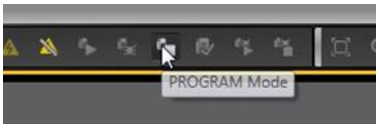
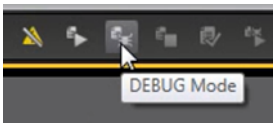
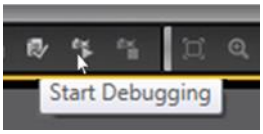



SF_EDM_0
SF_EDM
E_Axis0_Status
Activate
Ready
E_Axis0_STO
E_Axis0_STO_In_ALL
S_OutControl
S_EDM_Out
E_Axis0_STO_Active
S_EDM1
Error
E_Axis0_STO_Active
S_EDM2
DiagCode
t#300ms
MonitoringTime
TRUE
S_StartReset
SI_ResetSignal_Out
Reset
OC_SF_ResetSafetyError_0
OC_SF_ResetSafetyError
E_Axis0_Safety_Connection_Status
Activate
Ready
E_Axis0_Error_Ack
ResetSignalFromNX
Reset
ErrorAck
t#350ms
ResetPulseWidth

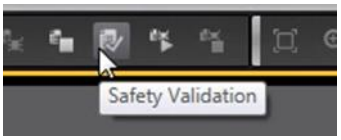
■ **Setting the Standard Controller**

1. **The program is the same as that of the STO function. For further details, refer to *3.6 Creating a Motor Control Program*.**
   Confirm that the program is as follows.

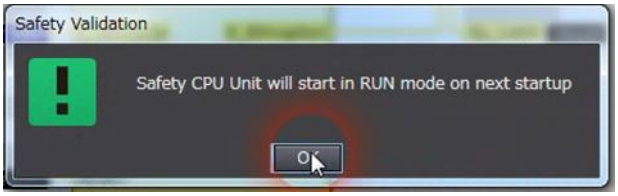


2.	**Transfer to the standard controller.** Select *new_Controller_0* from the list.  Connect to the standard controller.  Click the **Synchronization** Button to synchronize with the standard controller.  Transfer to the standard controller. 
3.	**Download the safety application.** Select *new_SafetyCPU0* 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.

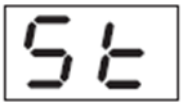
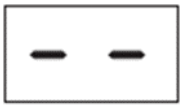
4. **The FSoE communications are now established.**

The FS indicator is lit in green.

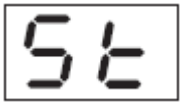
FS	Displays FSoE communications status.	Green	ON	FSoE slave connection established
			Flashing	FSoE slave connection establishment in progress
		Red	Flashing	Safety Parameter Error, Safety Communications Timeout, or other errors
		---	OFF	The safety functions are disabled by FSoE, the power is not supplied,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

■ Checking Operation of the SBC Function Interlocked with the STO Function

■ Checking Operation of the SBC Function Using the Emergency Stop Pushbutton Switch

1.	**Press the safety reset button.** 
2.	**Press the Emergency Stop Pushbutton Switch.**  Check that STO is activated to apply the brake. (Make sure that no SBC stuck-at-high error is detected.) Check that the 7-segment LED display shows ‘st’. 
3.	**Release the Emergency Stop Pushbutton Switch and press the safety reset button.**  Check that STO is released and the 7-segment LED display shows ‘--’. 

■ Checking Operation of SBC Function Using Safety-door Switch

1.	**Press the safety reset button.** 
2.	**Open the guard with the Safety-door Switch.**  Check that STO is activated to apply the brake. Check that the 7-segment LED display shows ‘st’. 

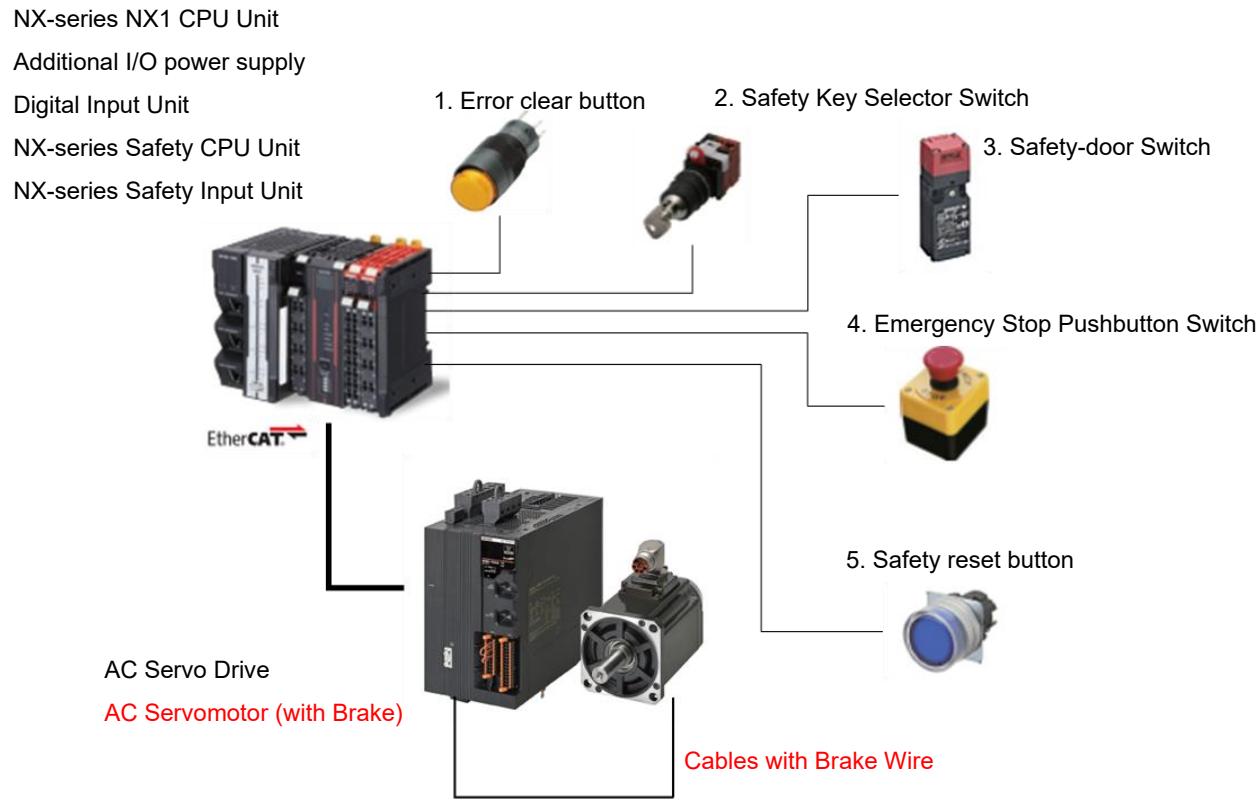
3.	**Close the guard and press the safety reset switch.**  Check that STO is released and the 7-segment LED display shows ‘--’. 

4.2. Adding the Safe Stop 1 (SS1) Function

This section describes how to add the SS1 function to the project created in *3. Performing Setup*. It also describes the procedure for adding the SBC function to the SS1 function.
The SBC function is used to interlock it with the Brake Interlock Output (BKIR).

■ Changes in System Configuration

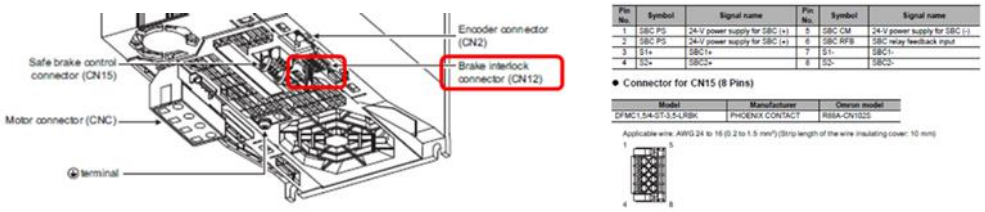
Change the Servomotor to a motor with a brake.



Device name	Model	Manual name
AC Servomotor (with Brake)	R88M-1A[]-B[]	1S-series with Built-in EtherCAT Communications and Safety Functionality User's Manual (Cat. No. I621)

■ Changes in Wiring

1.	**When you use the SBC function, plug the brake cable into the Servo Drive. (CN15)**

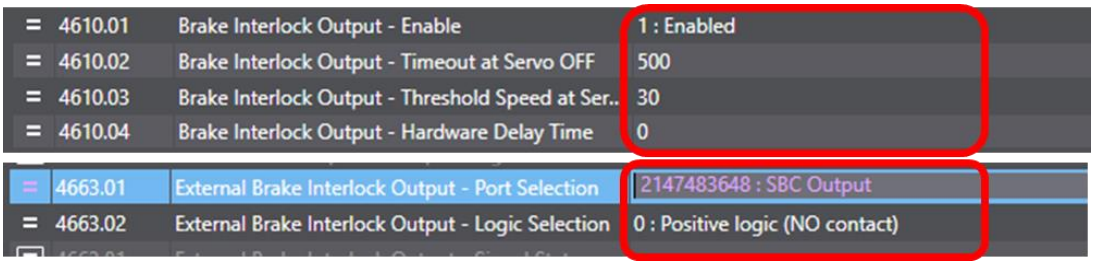


■ **Changes in Drive Parameters**

1. **Set Drive parameters.**

In this guide, set them as follows.

Name	Object	Value	Unit
Brake Interlock Output	**4610-01 hex**	**1: Enabled**	**-**
Timeout at Servo OFF	**4610-02 hex**	**500**	**ms**
Threshold Speed at Servo OFF	**4610-03 hex**	**30**	**r/min**
Hardware Delay Time	**4610-04 hex**	**0**	**ms**
External Brake Interlock Output	**4663-01 hex**	**SBC Output**	**-**



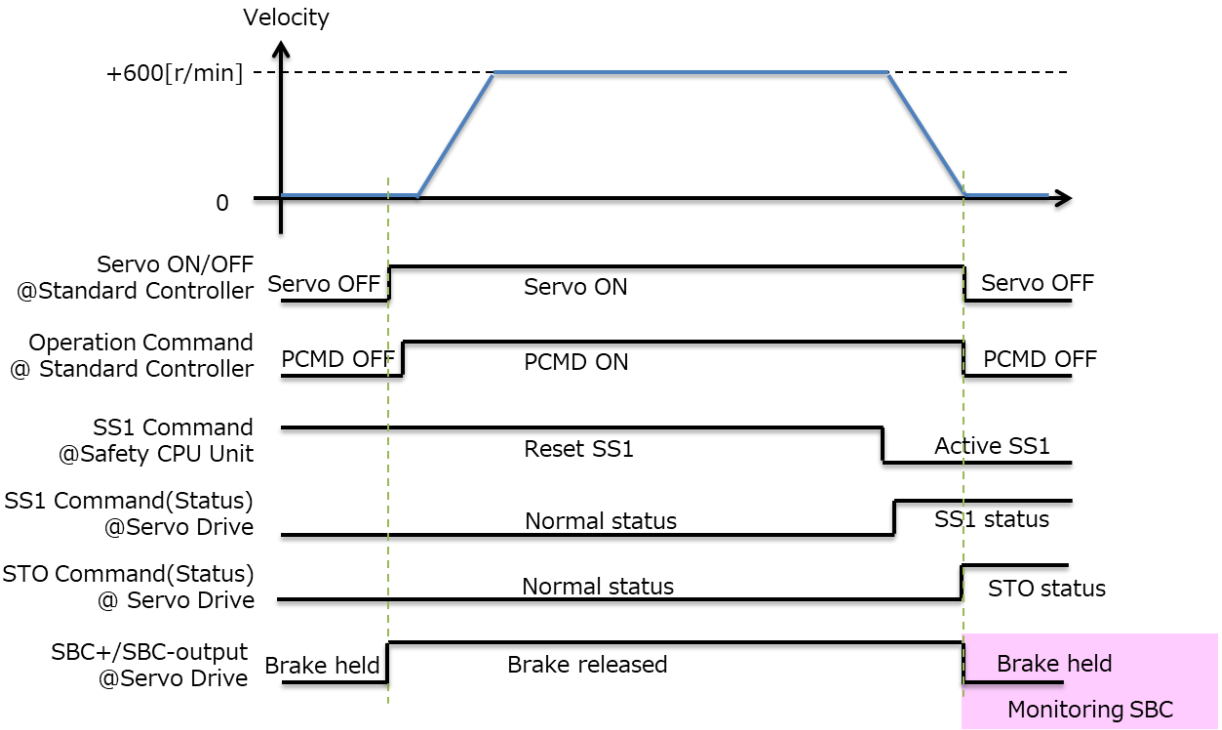
The operation of the servo system set up in this section is explained below.

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. After the torque is turned OFF, the Servo Drive activates the SBC function to monitor the brake signal.
3. When the Emergency Stop Pushbutton Switch is pressed, the motor torque is turned OFF. (If the Servo Drive activates the SBC function after the torque is turned OFF, you need to perform the setting procedure described in 4.1.)
4. When the safety reset button is pressed, the STO status is reset.

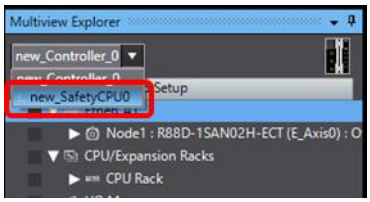
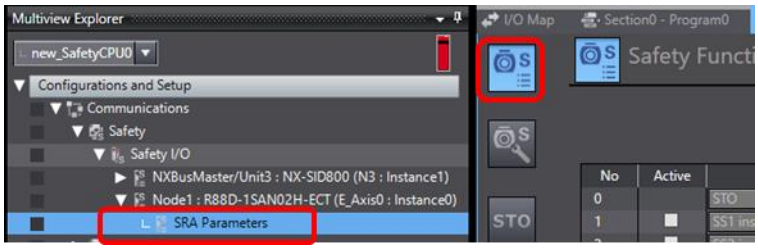
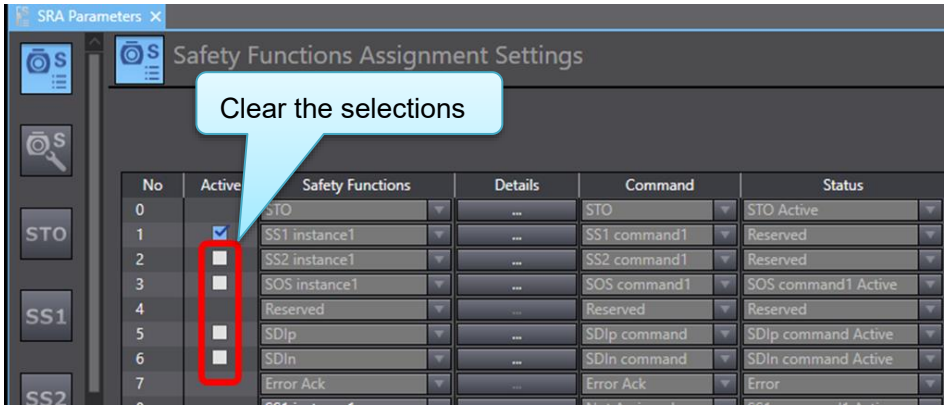
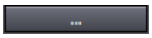
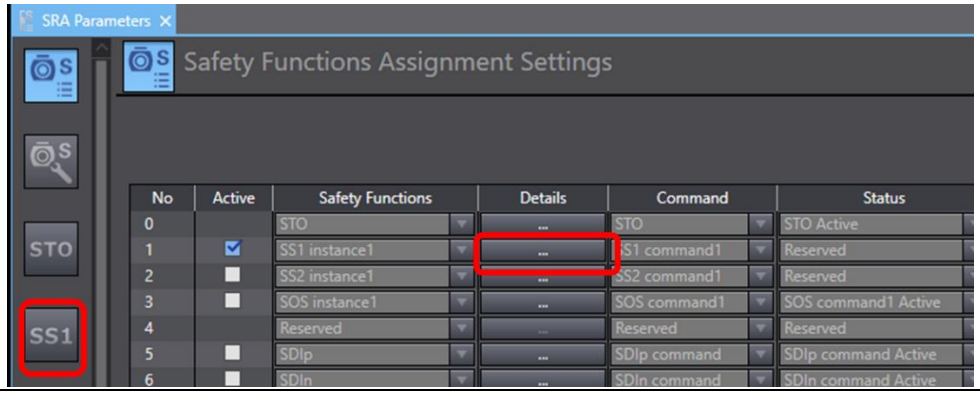
Input device	State	Operation
1. Error clear button	ON	Enable error reset command
	OFF	Disable error reset command
2. Safety Key Selector Switch	Normal operating mode	Run Servomotor at normal velocity.
	Safety active mode	Make Servomotor decelerate to a stop and activate STO function using SS1 function. After the torque is turned OFF, the Servo Drive activates the SBC function to monitor the brake signal.
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 SBC Function Interlocked with Motion Control and SS1 Function**

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 600 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. After the torque is turned OFF, the Servo Drive activates the SBC function to monitor the brake signal.



■ Setting the Safety Controller

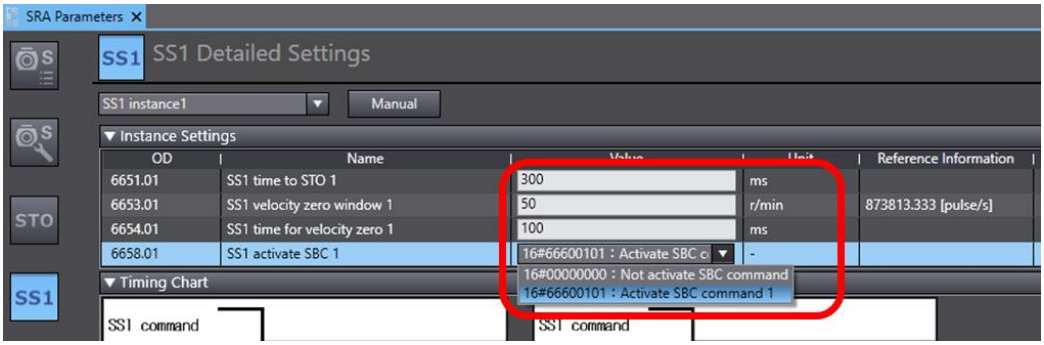
1.	**Select *new_SafetyCPU0* from the list.** 
2.	**Double-click *SRA Parameters* and click the *Safety Function Assignment Settings* Button.** 
3.	**Deactivate safety functions except for the SS1 function.** Clear the selections of the *Active* Check Boxes for SS2 instance1, SOS instance1, SDIp, and SDIn to deactivate the unused safety functions. 
4.	Click the  **Button to display the SS1 Detailed Settings view.** You can also use  the Button to display the SS1 Detailed Settings view. 

5. **Set SS1 parameters.**

In this guide, set them as follows.

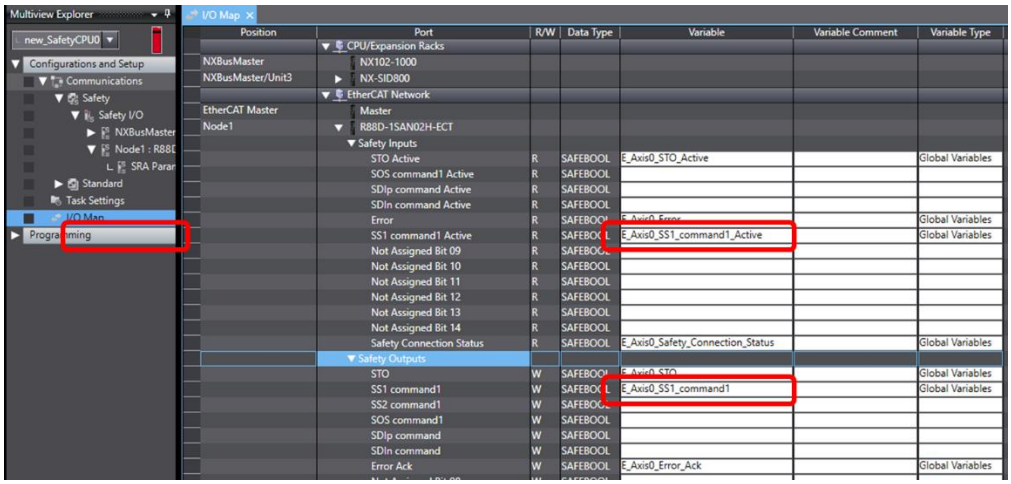
Name	Value	Unit
SS1 time to STO 1	**300**	**ms**
SS1 velocity zero window 1	**50**	**r/min**
SS1 time for velocity zero 1	**100**	**ms**
SS1 activate SBC 1	**Activate SBC command 1.**	**–**

Note: Set times so that SS1 time for velocity zero 1 is less than or equal to SS1 time to STO 1.

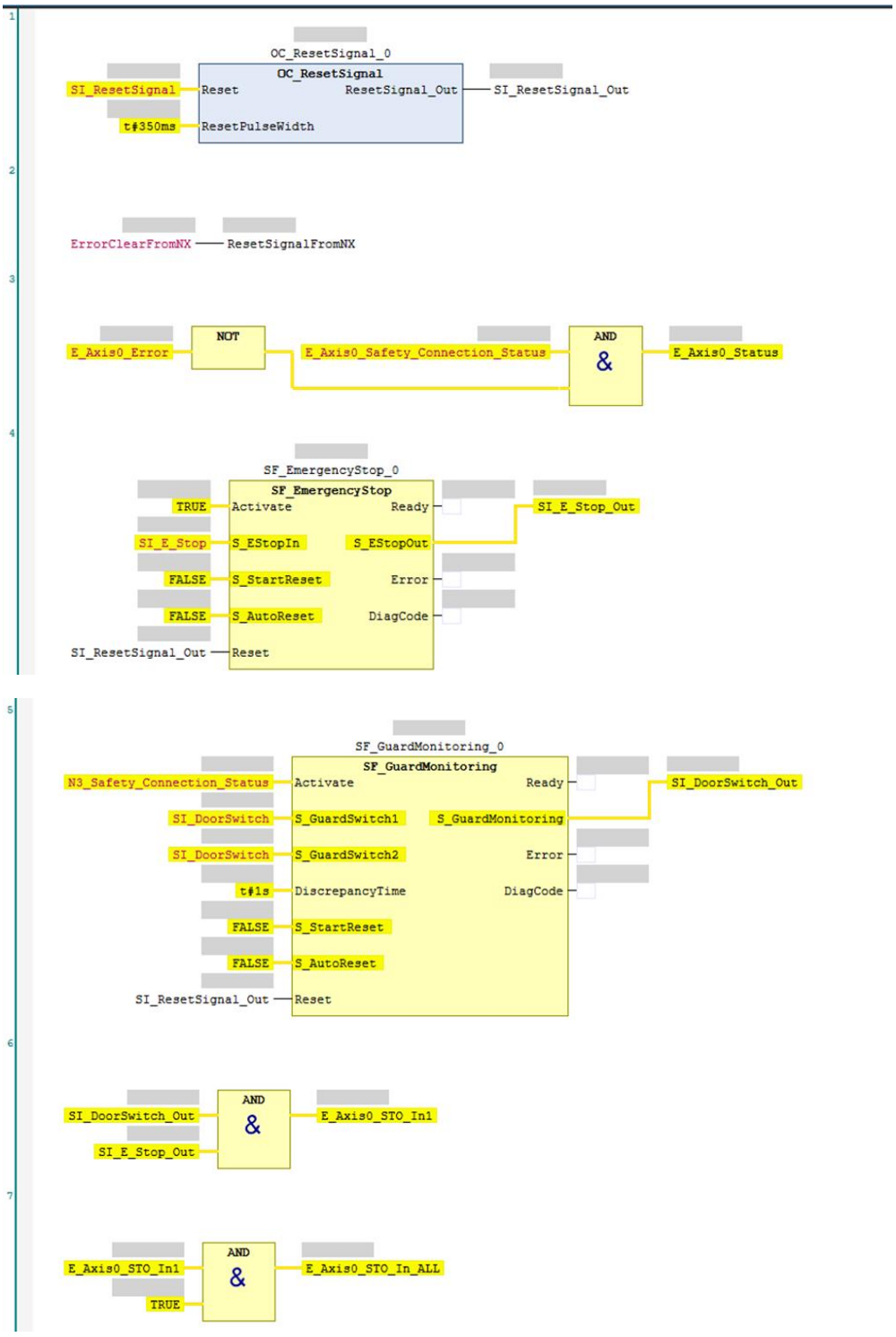


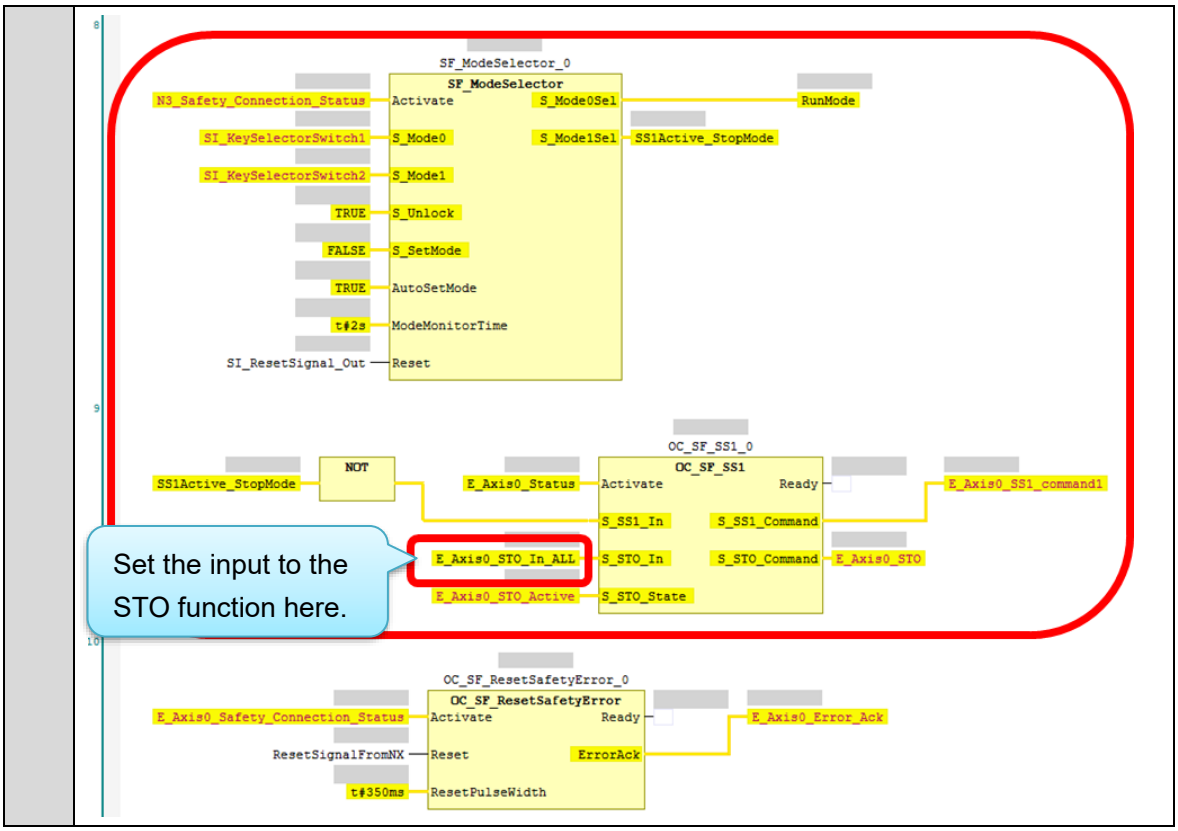
6. **Open the I/O Map and create device variables.**

Port	Variable name
SS1 command1 Active for R88D-1SAN02H-ECT	**E_Axis0_SS1_command1_Active**
SS1 command1 for R88D-1SAN02H-ECT	**E_Axis0_SS1_command1**



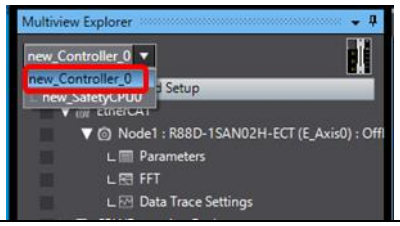
7.	**Create a safety program.** **Add the following code to AutoProgram1.**



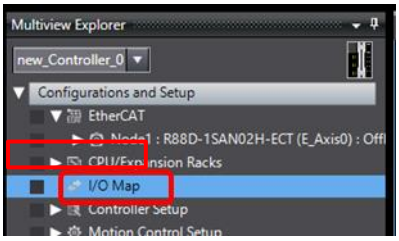

SF_ModeSelector_0
SF_ModeSelector
N3_Safety_Connection_Status
Activate
S_Mode0Sel
RunMode
SI_KeySelectorSwitch1
S_Mode0
S_Mode1Sel
SS1Active_StopMode
SI_KeySelectorSwitch2
S_Mode1
TRUE
S_Unlock
FALSE
S_SetMode
TRUE
AutoSetMode
t#2s
ModeMonitorTime
SI_ResetSignal_Out
Reset
OC_SF_SS1_0
OC_SF_SS1
SS1Active_StopMode
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

■ Setting the Standard Controller

1. **Select *new_Controller_0* from the list.**

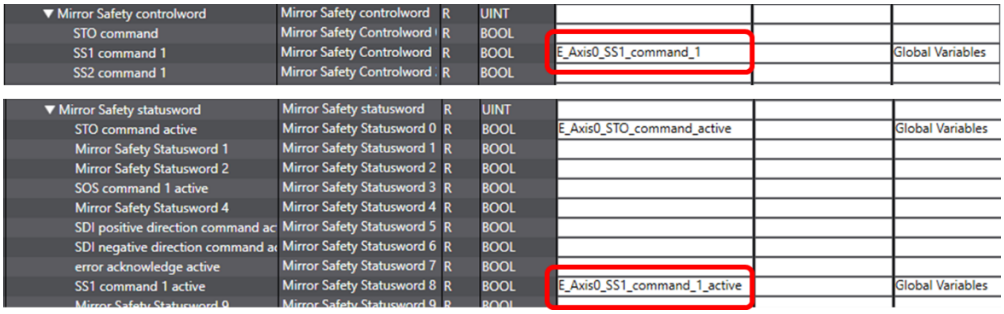


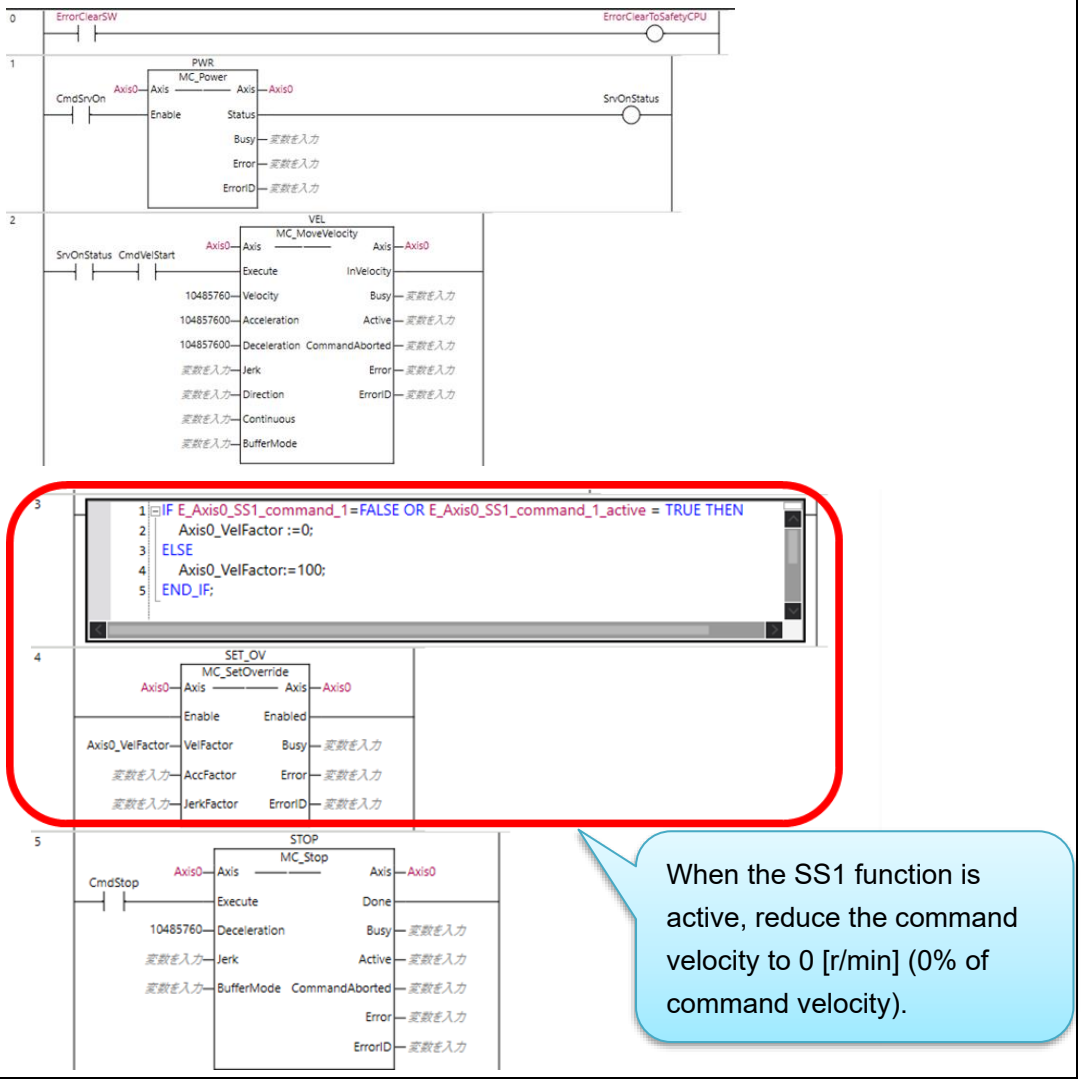
2. **Double-click *I/O Map*.**

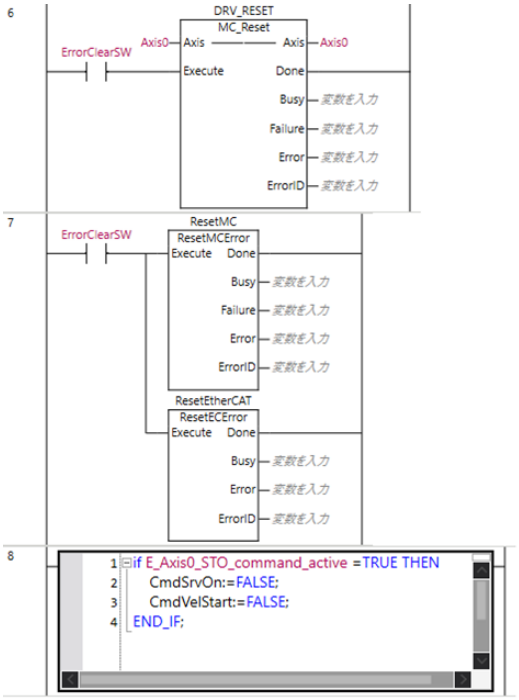


3. **Create device variables.**

Port	Variable name
SS1 command1 for R88D-1SAN02H-ECT	**E_Axis0_SS1_command_1**
SS1 command1 active for R88D-1SAN02H-ECT	**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. 



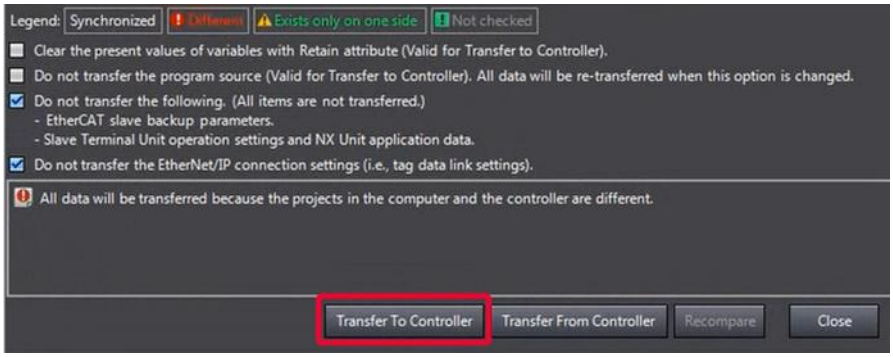
5. **Transfer to the standard controller.**

Select *new_Controller_0* from the list.

Connect to the standard controller.

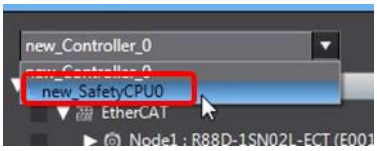
Click the **Synchronization** Button to synchronize with the standard controller.

Transfer to the standard controller.

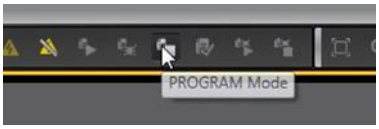


6. **Download the safety application.**

Select *new_SafetyCPU0* from the list.

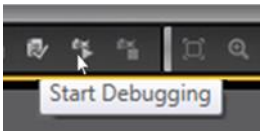


Click the **PROGRAM Mode** Button to switch to PROGRAM mode.

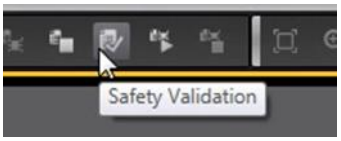


Click the **DEBUG Mode** Button to enter DEBUG mode.

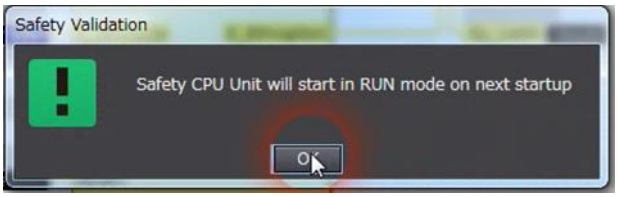
Click the **Start Debugging** Button to start DEBUG mode.



Click the **Safety Validation** Button.



Click the **OK** Button.



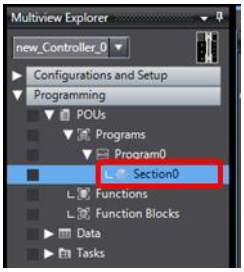
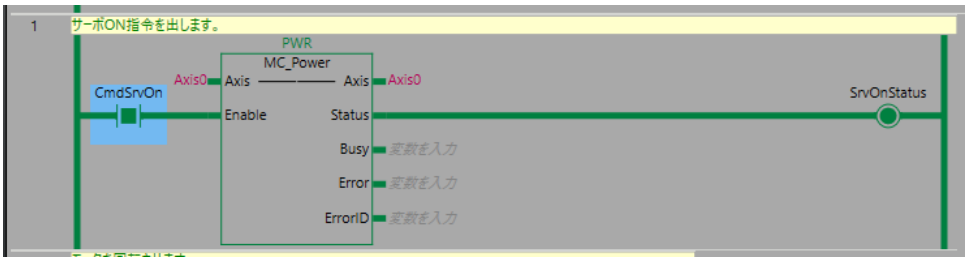
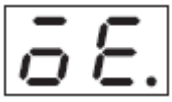
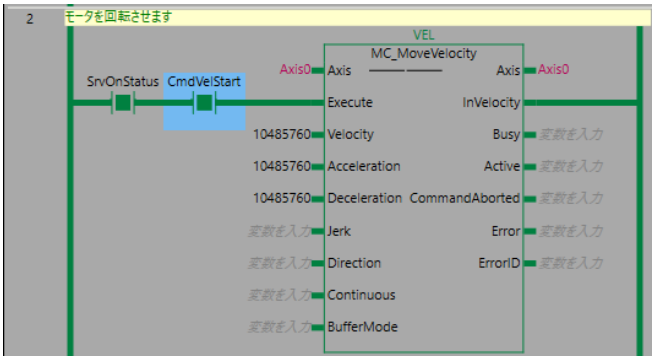
Click the **Run** Button.

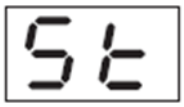
7. **The FSoE communications are now established.**

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

■ 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 600 r/min.

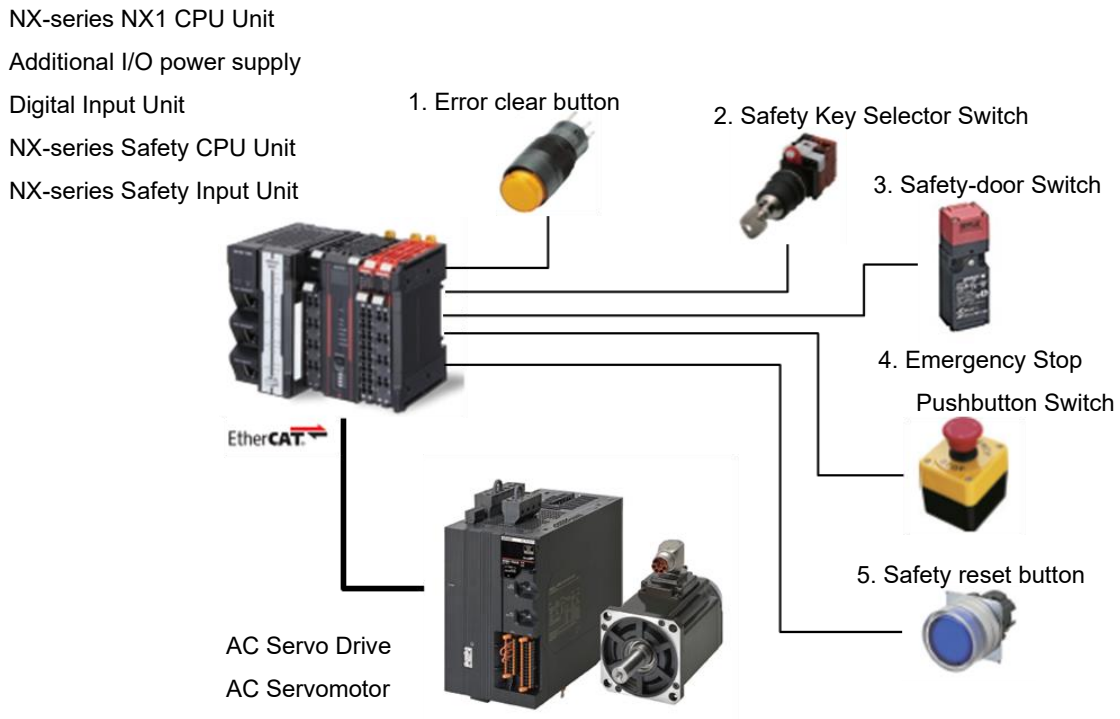
6.	**Operate the Safety Key Selector Switch to switch to safety active mode.**  The Servomotor decelerates to a stop and the Servo Drive goes into STO state. Check that the brake is applied. (Make sure that no SBC stuck-at-high error is detected.) Check that the 7-segment LED display shows ‘st’. 

4.3. Adding the Safe Stop 2 (SS2) Function

This section describes how to add the SS2 function to the project created in *3. Performing Setup*.

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

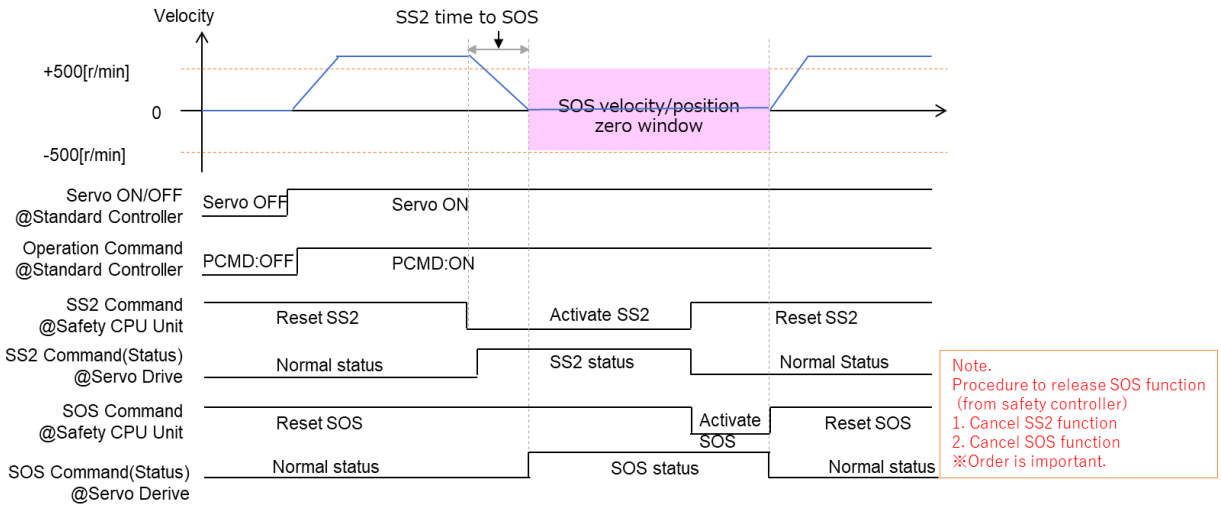
1. When the error clear button is pressed, the errors of the standard controller and Servo Drive are reset.
2. When the Safety Key Selector Switch is operated to switch to safety active mode, the standard controller lets the Servomotor decelerate to a stop. The Servo Drive activates the SOS function using the SS2 function to monitor the Servomotor position and velocity.
3. When the guard with the Safety-door Switch is opened while the SOS 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.



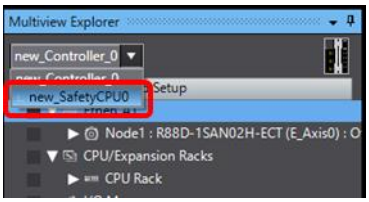
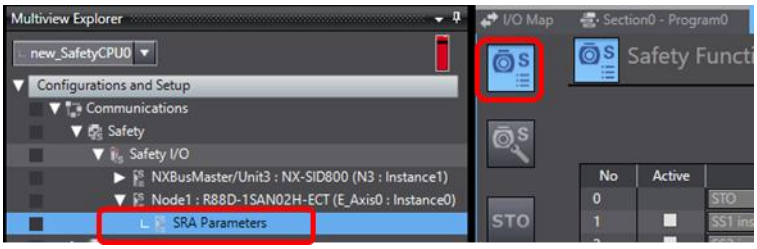
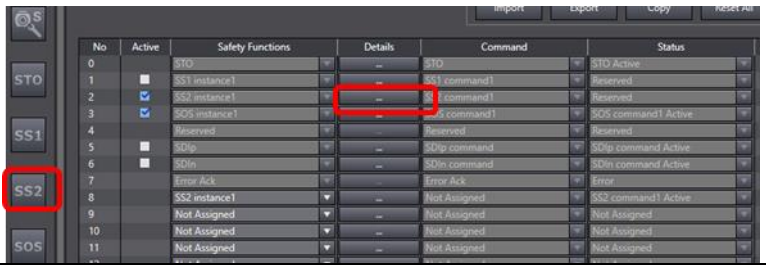
Input device	State	Operation
1. Error clear button	ON	Enable error reset command
	OFF	Disable error reset command
2. Safety Key Selector Switch	Normal operating mode	Run Servomotor at normal velocity and deactivate SOS function.
	Safety active mode	Make Servomotor decelerate to a stop and activate SOS function using SS2 function. When position or velocity exceeds SOS position or velocity zero window, 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 SS2 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 600 r/min.
3. When the SS2 function is executed, the Servo Drive shifts to the SOS state after the wait time (SS2 time to SOS 1) and monitors the motor position and velocity.
   The standard controller lets the Servomotor decelerate to a stop.
4. When the SS2 or SOS function is released, the Servo Drive goes into the normal state and stops monitoring the motor position and velocity.
   The standard controller sets the command velocity to the Servomotor to 600 r/min.



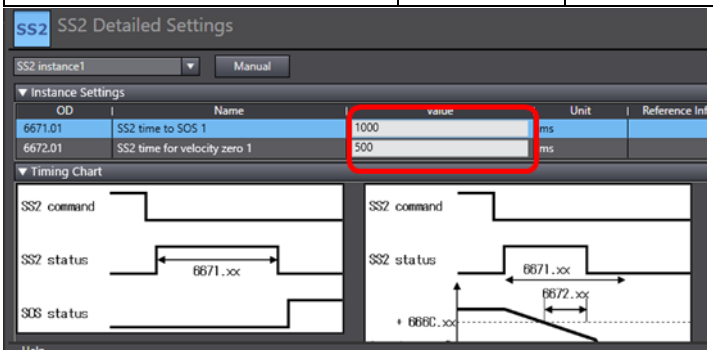
■ Setting the Safety Controller

1.	**Select *new_SafetyCPU0* from the list.** 
2.	**Double-click *SRA Parameters* and click the *Safety Function Assignment Settings* Button.** 
3.	**Assign STO, SS2 instance1, and SOS instance1.** 
4.	**Click the SS2 Button or the ... Button to display the SS2 Detailed Settings view.** 

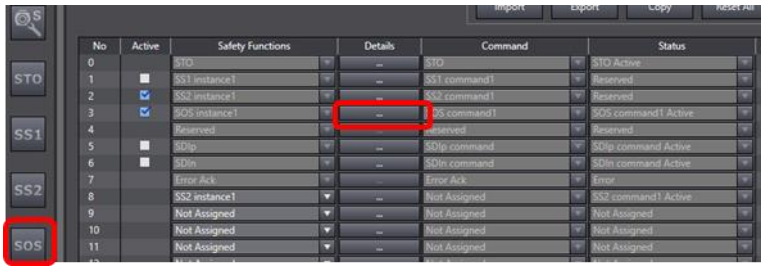
5. **Set SS2 parameters.**

In this Guide, set as follows:

Name	Value	Unit
SS2 time to SOS 1	**1000**	**ms**
SS2 time for velocity zero 1	**500**	**ms**



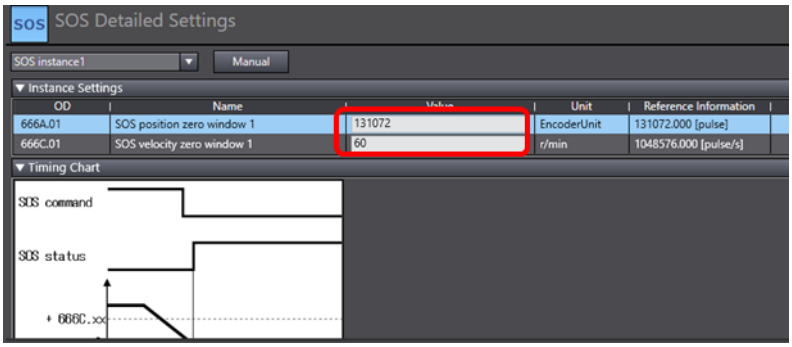
6. **Click the SOS Button or the ... Button to display the SOS Detailed Settings view.**



7. **Set SOS parameters.**

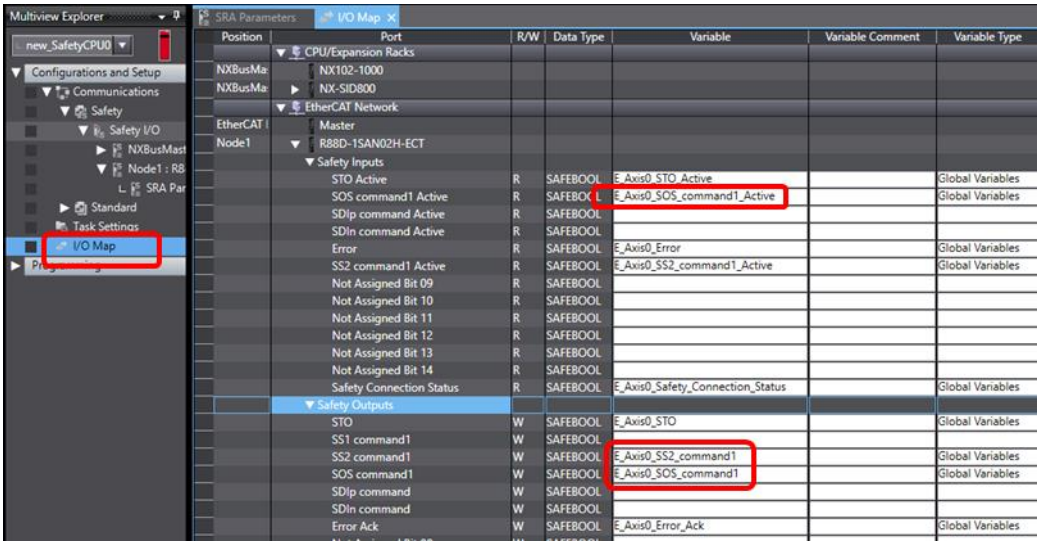
In this Guide, set as follows:

Name	Value	Unit
SOS position zero window 1	**131072**	**Encoder Unit**
SOS velocity zero window 1	**60**	**r/min**



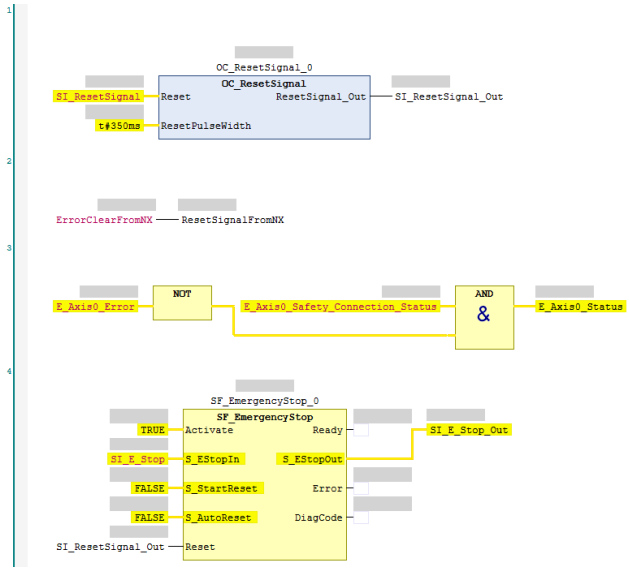
8. **Open the I/O Map and create device variables.**

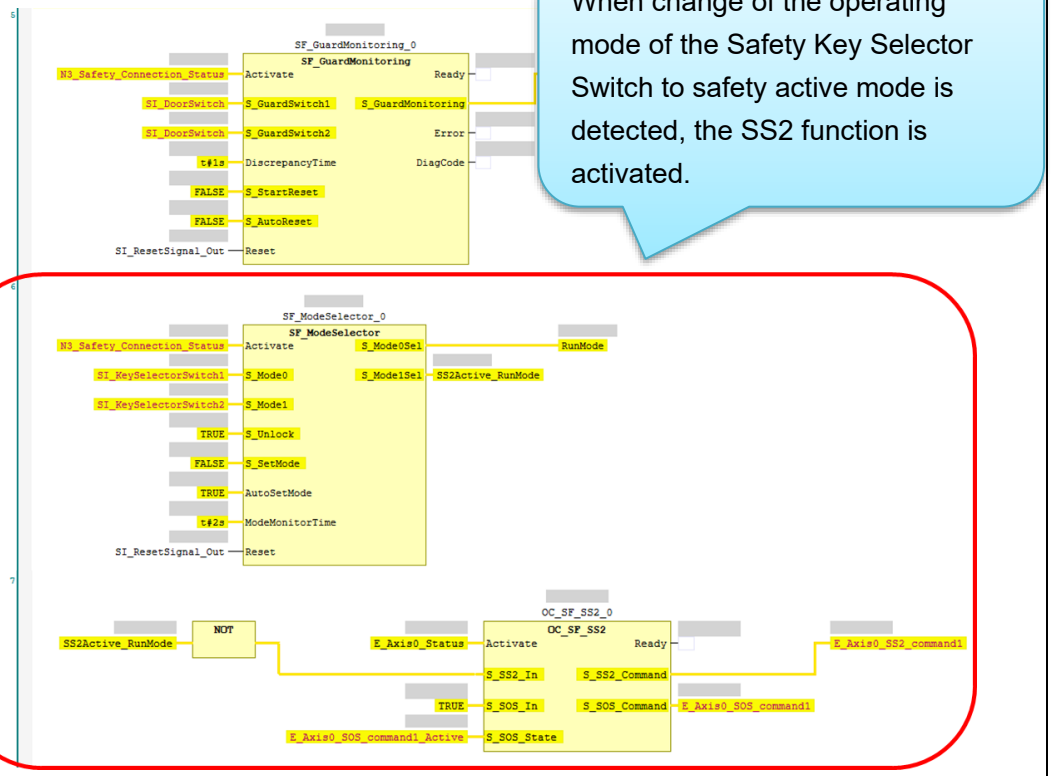
Port	Variable name
SOS command1 Active for R88D-1SAN02H-ECT	**E_Axis0_SOS_command1_Active**
SS2 command1 for R88D-1SAN02H-ECT	**E_Axis0_SS2_command1**
SOS command1 for R88D-1SAN02H-ECT	**E_Axis0_SOS_command1**



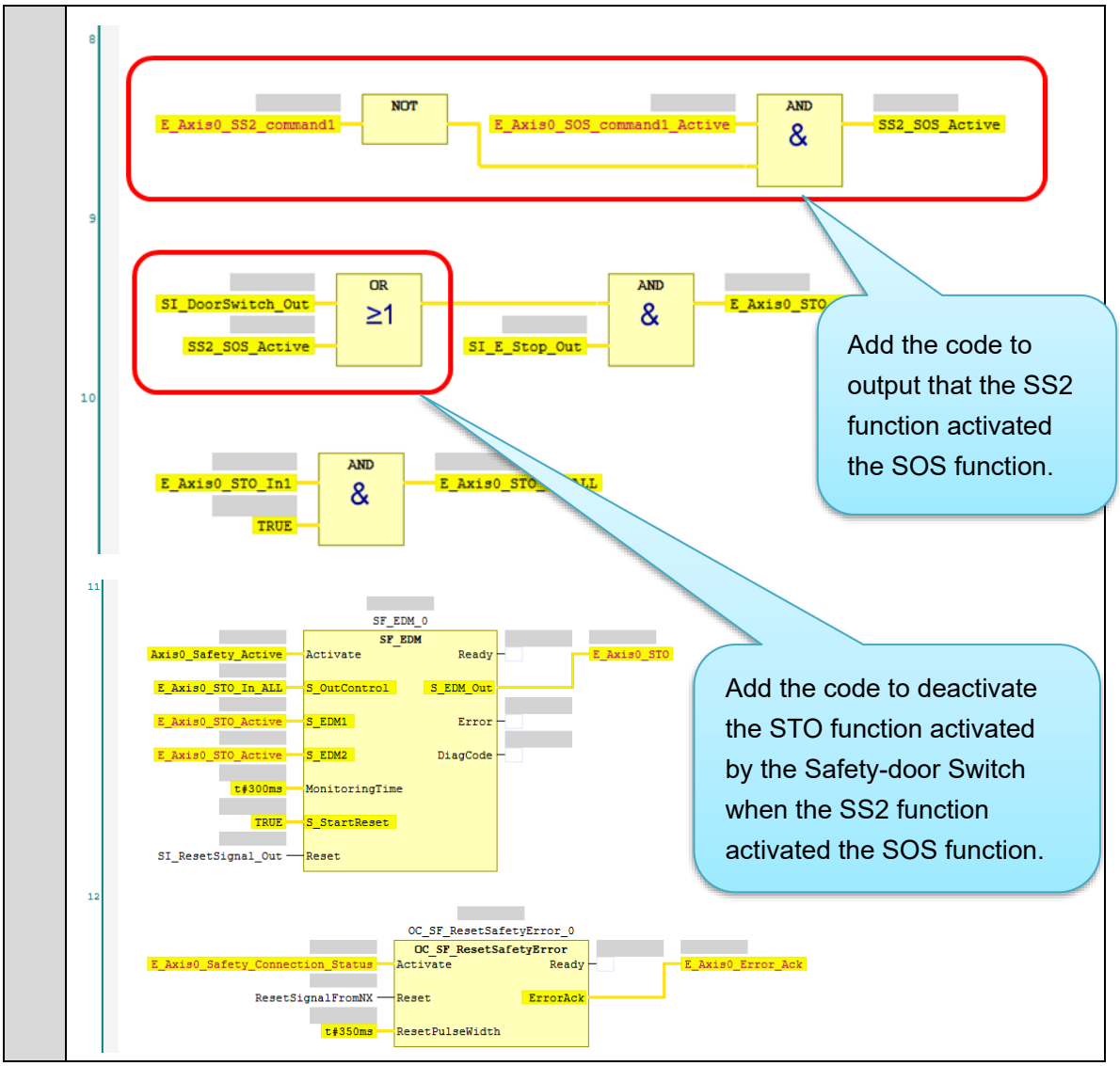
9. **Create a safety program.**

Add the following code to AutoProgram1.



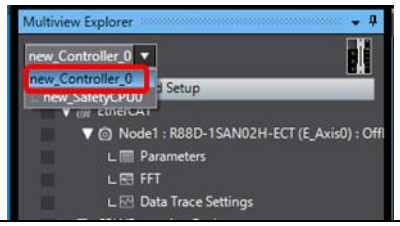


When change of the operating mode of the Safety Key Selector Switch to safety active mode is detected, the SS2 function is activated.

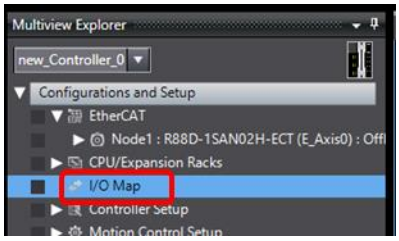

8
E_Axis0_SS2_command1
NOT
E_Axis0_SOS_command1_Active
AND
&
SS2_SOS_Active
9
SI_DoorSwitch_Out
SS2_SOS_Active
OR
≥1
SI_E_Stop_Out
AND
&
E_Axis0_STO
10
E_Axis0_STO_In1
TRUE
AND
&
11
SF_EDM_0
SF_EDM
Axis0_Safety_Active
Activate
Ready
E_Axis0_STO
E_Axis0_STO_In_ALL
S_OutControl
S_EDM_Out
E_Axis0_STO_Active
S_EDM1
Error
E_Axis0_STO_Active
S_EDM2
DiagCode
t#300ms
MonitoringTime
TRUE
S_StartReset
SI_ResetSignal_Out
Reset
12
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 output that the SS2 function activated the SOS function.
Add the code to deactivate the STO function activated by the Safety-door Switch when the SS2 function activated the SOS function.

■ Setting the Standard Controller

1. **Select *new_Controller_0* from the list.**

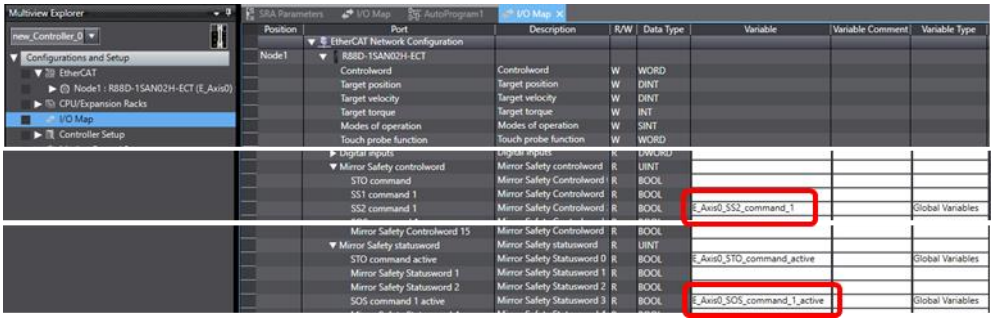


2. **Double-click *I/O Map*.**



3. **Create device variables.**

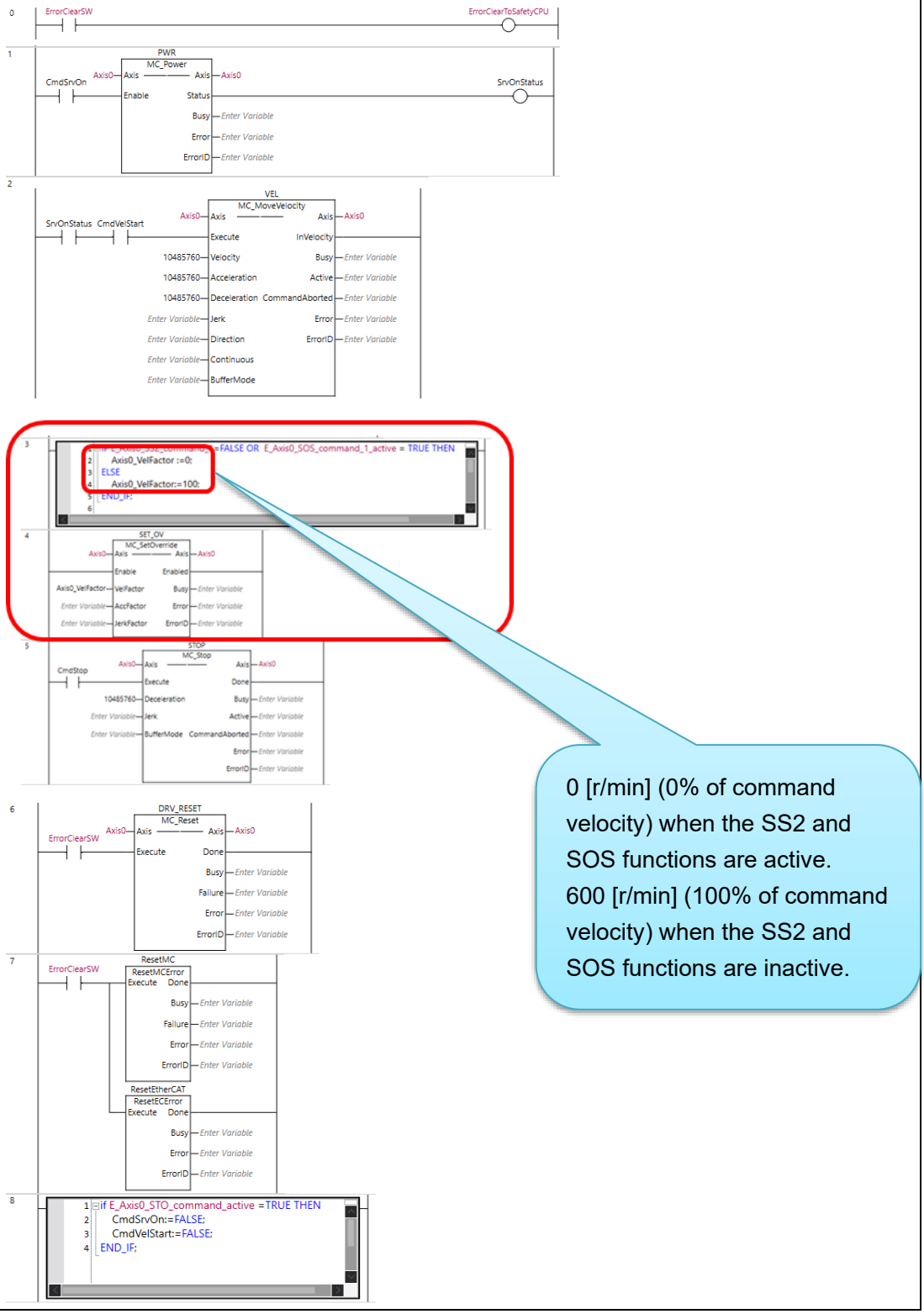
Port	Variable name
SS2 command 1 for R88D-1SAN02H-ECT	**E_Axis0_SS2_command_1**
SOS command 1 active for R88D-1SAN02H-ECT	**E_Axis0_SOS_command_1_active**

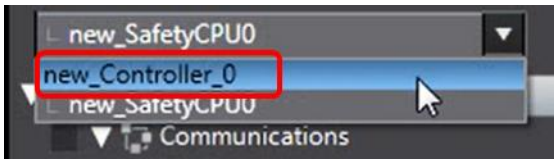
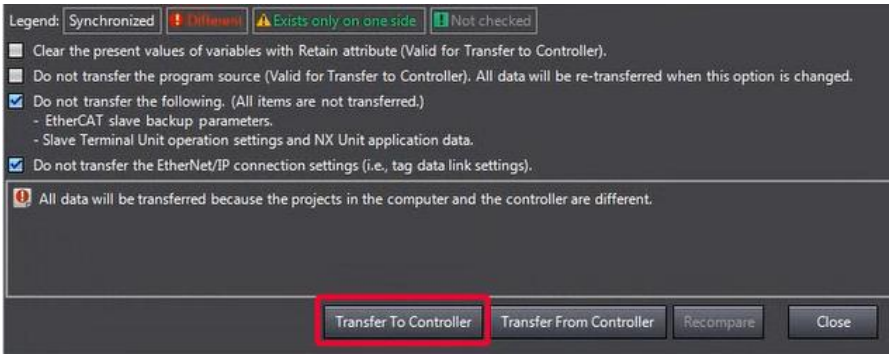
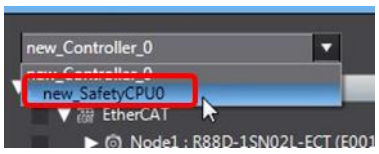
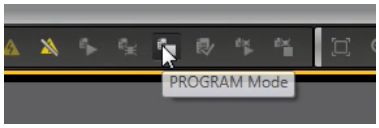
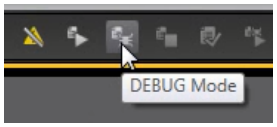
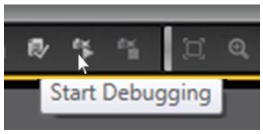


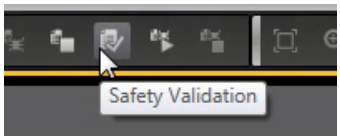
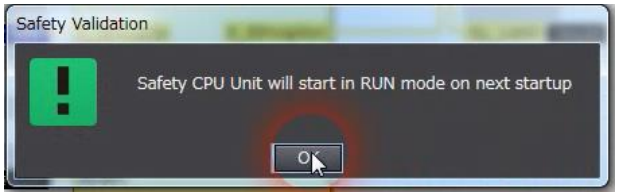
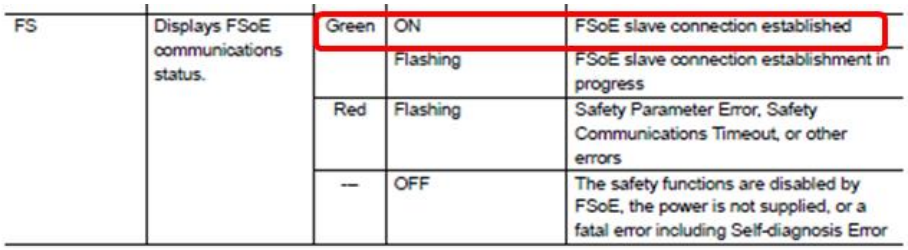
4. **Create code for the standard program.**

Add the code to change the command velocity.

- When the SS2 and SOS functions are active, reduce the command velocity to 0 r/min.
- When the SS2 and SOS functions are inactive, increase the command velocity to 600 r/min.

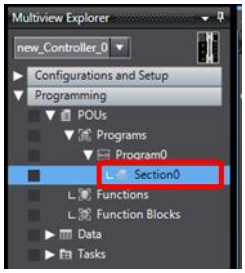


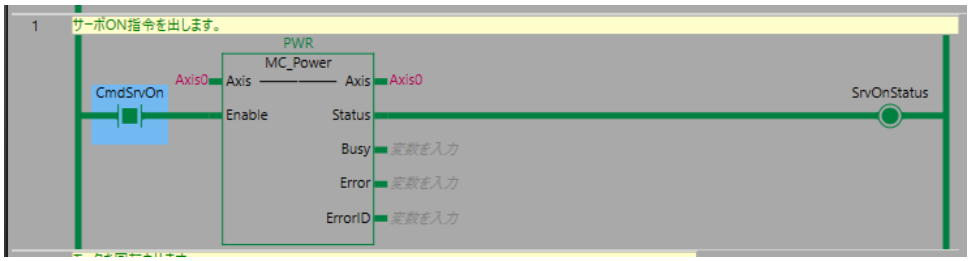
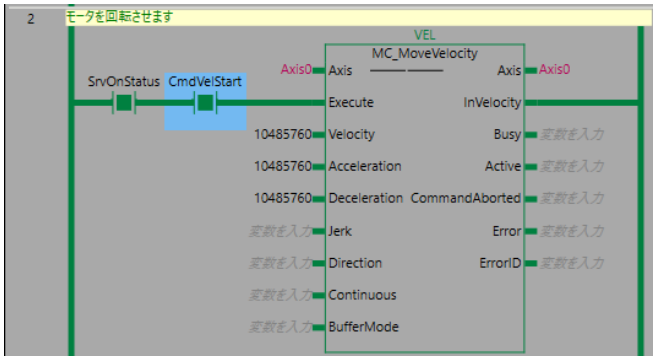
5.	**Transfer to the standard controller.** Select *new_Controller_0* from the list.  Connect to the standard controller.  Click the **Synchronization** Button to synchronize with the standard controller.  Transfer to the standard controller. 
6.	**Download the safety application.** Select *new_SafetyCPU0* 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.  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

■ Checking Operation of the SS2 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 *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 600 r/min.
6.	**Operate the Safety Key Selector Switch to switch to safety active mode.**  Check that the Servomotor decelerates to a stop. Check that the 7-segment LED display shows ‘SF’. 
7.	**Open the guard with the Safety-door Switch.**  Check that the 7-segment LED display still shows ‘SF’.
8.	**Close the guard and press the safety reset switch.**

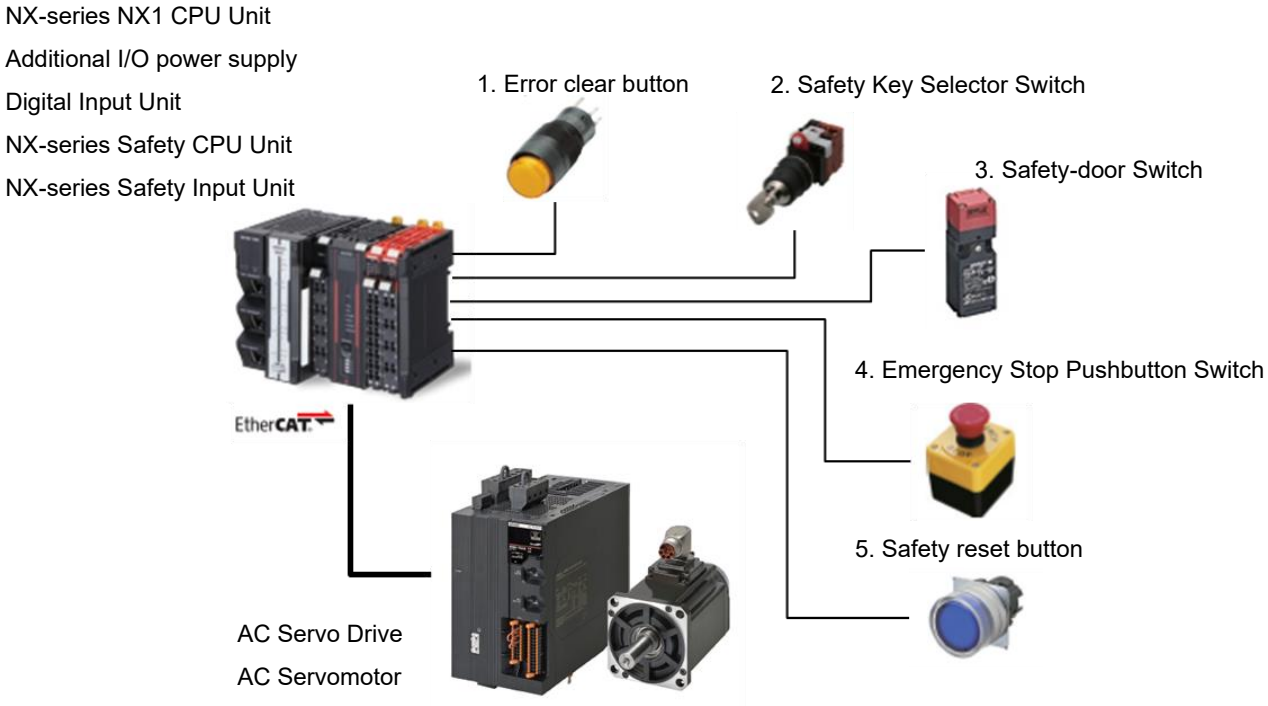
9.	**Operate the Safety key Selector Switch to switch to normal operating mode.**  Check that the Servomotor rotates at about 600 r/min. Check that the 7-segment LED display shows ‘oE.’. 

4.4. Adding the Safe Operating Stop (SOS) Function

This section describes how to add the SOS 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 Servo Drive activates the SOS function to monitor the Servomotor position and velocity.
3. When the guard with the Safety-door Switch is opened while the SOS 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.

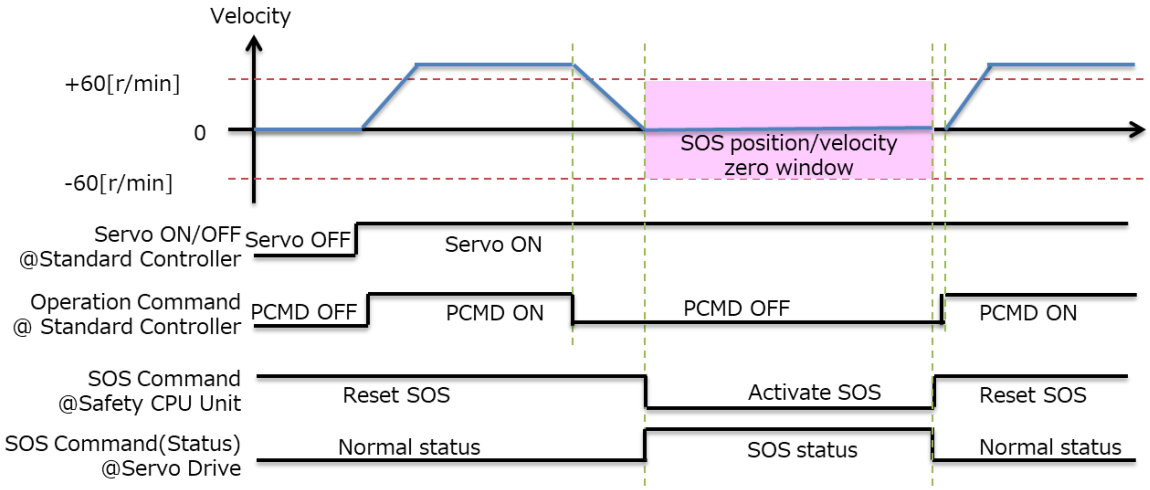


Input device	State	Operation
1. Error clear button	ON	Enable error reset command
	OFF	Disable error reset command
2. Safety Key Selector Switch	Normal operating mode	Deactivate SOS function.
	Safety active mode	Activate SOS function. When position or velocity exceeds SOS position or velocity zero window, Servo Drive goes into STO state and Excessive Limit Value Error occurs.

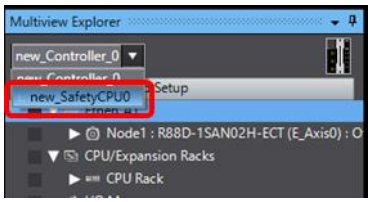
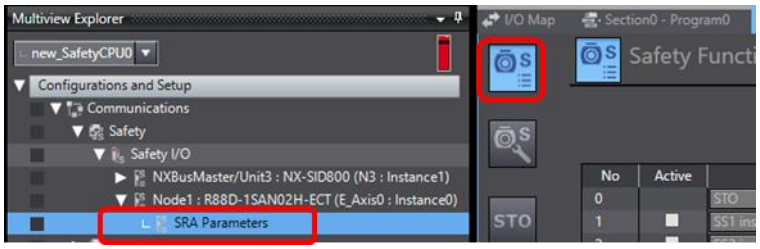
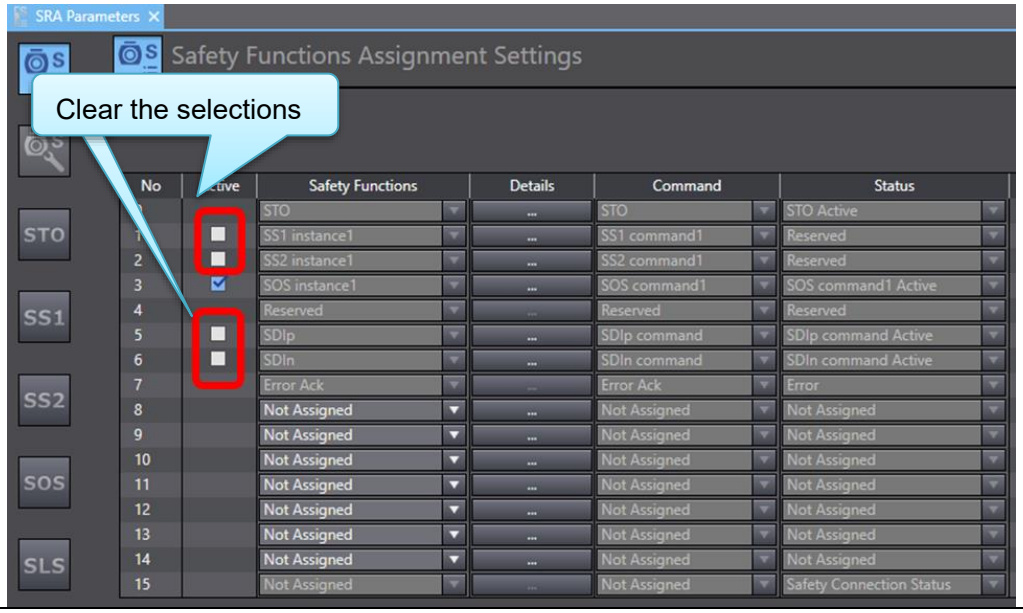
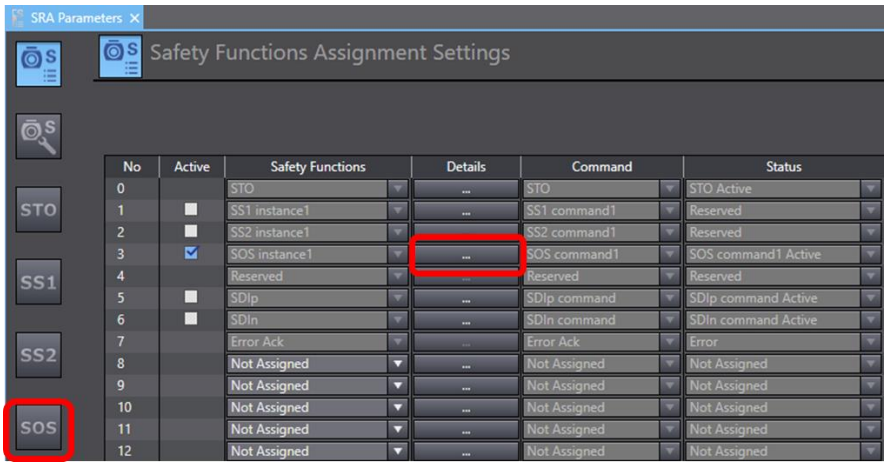
Input device	State	Operation
3. Safety-door Switch	Open	SOS function deactivated: Enable STO command SOS function activated: Disable STO command
	Close	Disable STO command
4. Emergency Stop Pushbutton Switch	ON	Enable STO command
	OFF	Disable STO command
5. Safety reset button	ON	Enable reset STO status command
	OFF	Disable reset STO status command

■ Operation of SOS 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 600 r/min.
3. When the operation command is disabled, the Servomotor decelerates to a stop.
4. When the SOS function is executed after the Servomotor stops, the Servo Drive shifts to the SOS state and monitors the motor position and velocity.
5. When the SOS function is released, the Servo Drive goes into the normal state. When an operation command is enabled, the command velocity to the Servomotor is set to 600 r/min.



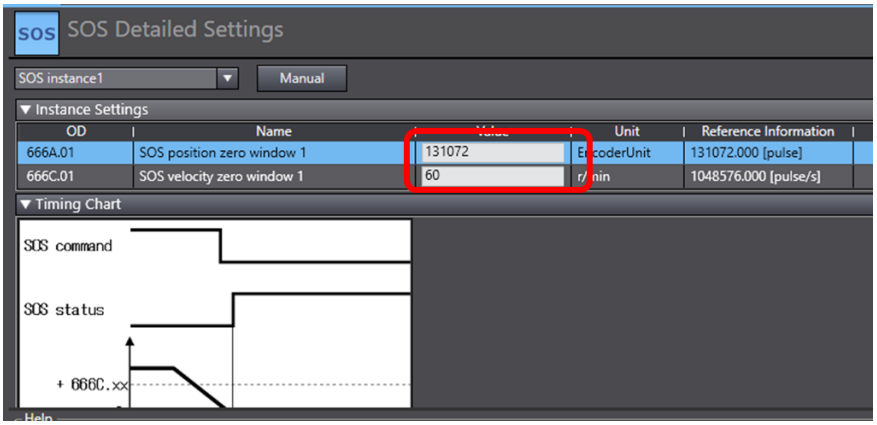
■ Setting the Safety Controller

1.	**Select *new_SafetyCPU0* from the list.** 
2.	**Double-click *SRA Parameters* and click the *Safety Function Assignment Settings* Button.** 
3.	**Assign STO, SS2 instance1, and SOS instance1.** 
4.	Click the SS2 **Button to display the SOS Detailed Settings view.** You can also use the ... Button to display the SOS Detailed Settings view. 

5. **Set SOS parameters.**

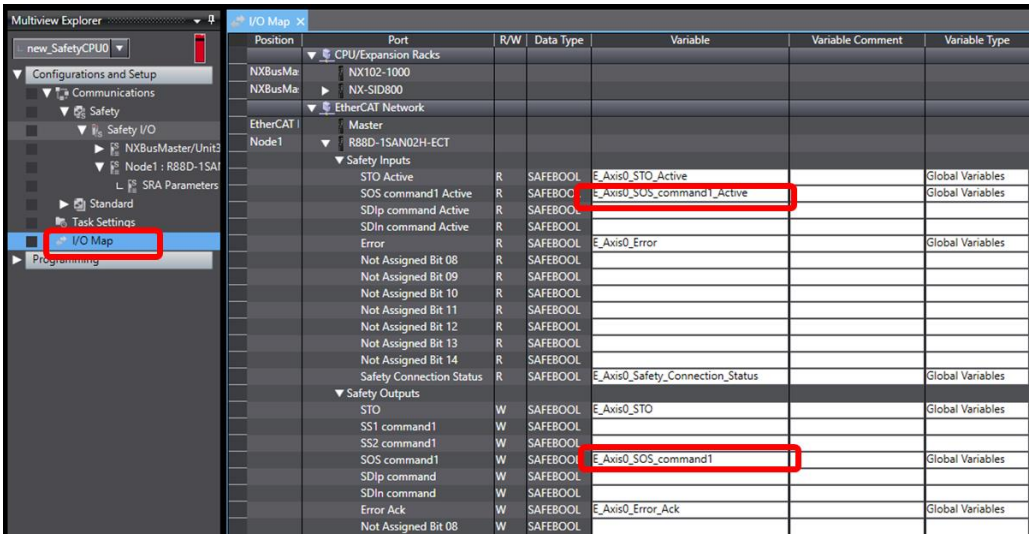
In this guide, set them as follows.

Name	Value	Unit
SOS position zero window	**131072**	**EncoderUnit**
SOS velocity zero window	**60**	**r/min**



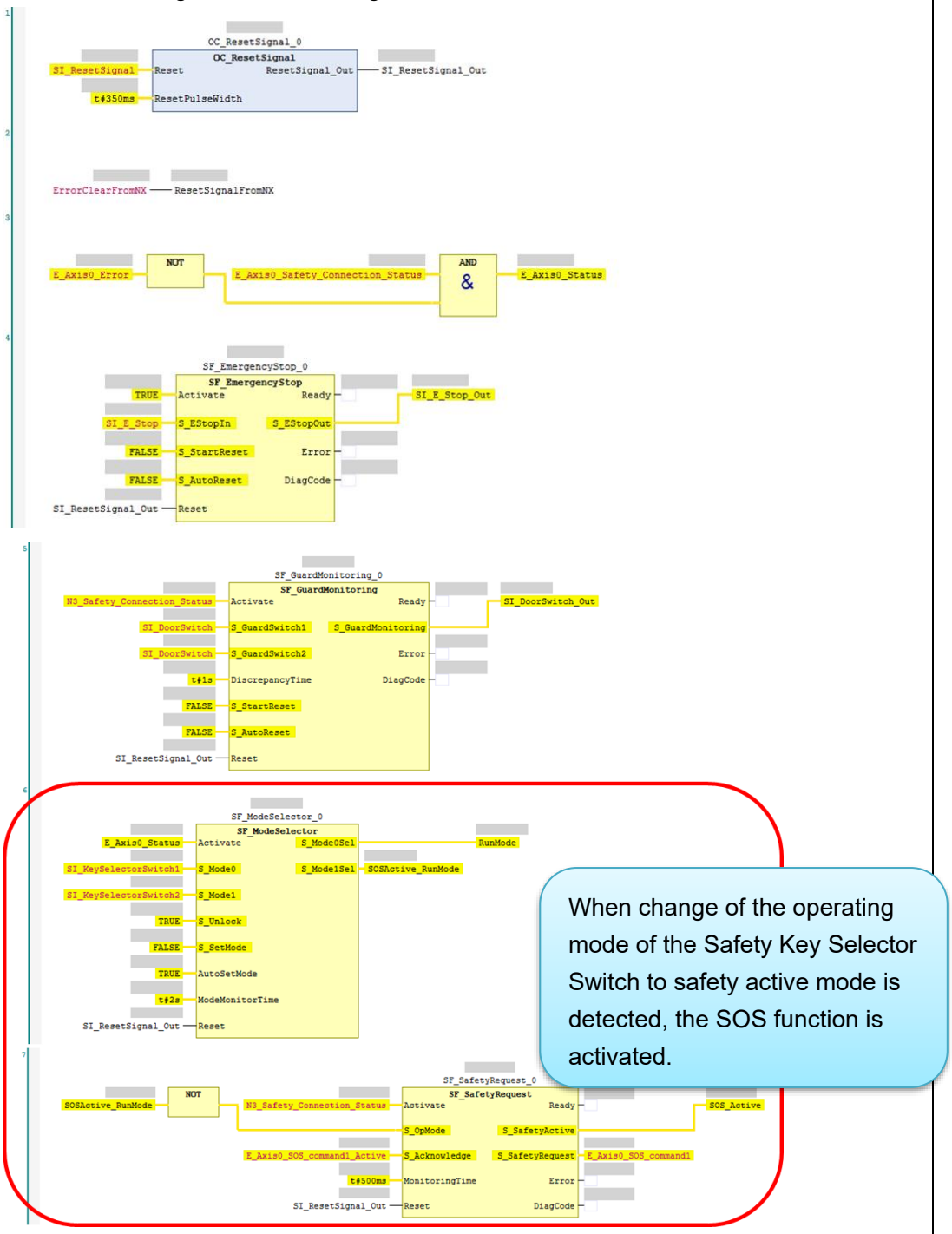
6. **Open the I/O Map and create device variables.**

Port	Variable name
SOS command1 Active for R88D-1SAN02H-ECT	**E_Axis0_SOS_command1_Active**
SOS command1 for R88D-1SAN02H-ECT	**E_Axis0_SOS_command1**

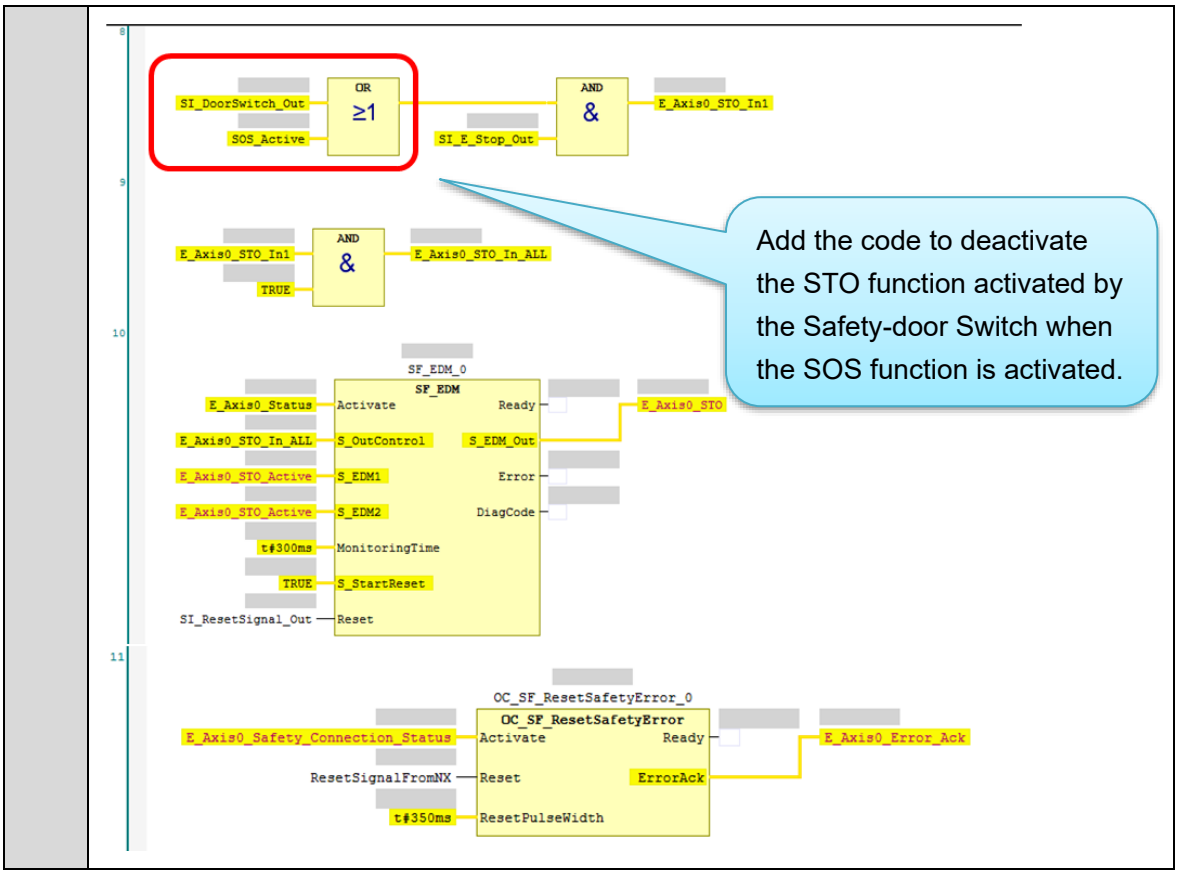


7. **Create a safety program.**

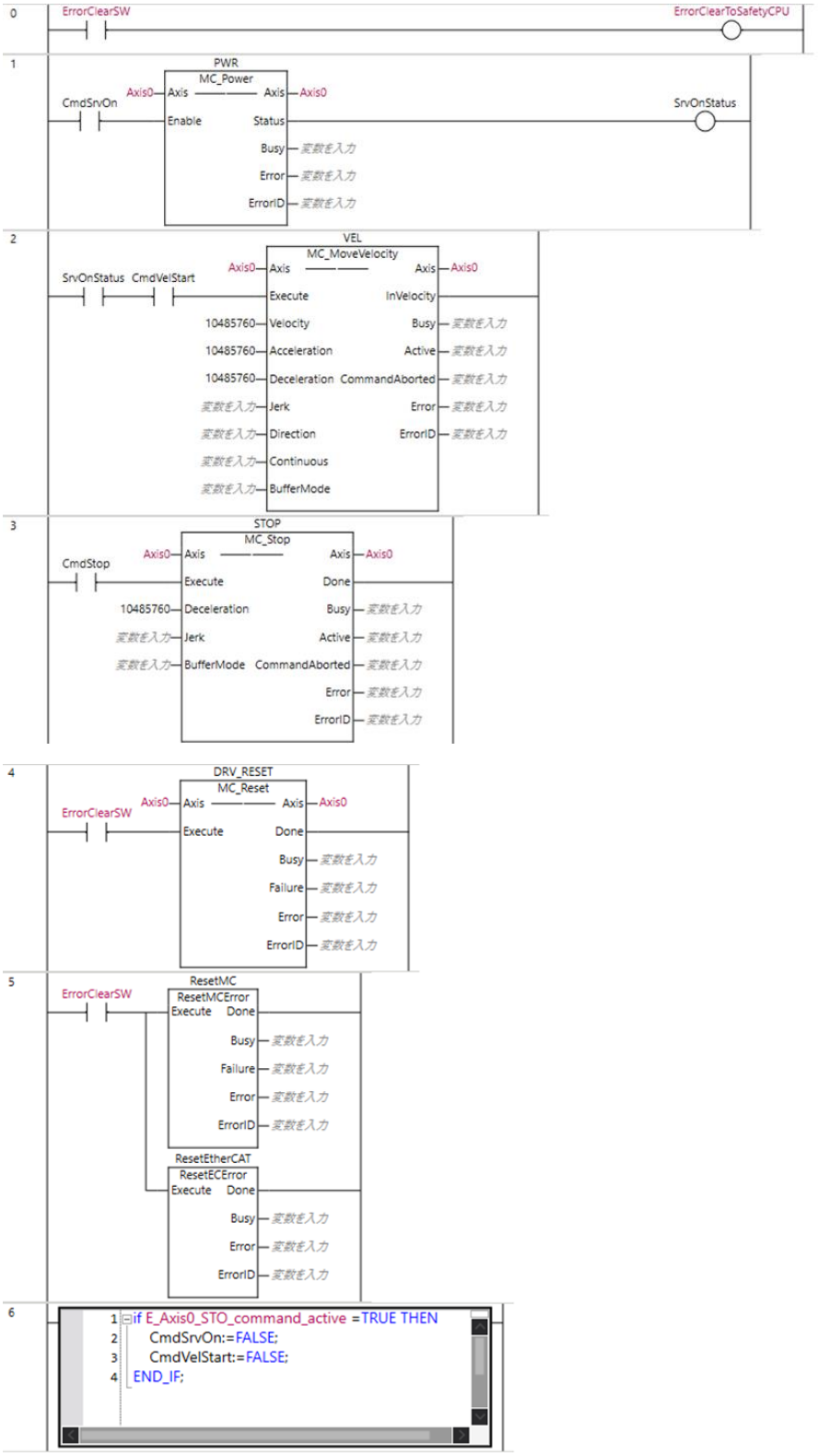
Add the following code to AutoProgram1.

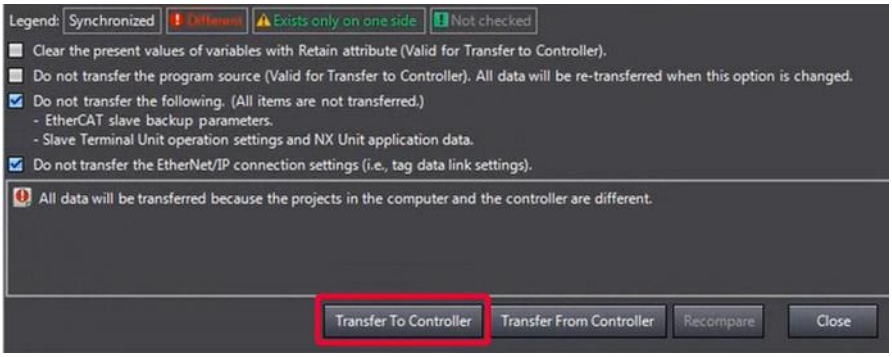
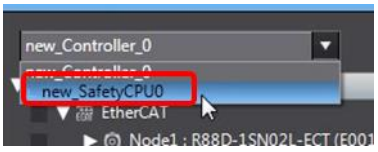
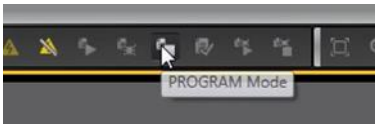
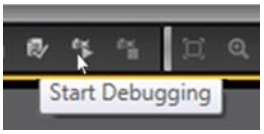


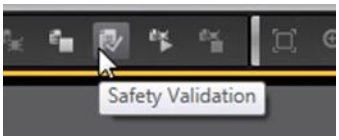
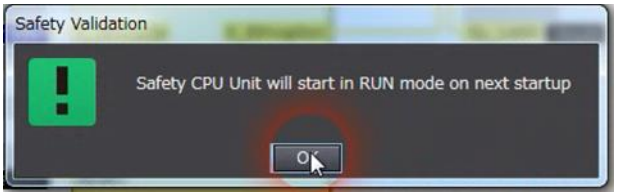
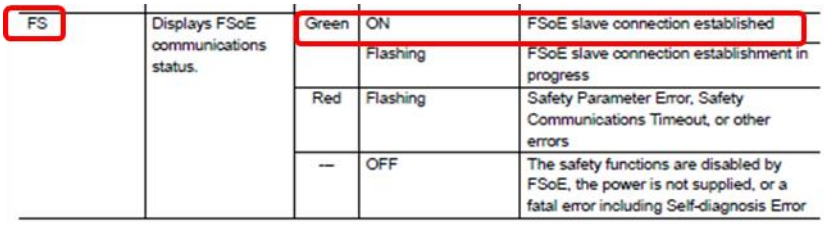
When change of the operating mode of the Safety Key Selector Switch to safety active mode is detected, the SOS function is activated.


OR
≥1
SI_DoorSwitch_Out
SOS_Active
AND
&
SI_E_Stop_Out
E_Axis0_STO_In1
AND
&
E_Axis0_STO_In1
TRUE
E_Axis0_STO_In_ALL
Add the code to deactivate the STO function activated by the Safety-door Switch when the SOS function is activated.
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

■ **Setting the Standard Controller**

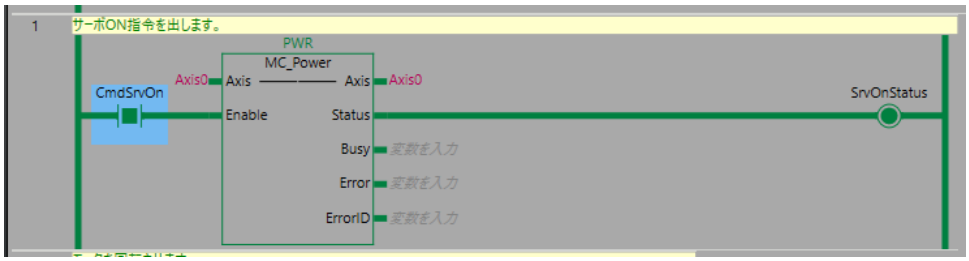
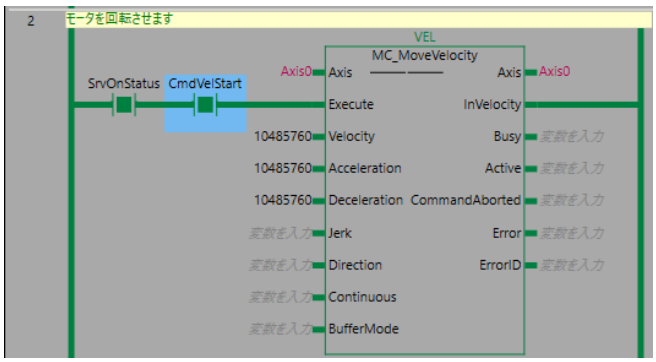
1.	**The program is the same as that of the STO function. For further details, refer to *3.6 Creating a Motor Control Program*.** **Confirm that the program is as follows.** 

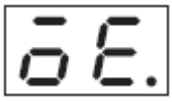
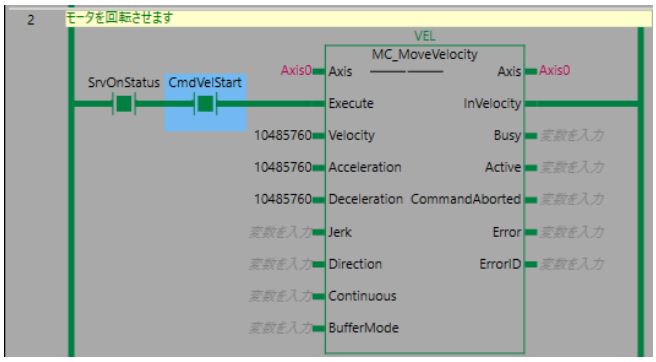
2.	**Transfer to the standard controller.** Select *new_Controller_0* from the list.  Connect to the standard controller.  Click the **Synchronization** Button to synchronize with the standard controller.  Transfer to the standard controller. 
3.	**Download the safety application.** Select *new_SafetyCPU0* 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. 
4.	**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

■ Checking Operation of the SOS 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 600 r/min.
6.	**Right-click *CmdVelStart* and select *Set/Reset – Reset*.** The Servomotor decelerates to a stop.

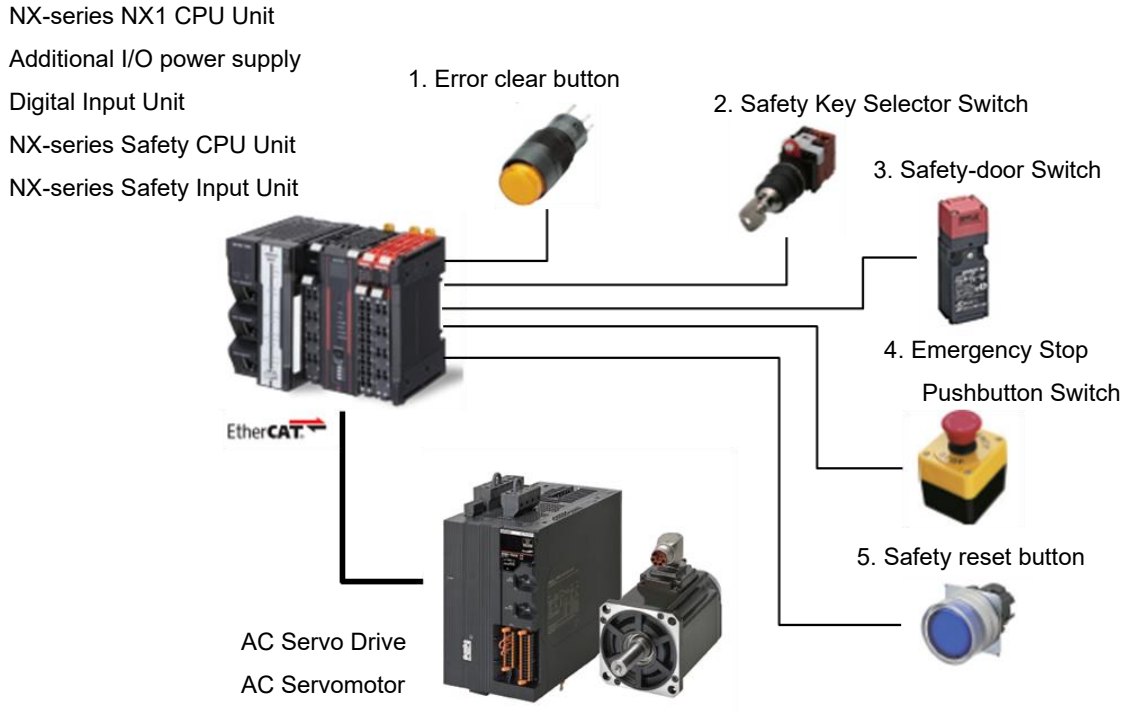
7.	**Operate the Safety Key Selector Switch to switch to safety active mode.**  Check that the 7-segment LED display shows ‘SF’. 
8.	**Open the guard with the Safety-door Switch.**  Check that the 7-segment LED display still shows ‘SF’.
9.	**Close the guard and press the safety reset switch.**
10.	**Operate the Safety Key Selector Switch to switch to normal operating mode.**  Check that the 7-segment LED display shows ‘oE.’. 
11.	**Right-click *CmdVelStart* and select *Set/Reset* – *Set*.**  The Servomotor rotates at about 600 r/min.

4.5. 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.

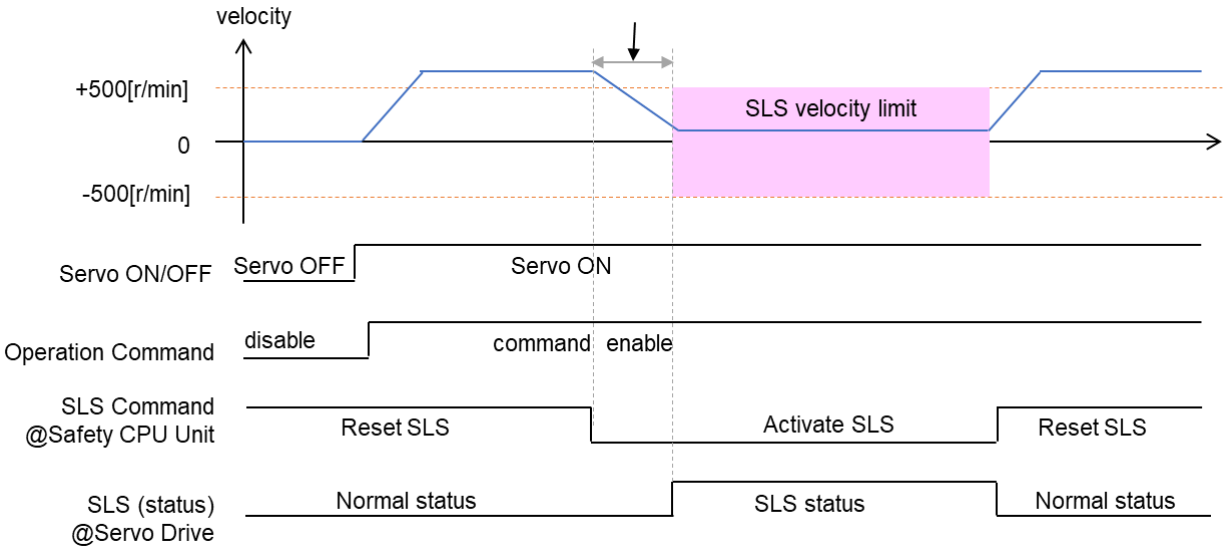
1. When the error clear button is pressed, the errors of the standard controller and Servo Drive are reset.
2. When the Safety Key Selector Switch is operated to switch to safety active mode, the standard controller changes the velocity command value to low speed. The Servo Drive activates the SLS function 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.



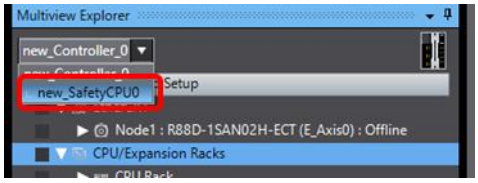
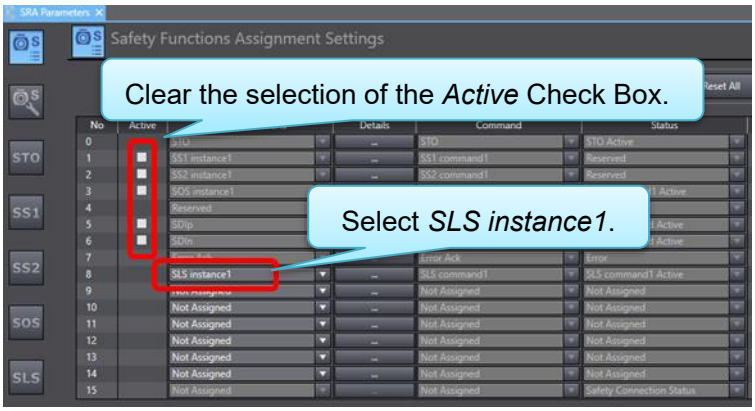
Input device	State	Operation
1. Error clear button	ON	Enable error reset command
	OFF	Disable error reset command
2. Safety Key Selector Switch	Normal operating mode	Run Servomotor at 600 [r/min] and deactivate SLS function.
	Safety active mode	Run Servomotor at 60 [r/min] and activate SLS function. 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 600 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 60 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 600 r/min.



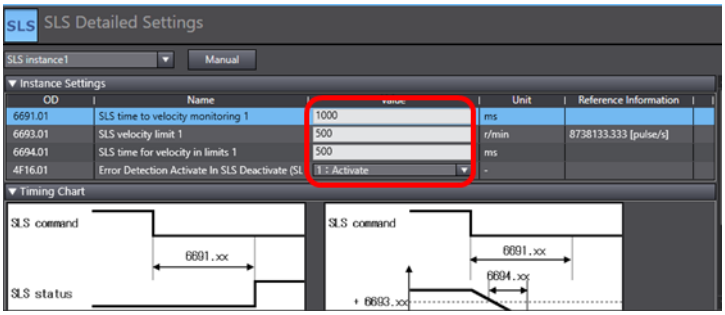
■ **Setting the Safety Controller**

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.**

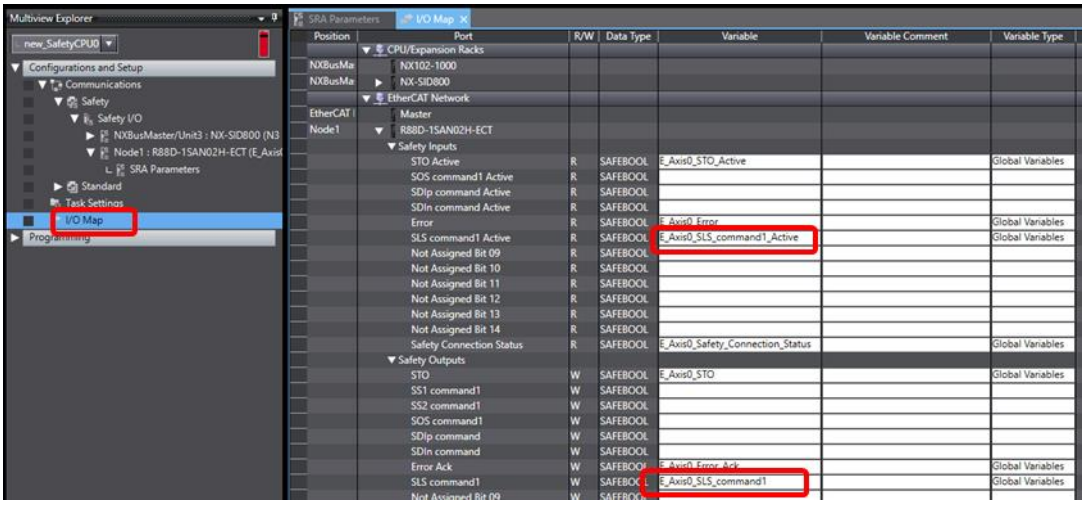
In this Guide, set as follows:

Name	Value	Unit
SLS time to velocity monitoring 1	1000	ms
SLS velocity limit 1	500	r/min
SLS time for velocity in limits 1	1000	ms
Error Detection Activate In SLS Deactivate 1	Activate	-



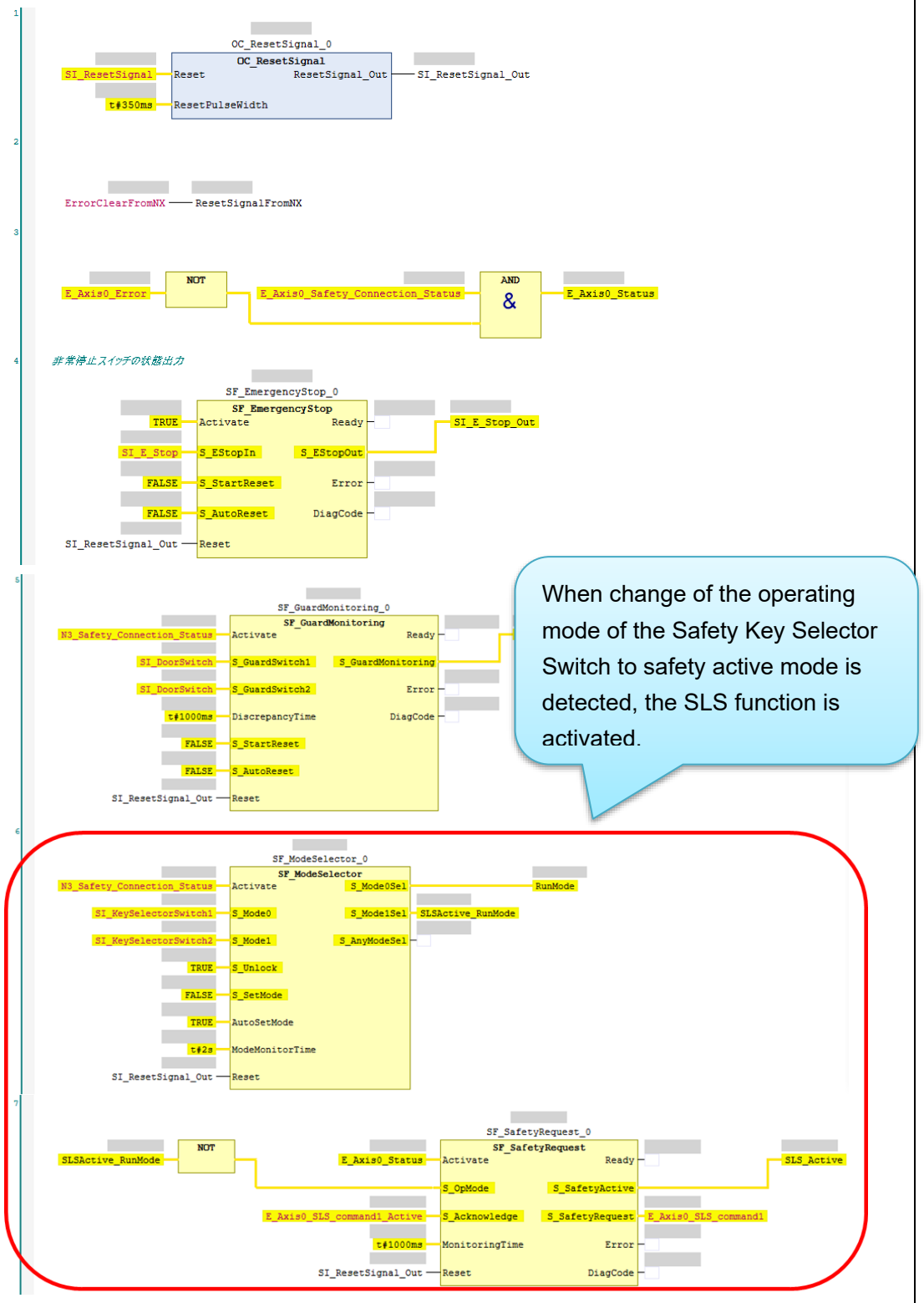
6. **Open the I/O Map and create device variables.**

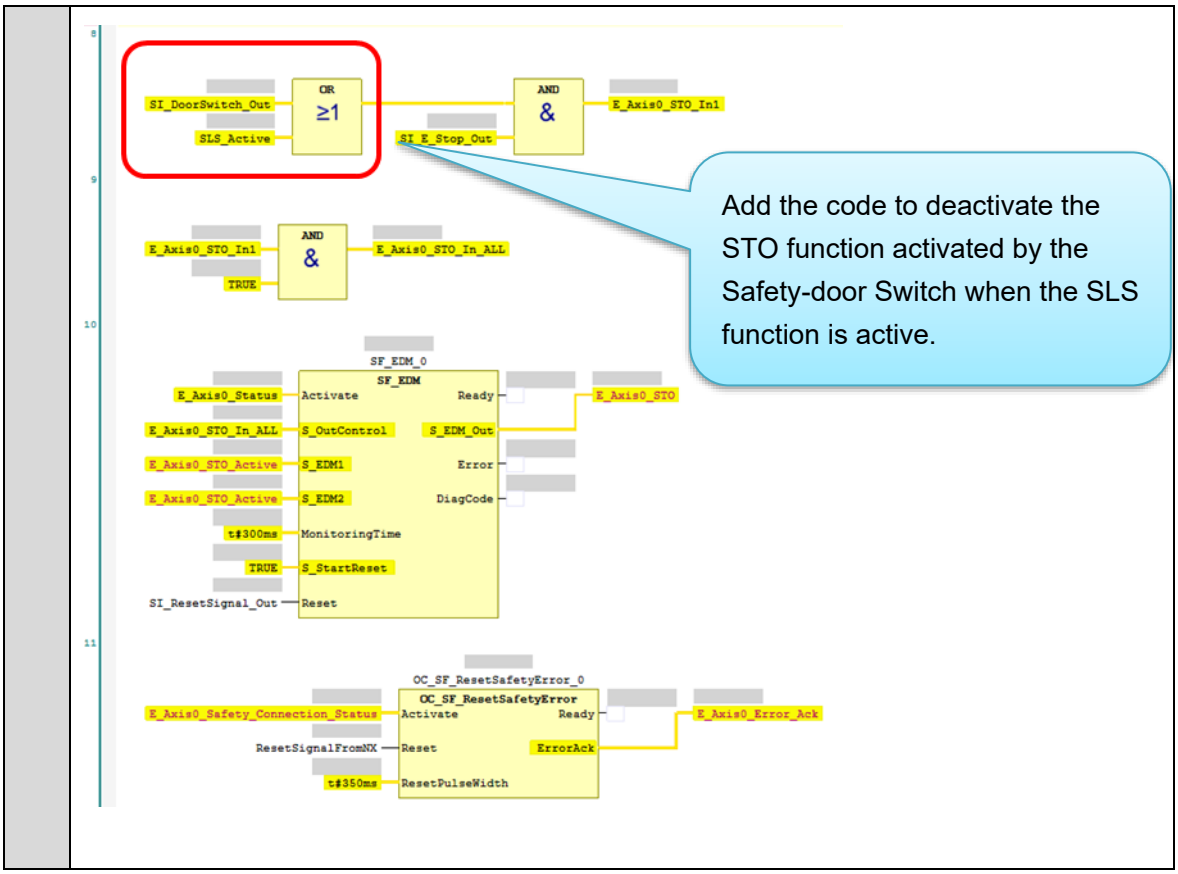
Port	Variable name
SLS command1 Active for R88D-1SAN02H-ECT	**E_Axis0_SLS_command1_Active**
SLS command1 for R88D-1SAN02H-ECT	**E_Axis0_SLS_command1**



7. **Create a safety program.**

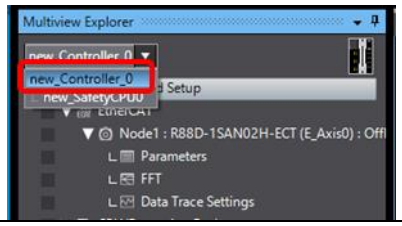
Add the following code to AutoProgram1.



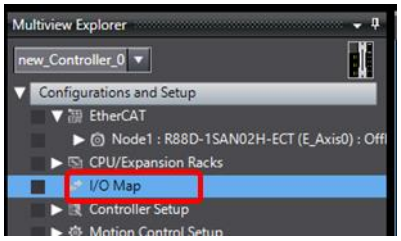

SI_DoorSwitch_Out
SLS_Active
OR
≥1
AND
&
SI_E_Stop_Out
E_Axis0_STO_In1
E_Axis0_STO_In1
TRUE
AND
&
E_Axis0_STO_In_ALL
SF_EDM_0
SF_EDM
E_Axis0_Status
Activate
Ready
E_Axis0_STO
E_Axis0_STO_In_ALL
S_OutControl
S_EDM_Out
E_Axis0_STO_Active
S_EDM1
Error
E_Axis0_STO_Active
S_EDM2
DiagCode
t#300ms
MonitoringTime
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.

■ Setting the Standard Controller

1. **Select *new_Controller_0* from the list**

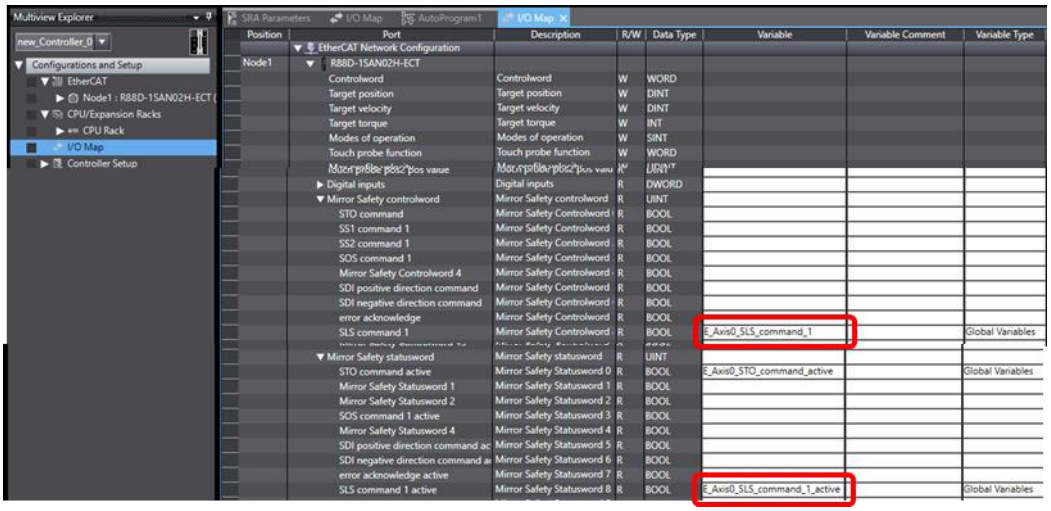


2. **Double-click *I/O Map*.**



3. **Create device variables.**

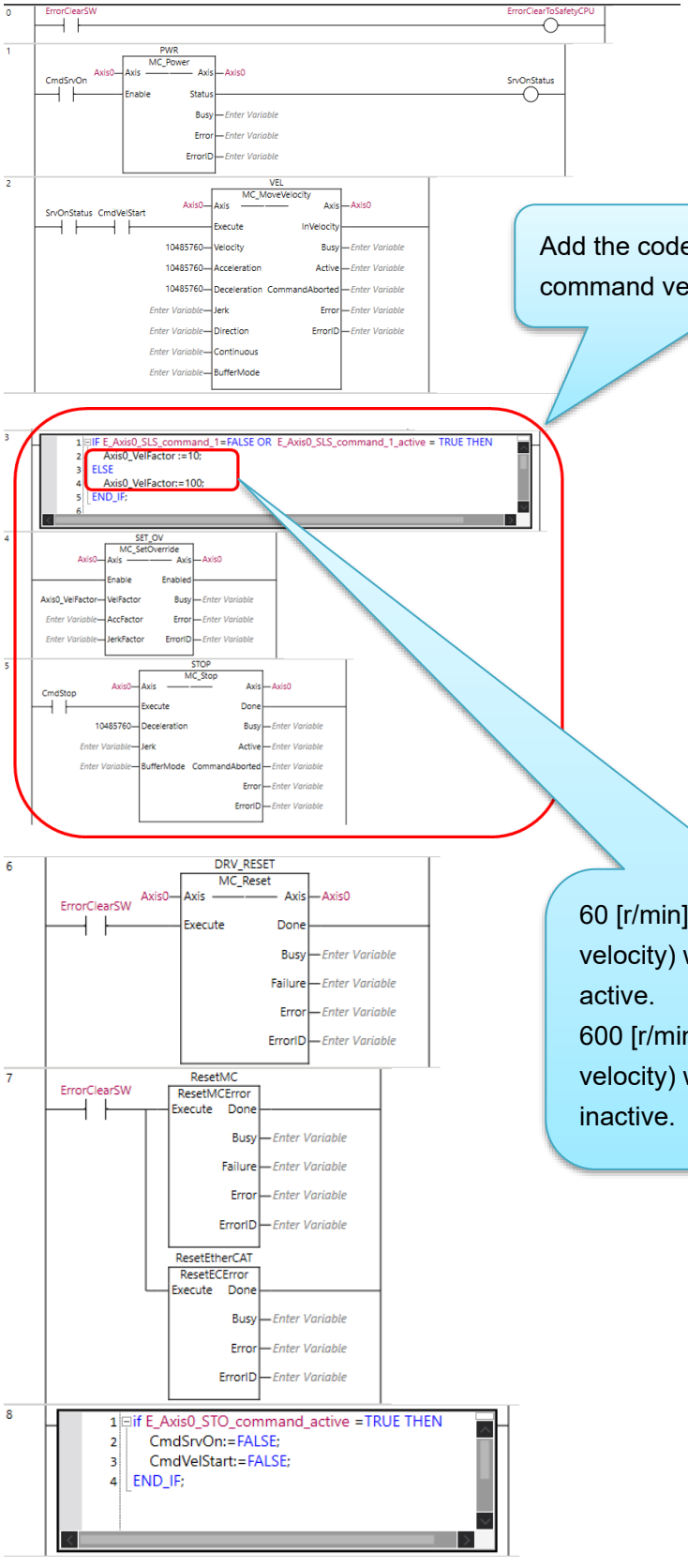
Port	Variable name
SLS command 1 for R88D-1SAN02H-ECT	**E_Axis0_SLS_command_1**
SLS command 1 active for R88D-1SAN02H-ECT	**E_Axis0_SLS_command_1_active**



4. **Create a standard program.**

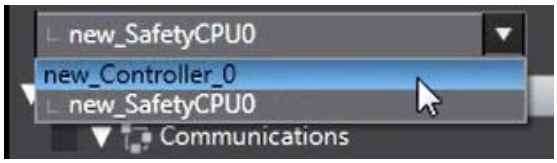
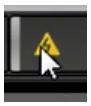
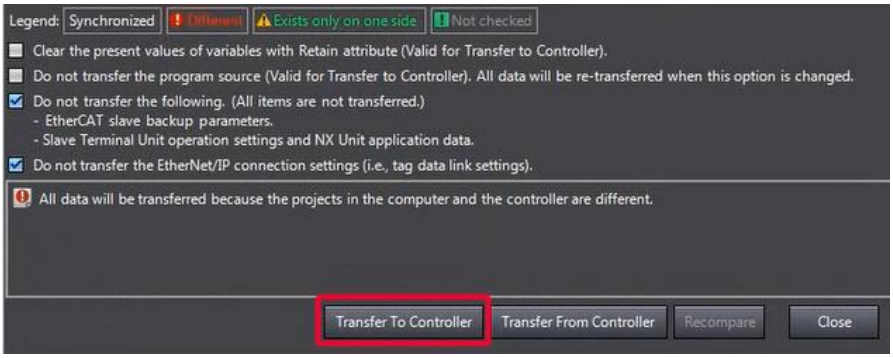
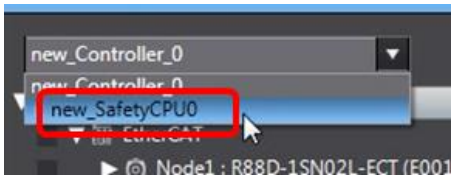
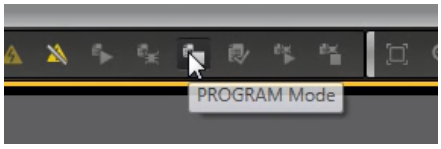
Add the code to change the command velocity.

- When the SLS function is active, reduce the command velocity to 60 r/min.
- When the SLS function is inactive, increase the command velocity to 600 r/min.

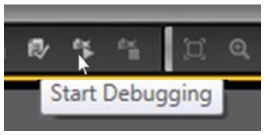


Add the code to change the command velocity here.

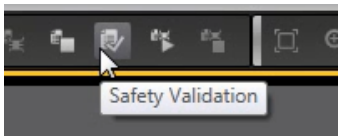
60 [r/min] (10% of command velocity) when the SLS function is active.
600 [r/min] (100% of command velocity) when the SLS function is inactive.

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. 

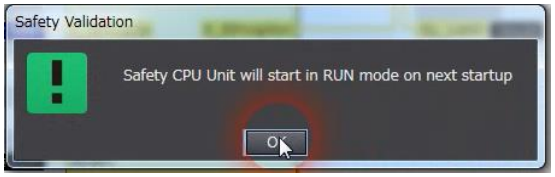
Click the **Start Debugging** Button to start DEBUG mode.



Click the **Safety Validation** Button.



The safety application is now ready to run.



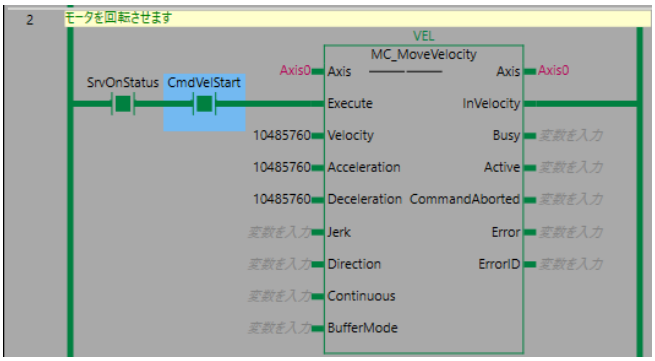
Click the **Run** Button.

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

■ **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 600 r/min.
5.	**Operate the Safety Key Selector Switch to switch to safety active mode.**  Check that the Servomotor rotates at about 60 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 600 r/min. Check that the 7-segment LED display shows ‘oE.’. 

4.6. Adding the Safely-limited Position (SLP) Function

This section describes how to add the SLP function (*SOPT1 and SOPT2 Input* in *Safety Origin Position Determination Method*) to the project created in *3. Performing Setup*.

■ Changes in System Configuration

Add the SOPT1 and SOPT2 input sensors.

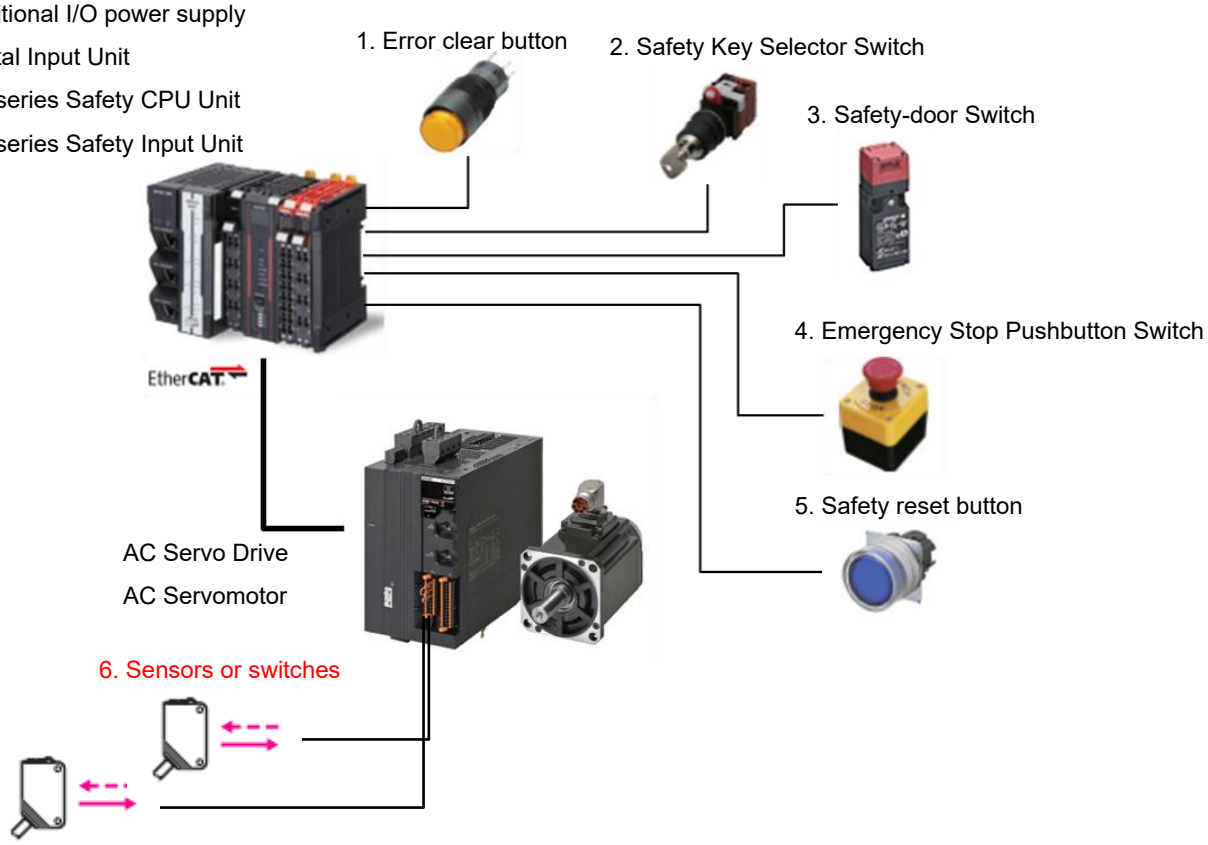
NX-series NX1 CPU Unit

Additional I/O power supply

Digital Input Unit

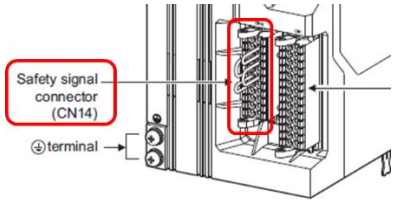
NX-series Safety CPU Unit

NX-series Safety Input Unit



■ Changes in Wiring

1.	**Plug the wires for SOPT1 and SOPT2 into the Servo Drive. (CN14)**



Safety I/O Signal Table

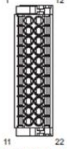
Pin No.	Symbol	Signal name	Pin No.	Symbol	Signal name
1	EDM+P	EDM+ Output with short-circuit protection	12	EDM-	EDM- Output
2	EDM+	EDM+ Output without short-circuit protection	13	SFA	Reserved
3	SF1+	SF1+ Input	14	SF1+	SF1+ Input
4	SF1-	SF1- Input	15	SF1-	SF1- Input
5	SF2+	SF2+ Input	16	SF2+	SF2+ Input
6	SF2-	SF2- Input	17	SF2-	SF2- Input
7	SFB	Reserved	18	NC	Reserved
8	TO1	Test Output 1	19	TO2	Test Output 2
9	SOPT1	SOPT1 Input	20	SOPT2	SOPT2 Input
10	IOV	Test output, 24-V power supply for SOPT input (+)	21	IOG	Test output, 24-V power supply for SOPT input (-)
11	FG	FG	22	FG	FG

● Connector for CN14 (22 Pins)

Model	Manufacturer	Omron model
DFMC1,5/11-ST-3,5-LRBK	PHOENIX CONTACT	R88A-CN101S*1

*1. Four short-circuit wires are connected to the connector.
Connection combinations:
3: SF1+ and 5: SF2+
6: SF2- and 7: SFB
13: SFA and 14: SF1+
15: SF1- and 17: SF2-

Applicable wire: AWG 24 to 16 (0.2 to 1.5 mm²) (Strip length of the wire insulating cover: 10 mm)



Note Connectors at Servo Drives side include a pin to prevent improper connection.

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

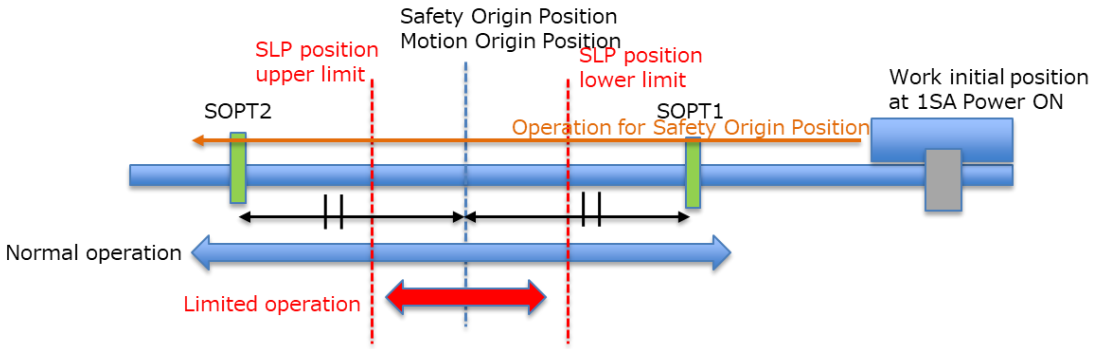
1. When the error clear button is pressed, the errors of the standard controller and Servo Drive are reset.
2. When the Safety Key Selector Switch is operated to switch to safety active mode, the Servo Drive activates the SLP function to monitor the Servomotor position. Before switching to safety active mode, you need to perform operation to limit the operating range (operation within the monitoring range) from the standard controller.
3. When the guard with the Safety-door Switch is opened while the SLP 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	Deactivate SLP function.
	Safety active mode	Activate SLP function. When SLP position upper/lower limit range is exceeded, Servo Drive goes into STO state and Excessive Limit Value Error occurs.
3. Safety-door Switch	Open	SLP function deactivated: Enable STO command SLP 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

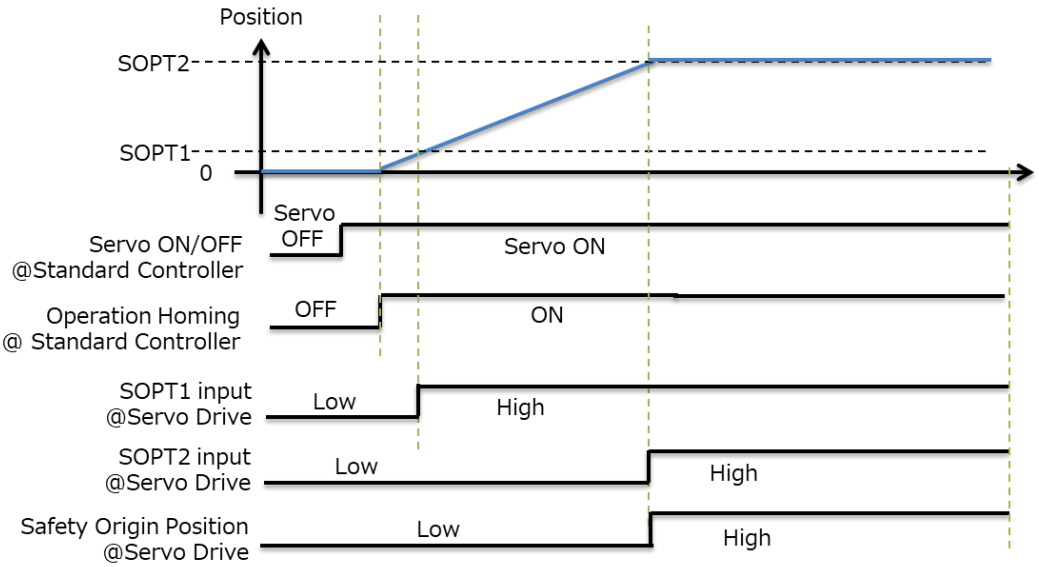
■ Operation of SLP Function with Motion Control

1. When the Servo ON command is enabled, the Servo Drive turns ON the Servo.
2. When the origin determination command is enabled, the Servo Drive starts a safety origin determination operation. The Servomotor velocity recommended for origin determination operation is 200 r/min or less. Once the safety origin is determined, the Servo Drive sets it as the motion origin.
3. When the operation command is enabled, the Servomotor performs a reciprocating operation with a motor shaft travel distance of 4 rotations.
4. When the operation limit command is enabled, the Servomotor performs a reciprocating operation with a motor shaft travel distance of 2 rotations (within the SLP position upper/lower limit range).
5. When the SLP function is executed, the Servo Drive goes into the SLP state and monitors the position.
6. When the SLP function is released, the Servo Drive goes into the normal state.
7. When the operation limit command is disabled, the Servo Drive performs a reciprocating operation with a motor shaft travel distance of 4 rotations.

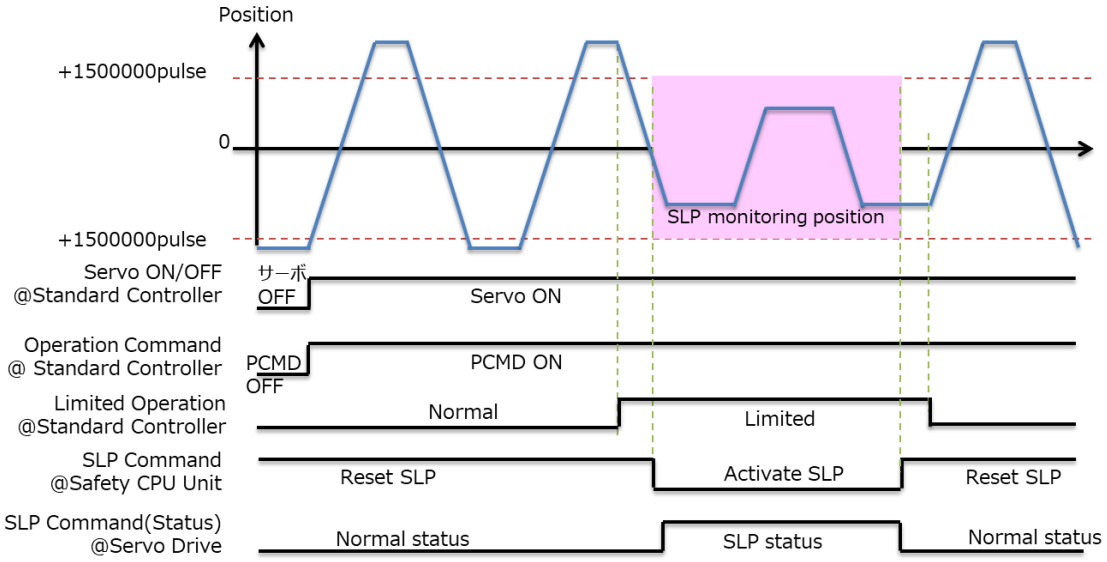
■ Procedure for Safety Origin Position Determination



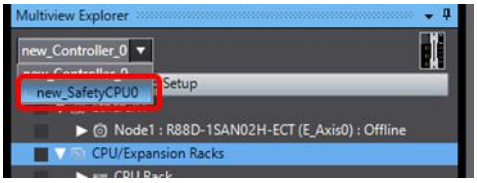
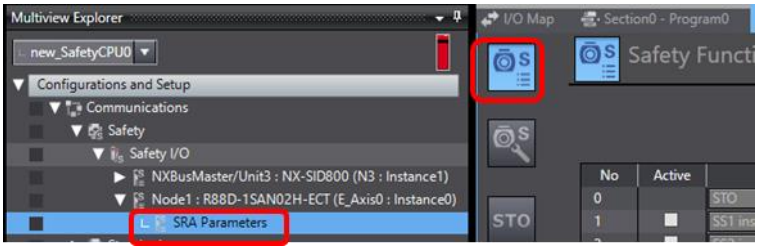
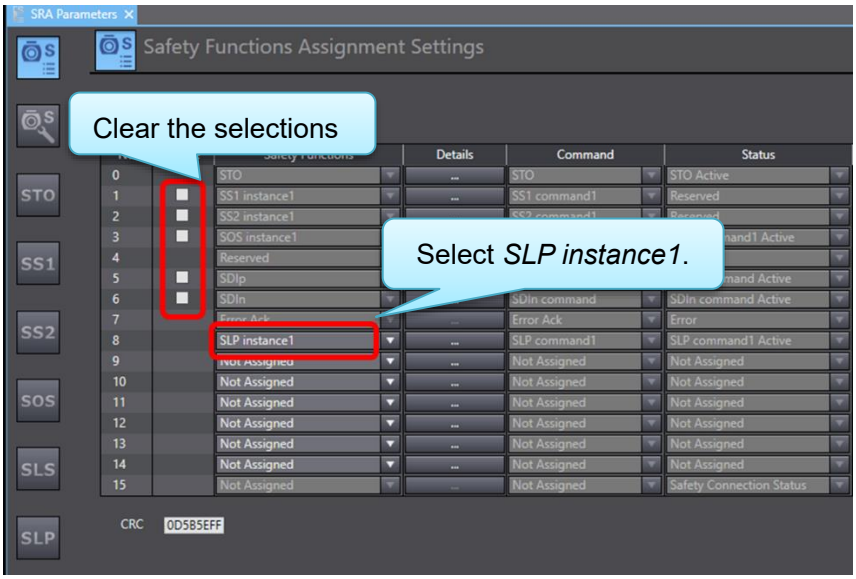
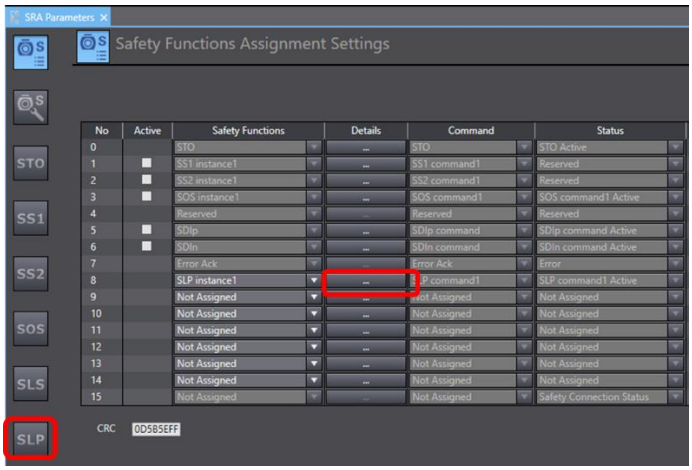
■ Safety Origin Determination Operation



■ SLP Monitoring Operation



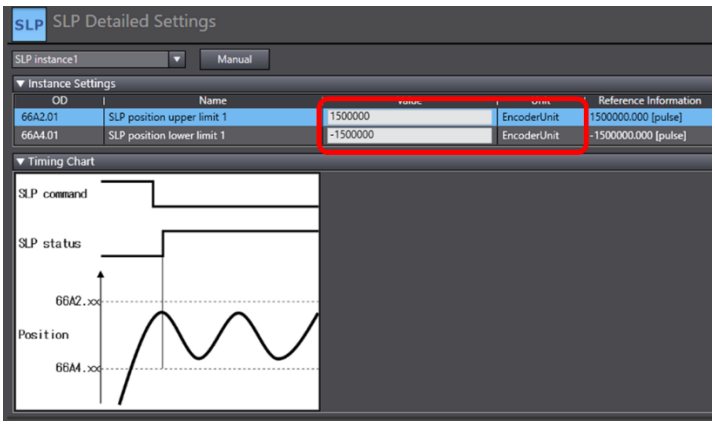
■ Setting the Safety Controller

1.	**Select *new_SafetyCPU0* from the list.** 
2.	**Click *SRA Parameters* and click the *Safety Function Assignment Settings* Button.** 
3.	**Assign the SLP function.** 
4.	**Click the SLS Button to display the SLP Detailed Settings view.** You can also use the ... Button to display the SLP Detailed Settings view. 

5. **Set SLP parameters.**

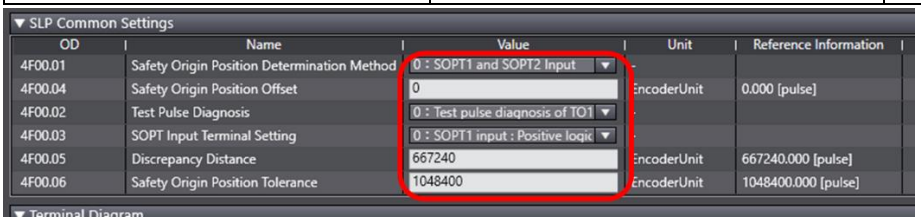
In this guide, set them as follows.

Name	Value	Unit
SLP position upper limit 1	1500000	EncoderUnit
SLP position lower limit 1	-1500000	EncoderUnit



Set SLP common settings.

Name	Value	Unit
Safety Origin Position Determination Method	0: SOPT1 and SOPT2 Input	-
Safety Origin Position Offset	0	EncoderUnit
Test Pulse Diagnosis	0: Test pulse diagnosis of TO1 output is not enable / Test pulse diagnosis of TO2 output is not enable	-
SOPT Input Terminal Setting	0: SOPT1 input : Positive logic / SOPT2 input : Positive logic	-
Discrepancy Distance	667240	EncoderUnit
Safety Origin Position Tolerance	1048400	EncoderUnit

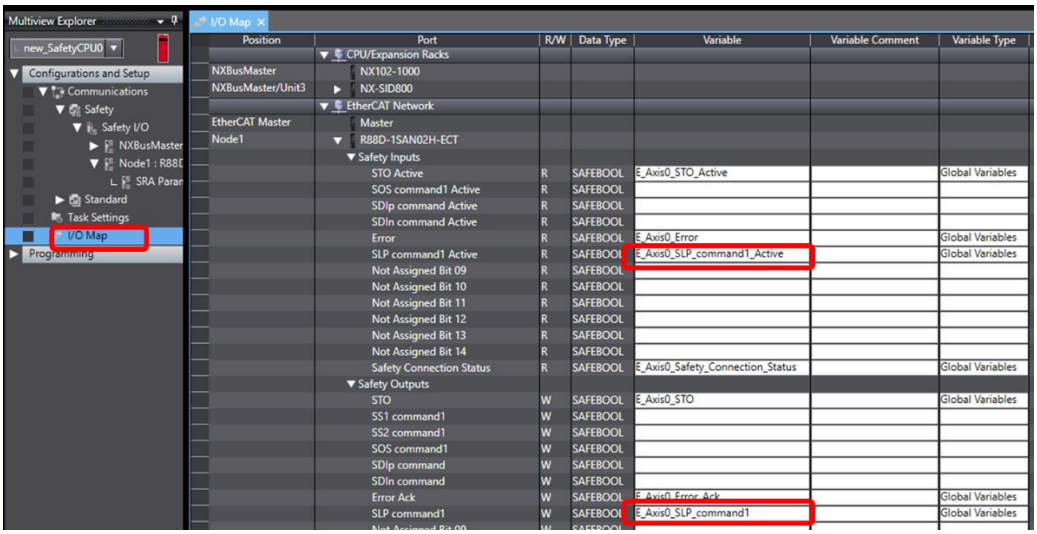


Procedure for Discrepancy Distance Setting

1) Set *Safety Origin Position Determination Method*, *Test Pulse diagnosis*, and *SOPT Input Terminal Setting* according to the sensor.
2) Set *Discrepancy Distance* to *-1*.
3) Set *Re-measurement of Discrepancy Distance Monitoring* to let a work carry out the behavior of origin determination shown in *Safety Origin Position Determination Method*.
4) Use the Discrepancy Distance Monitor to read the distance between the SOPTs.
5) After confirming the validity of this value, set *Discrepancy Distance* and *Safety Origin Position Tolerance*.

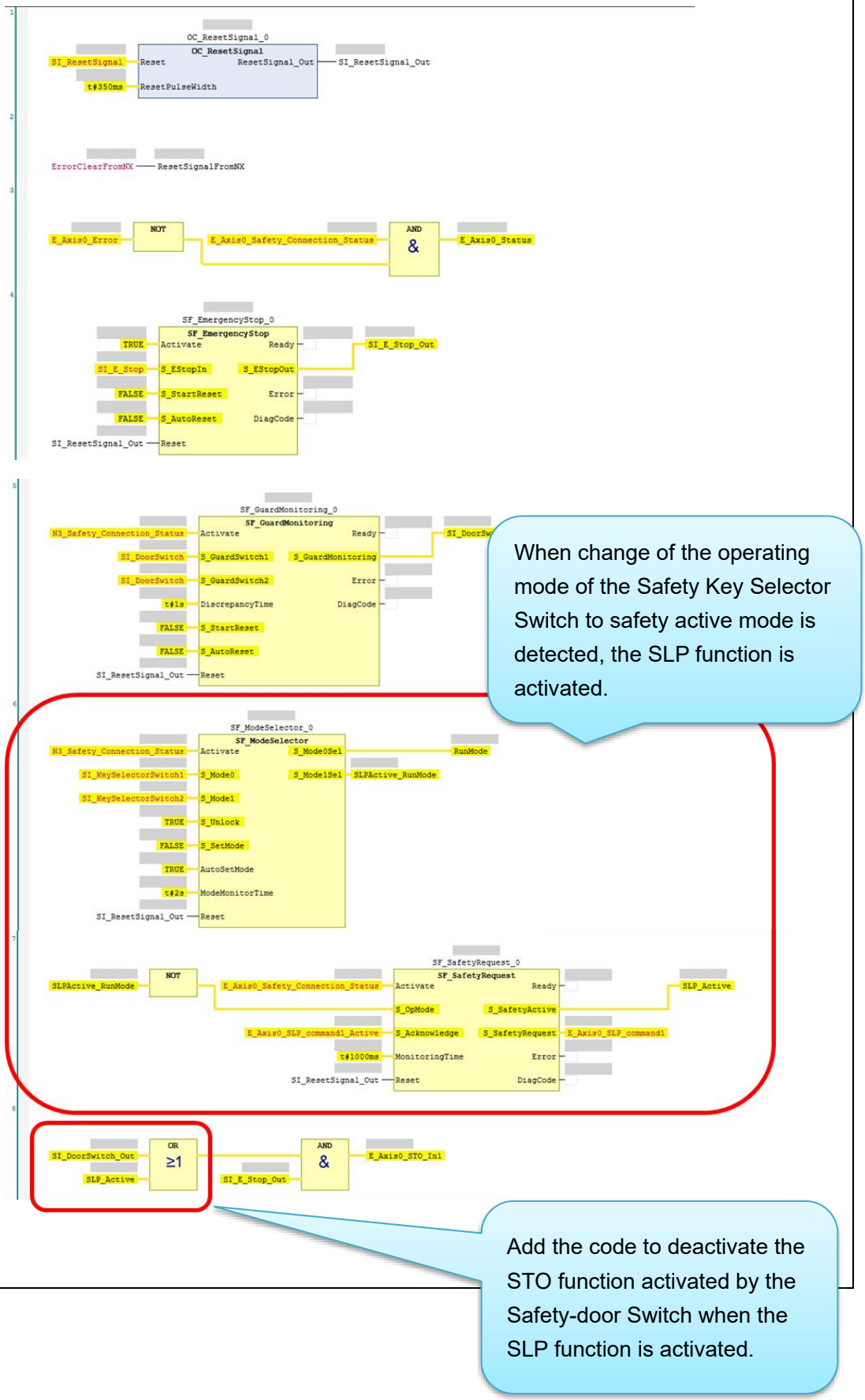
	* Set the above values after thoroughly verifying that the device safety can be secured even if the safety origin position is shifted.
6.	**Open the I/O Map and create device variables.**

Port	Variable name
SLP command1 Active for R88D-1SAN02H-ECT	**E_Axis0_SLP_command1_Active**
SLP command1 for R88D-1SAN02H-ECT	**E_Axis0_SLP_command1**



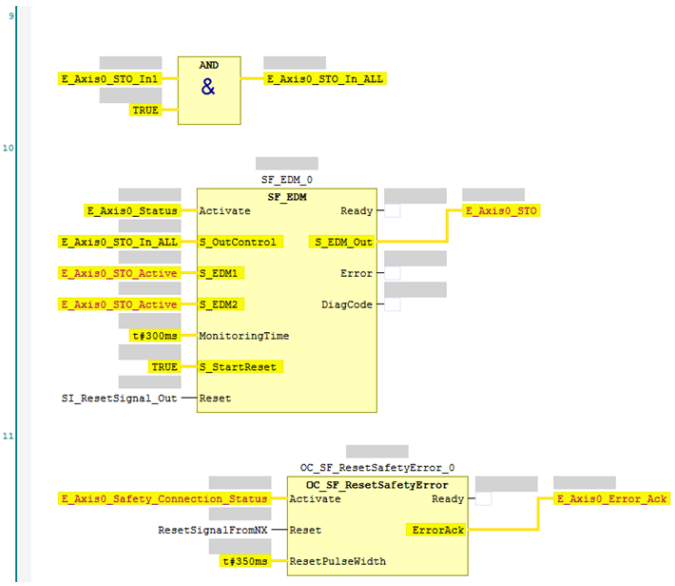
7. **Create a safety program.**

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 SLP function is activated.

Add the code to deactivate the STO function activated by the Safety-door Switch when the SLP function is activated.

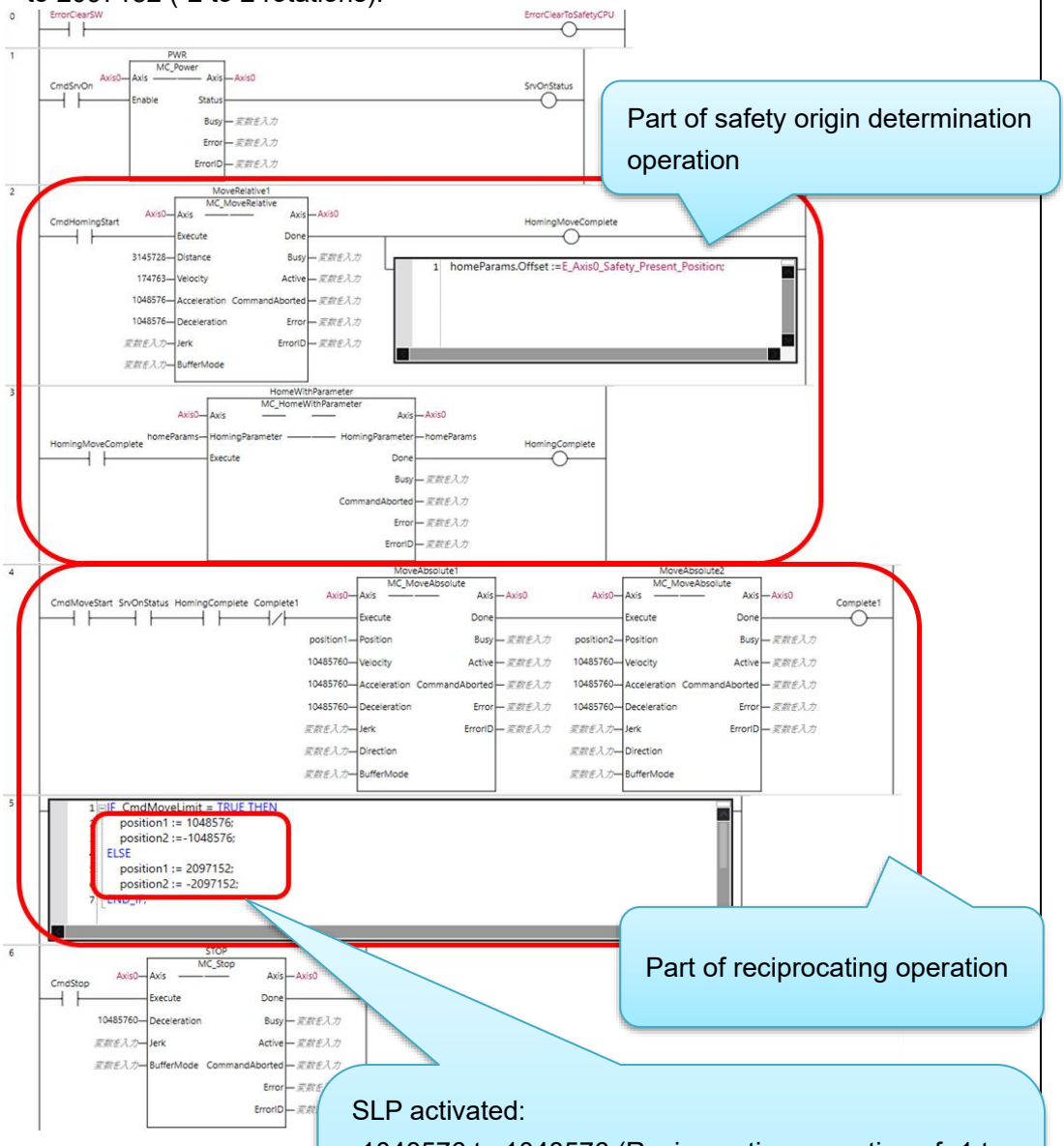

9
AND
&
E_Axis0_STO_In1
TRUE
E_Axis0_STO_In_ALL
10
SF_EDM_0
SF_EDM
E_Axis0_Status
Activate
Ready
E_Axis0_STO
E_Axis0_STO_In_ALL
S_OutControl
S_EDM_Out
E_Axis0_STO_Active
S_EDM1
Error
E_Axis0_STO_Active
S_EDM2
DiagCode
t#300ms
MonitoringTime
TRUE
S_StartReset
SI_ResetSignal_Out
Reset
11
OC_SF_ResetSafetyError_0
OC_SF_ResetSafetyError
E_Axis0_Safety_Connection_Status
Activate
Ready
E_Axis0_Error_Ack
ResetSignalFromNX
Reset
ErrorAck
t#350ms
ResetPulseWidth

■ Setting the Standard Controller

1. **Create code for the standard program.**

   Add the code to change the travel distance.

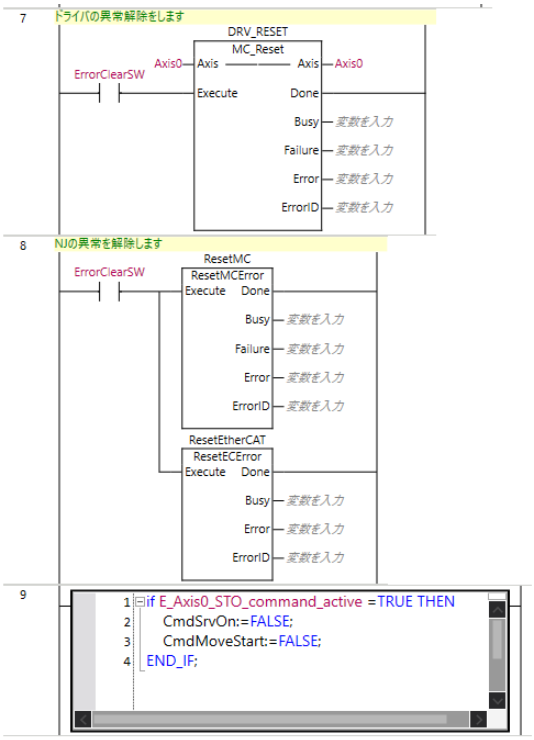
   - When the operation limit command is enabled, set the travel distance to -1048576 to 1048576 (-1 to 1 rotation).
   - When the operation limit command is disabled, set the travel distance to -2097152 to 2097152 (-2 to 2 rotations).



Part of safety origin determination operation

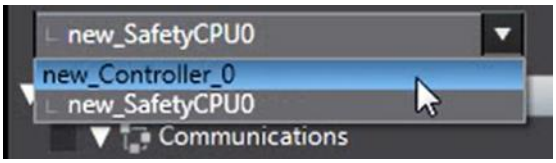
Part of reciprocating operation

SLP activated:
-1048576 to 1048576 (Reciprocating operation of -1 to 1 rotation)
SLP deactivated:
-2097152 to 2097152 (Reciprocating operation of -2 to 2 rotations)



2. **Transfer to the standard controller.**

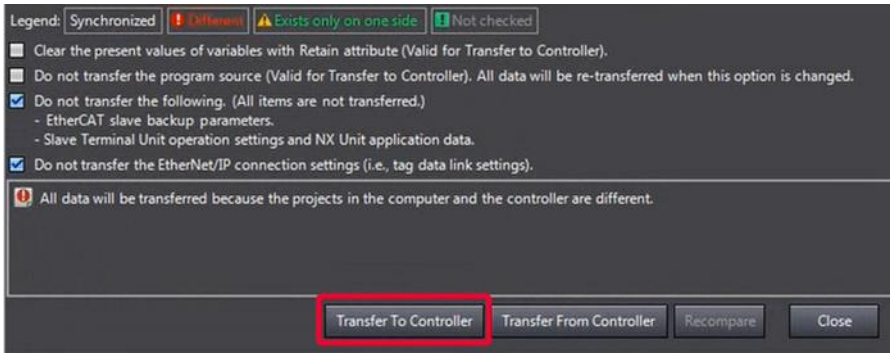
Select *new_Controller_0* from the list.

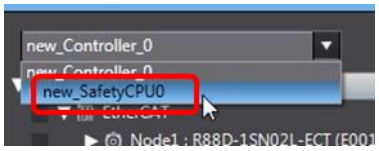
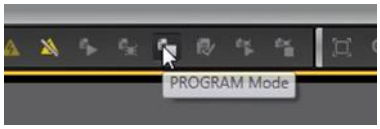
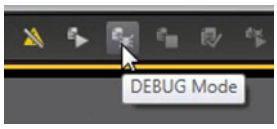
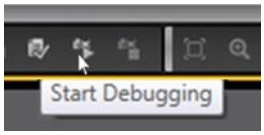
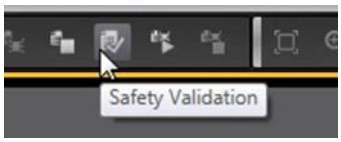
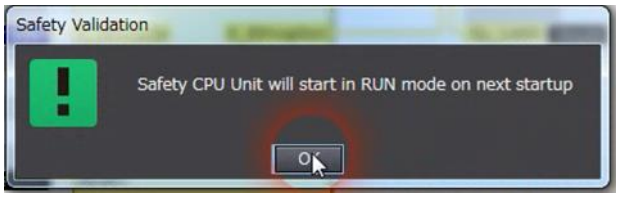


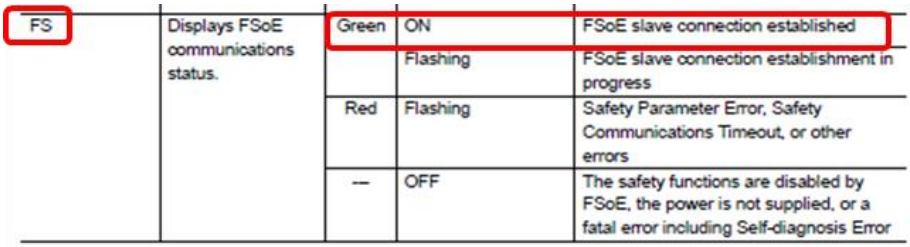
Connect to the standard controller.

Click the **Synchronization** Button to synchronize with the standard controller.

Transfer to the standard controller.

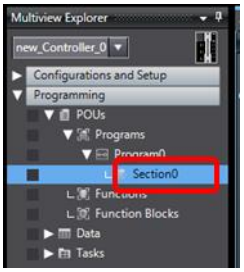
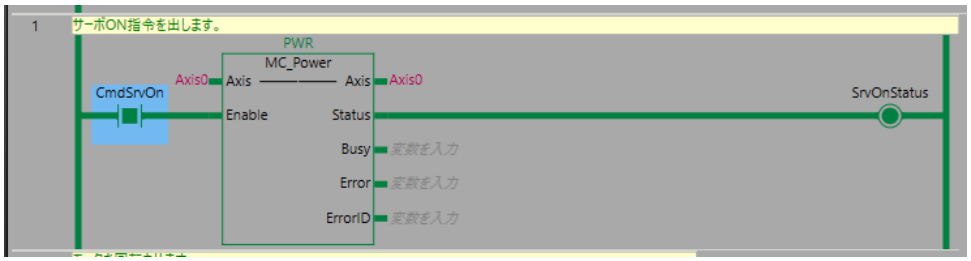
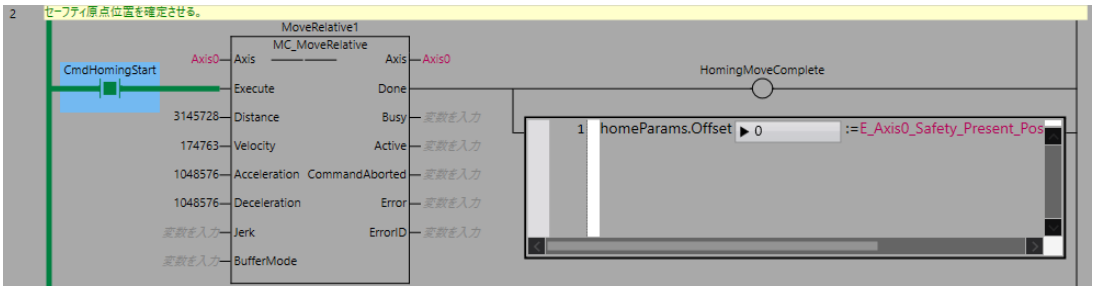


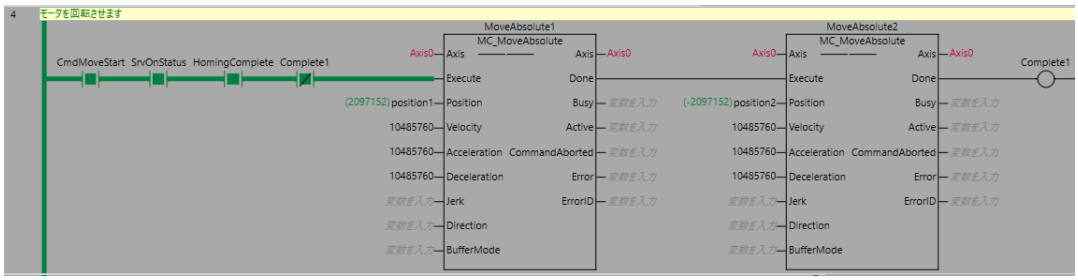
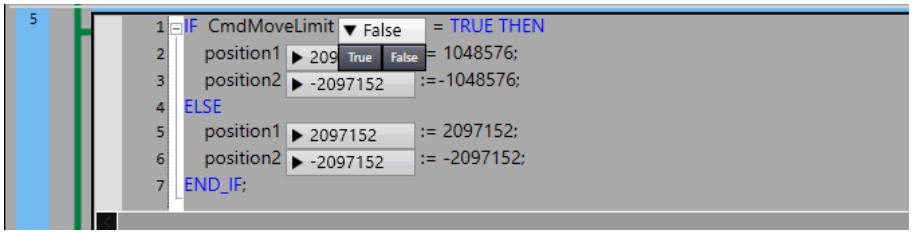
3.	**Download the safety application.** Select *new_SafetyCPU0* from the list.  Click the **PROGRAM Mode** Button to switch to PROGRAM mode.  Click the **DEBUG Mode** Button to enter DEBUG mode.  Click the **Start Debugging** Button to start DEBUG mode.  Click the **Safety Validation** Button.  Click the **OK** Button.  Click the **Run** Button. 

4.	**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

■ Checking Operation of the SLP 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 *CmdHomingStart* and select *Set/Reset – Set*.**  **Check that an origin determination operation starts and completes.**

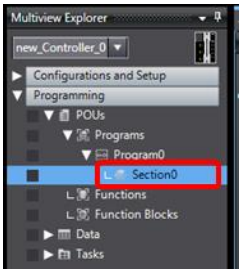
6.	**Right-click *CmdVelStart* and select *Set/Reset – Set*.**  Confirm that the Servomotor performs a reciprocating operation with a motor shaft travel distance of 4 rotations.
7.	When *CmdMoveLimit* is enabled (True), the Servomotor performs an operation with the travel distance limited (operation within the monitoring range).  Confirm that the Servomotor performs a reciprocating operation with a motor shaft travel distance of 2 rotations.
8.	**Operate the Safety Key Selector Switch to switch to safety active mode.**  Check that the 7-segment LED display shows ‘SF’. 
9.	**Open the guard with the Safety-door Switch.**  Check that the 7-segment LED display still shows ‘SF’.
10.	**Close the guard and press the safety reset switch.**

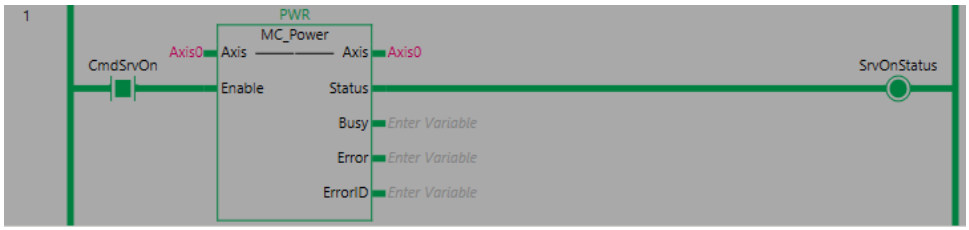
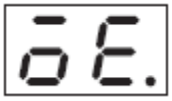
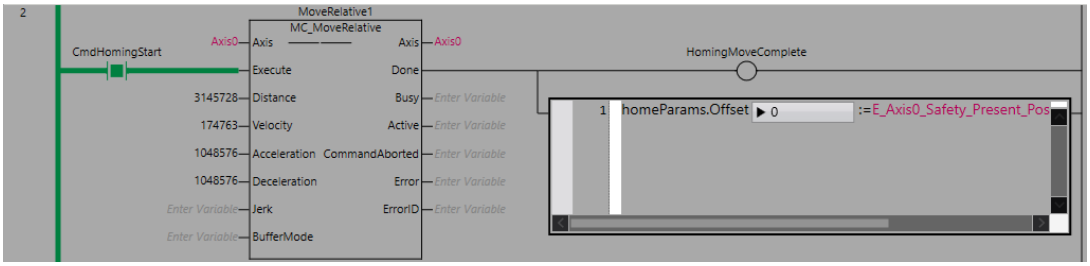
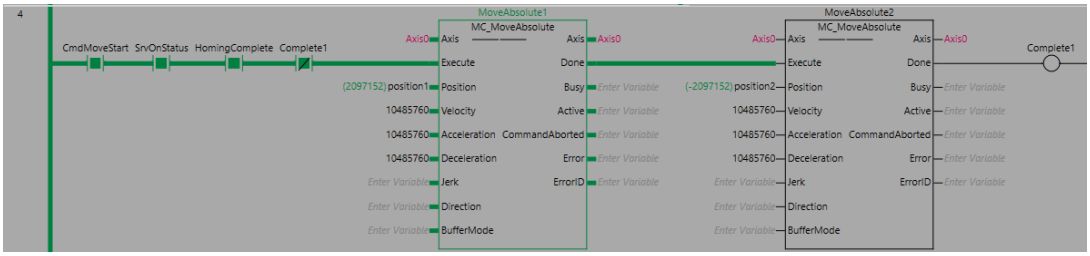
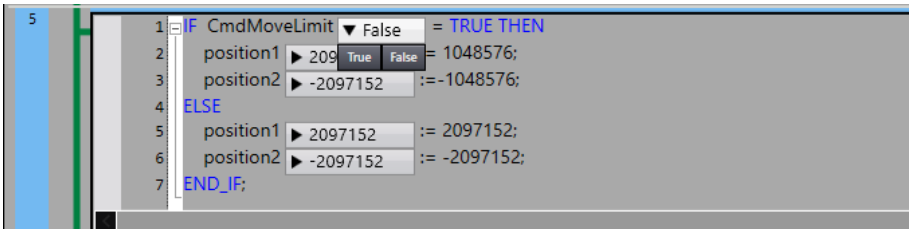
11.	**Operate the Safety key Selector Switch to switch to normal operating mode.**  Check that the 7-segment LED display shows ‘oE.’. 
12.	When *CmdMoveLimit* is disabled (False), the Servomotor performs an operation based on the original travel distance. Confirm that the Servomotor performs a reciprocating operation with a motor shaft travel distance of 4 rotations.

■ **Procedure for Recovery from an Excessive Limit Value Error (Er.71.03)**

If the motor position goes out of the SLP monitoring range during SLP monitoring, an Excessive Limit Value Error (Er.71.03) occurs.

Use the following procedure to reset the Excessive Limit Value Error (Er.71.03) and move the motor position into the SLP monitoring range.

1.	**Operate the Safety key Selector Switch to switch to normal operating mode.** 
2.	**Press the safety reset button.** 
3.	**Press the error clear button twice.** 
4.	**Double-click *Section0* to display the section.** 

5.	**Right-click *CmdSrvOn* and select *Set/Reset – Set*.**  **Check that the 7-segment LED display shows 'oE.'.** 
6.	**Right-click *CmdHomingStart* and select *Set/Reset – Set*.**  **Check that an origin determination operation starts and completes.**
7.	**Right-click *CmdVelStart* and select *Set/Reset – Set*.**  Confirm that the Servomotor performs a reciprocating operation with a motor shaft travel distance of 4 rotations.
8.	When *CmdMoveLimit* is enabled (True), the Servomotor performs an operation with the travel distance limited (operation within the monitoring range).  Confirm that the Servomotor performs a reciprocating operation with a motor shaft travel distance of 2 rotations.

4.7. Adding the Safe Direction (SDI) Function

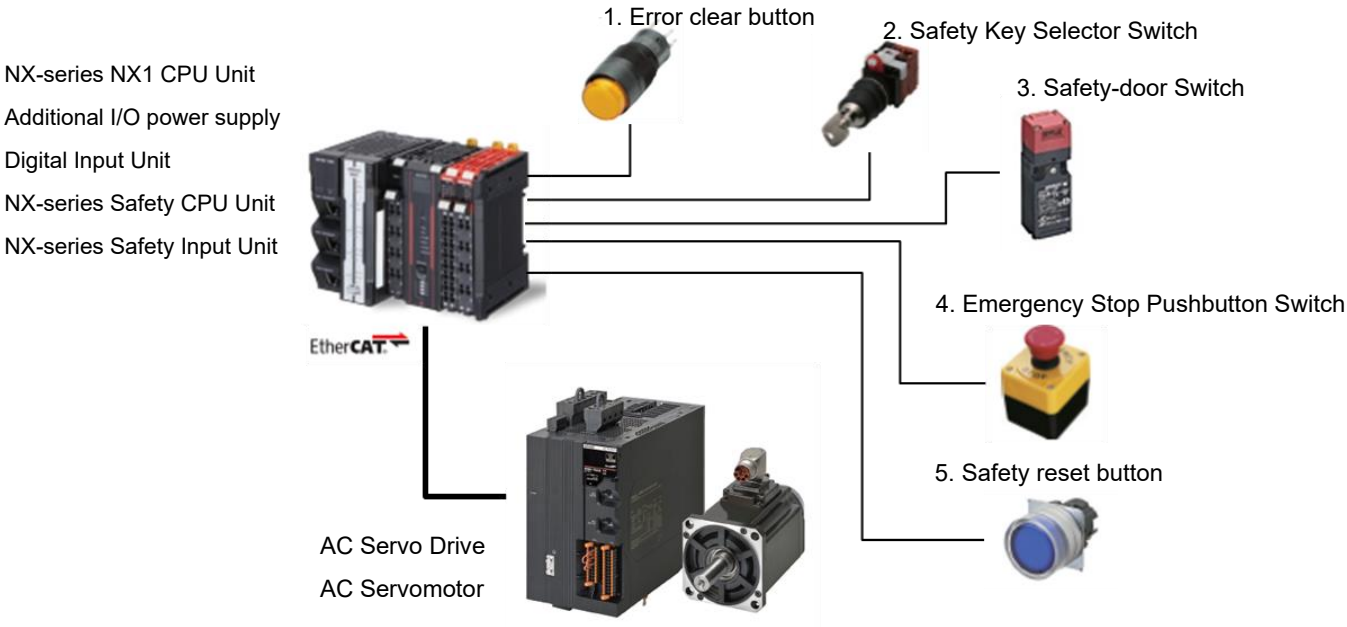
This section describes how to add the SDI function to the project created in *3. Performing Setup*. The SDI function monitors that a Servomotor is not operating toward a prohibited rotation direction.

To monitor that a motor axis is rotating in the positive direction: SDI negative direction command (SDIn)

To monitor that a motor axis is rotating in the negative direction: SDI positive direction command (SDIp)

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 Servo Drive activates the SDI function to monitor the Servomotor rotation direction.
3. When the guard with the Safety-door Switch is opened while the SDI 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.

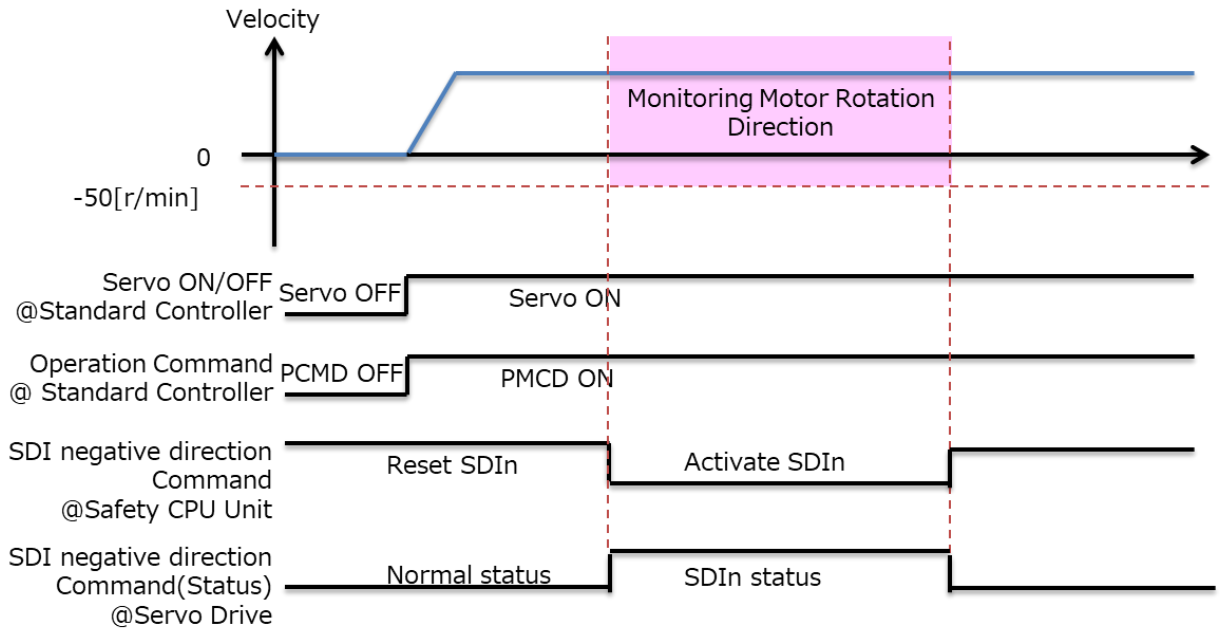


Input device	State	Operation
1. Error clear button	ON	Enable error reset command
	OFF	Disable error reset command
2. Safety Key Selector Switch	Normal operating mode	Deactivate SDIn function.
	Safety active mode	Activate SDIn function. When velocity zero window is exceeded, or position zero window is exceeded from stop position, Servo Drive goes into STO state and Excessive Limit Value Error occurs.

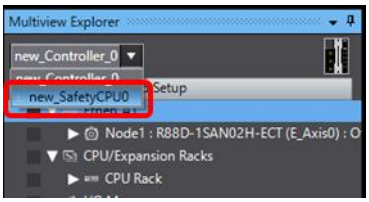
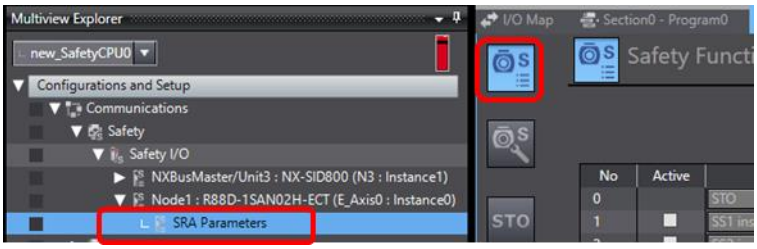
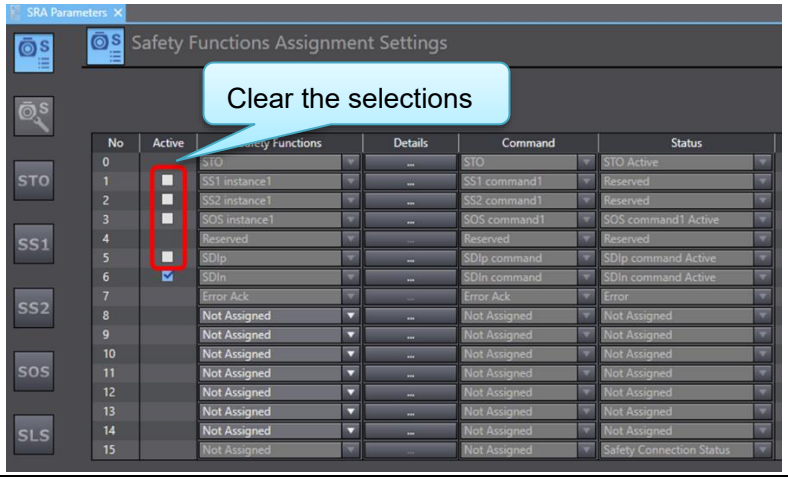
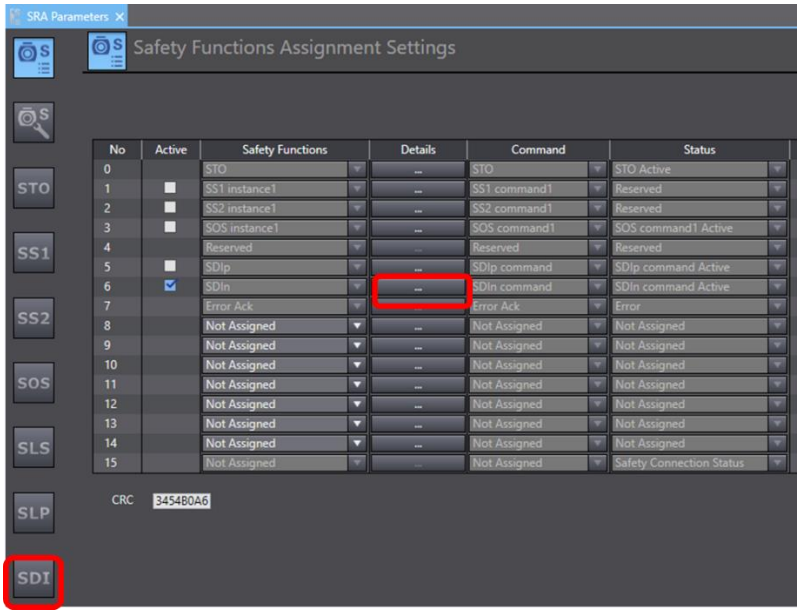
3. Safety-door Switch	Open	SDIn function deactivated: Enable STO command SDIn function activated: Disable STO command
	Close	Disable STO command
4. Emergency Stop Pushbutton Switch	ON	Enable STO command
	OFF	Disable STO command
5. Safety reset button	ON	Enable reset STO status command
	OFF	Disable reset STO status command

□ Operation of SDI 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 600 r/min.
3. When the SDIn function is executed, the Servo Drive goes into the SDIn active state and monitors the rotation direction and position zero window.
4. When the SDIn function is released, the Servo Drive goes into the normal state. The monitoring of the motor velocity stops.



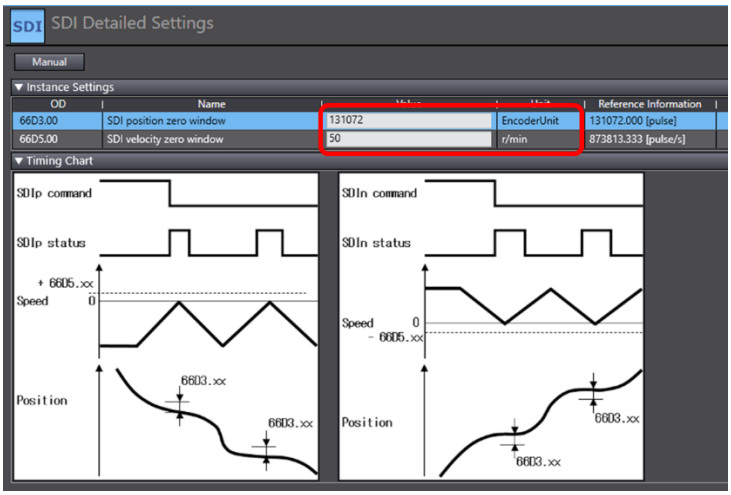
■ Setting the Safety Controller

1.	**Select *new_SafetyCPU0* from the list.** 
2.	**Click *SRA Parameters* and click the *Safety Function Assignment Settings* Button.** 
3.	**Assign the SDIn function.** 
4.	**Click the SLS Button to display the SDI Detailed Settings view.** You can also use the ... Button to display the SDI Detailed Settings view. 

5. **Set SDI parameters.**

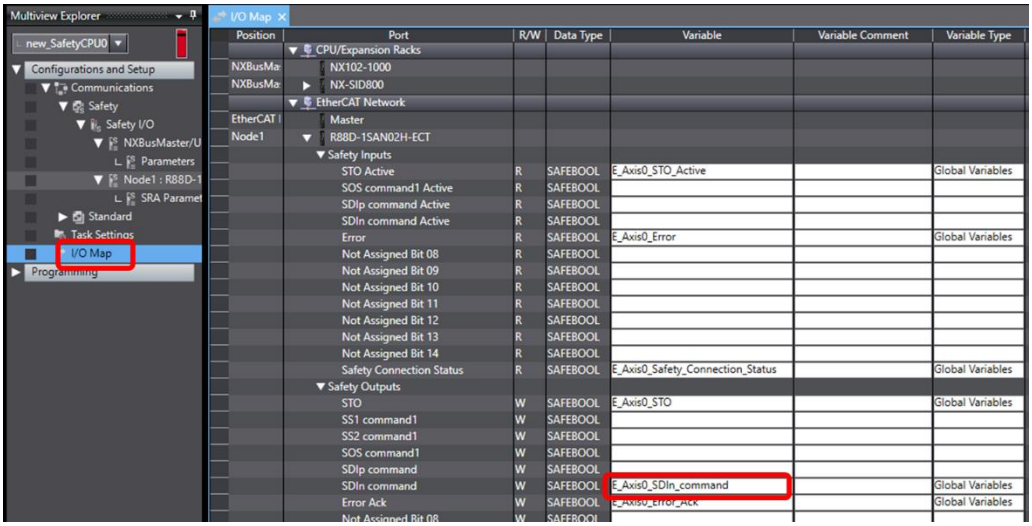
In this guide, set them as follows.

Name	Value	Unit
SDI position zero window	131072	EncoderUnit
SDI velocity zero window	50	r/min

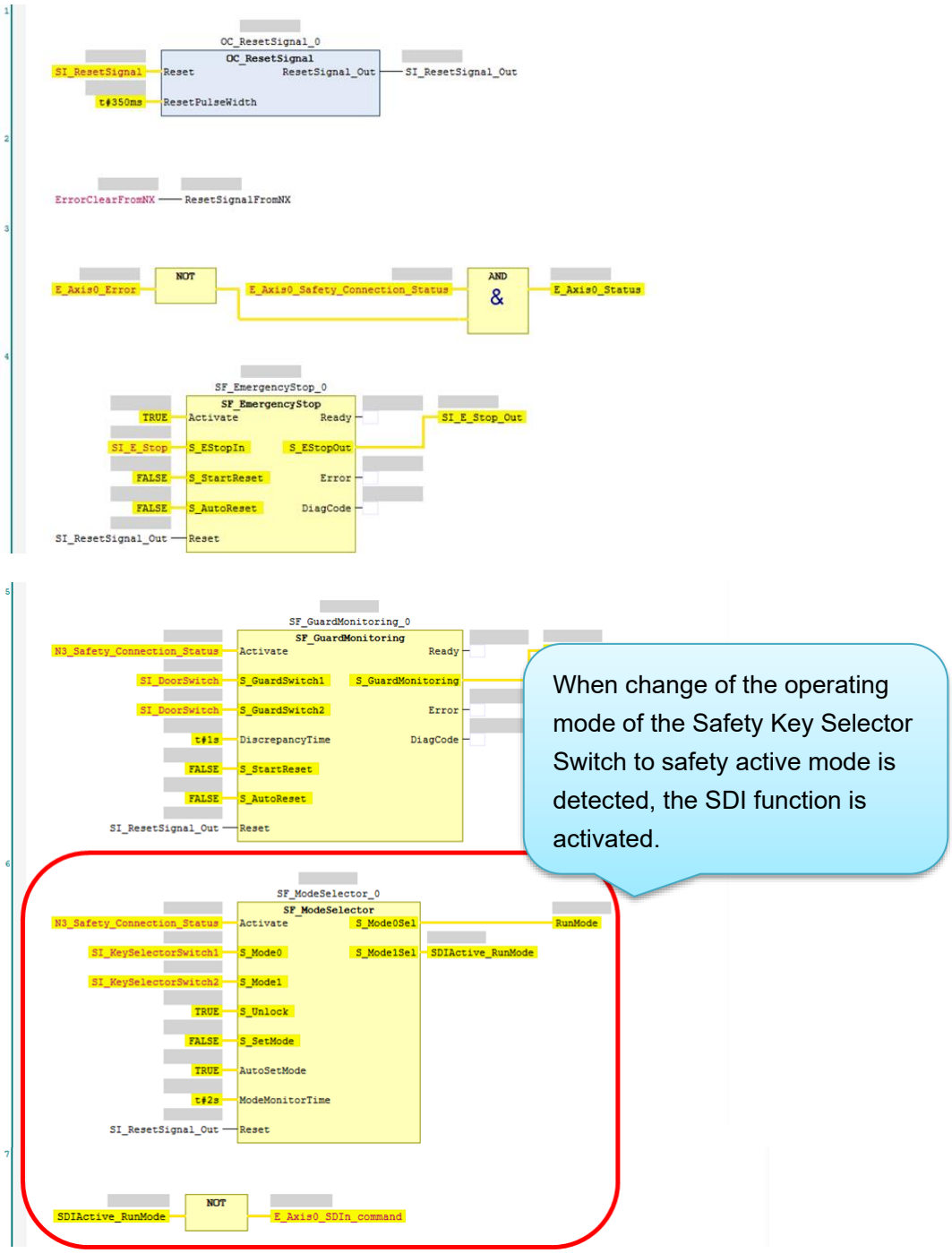


6. **Open the I/O Map and create device variables.**

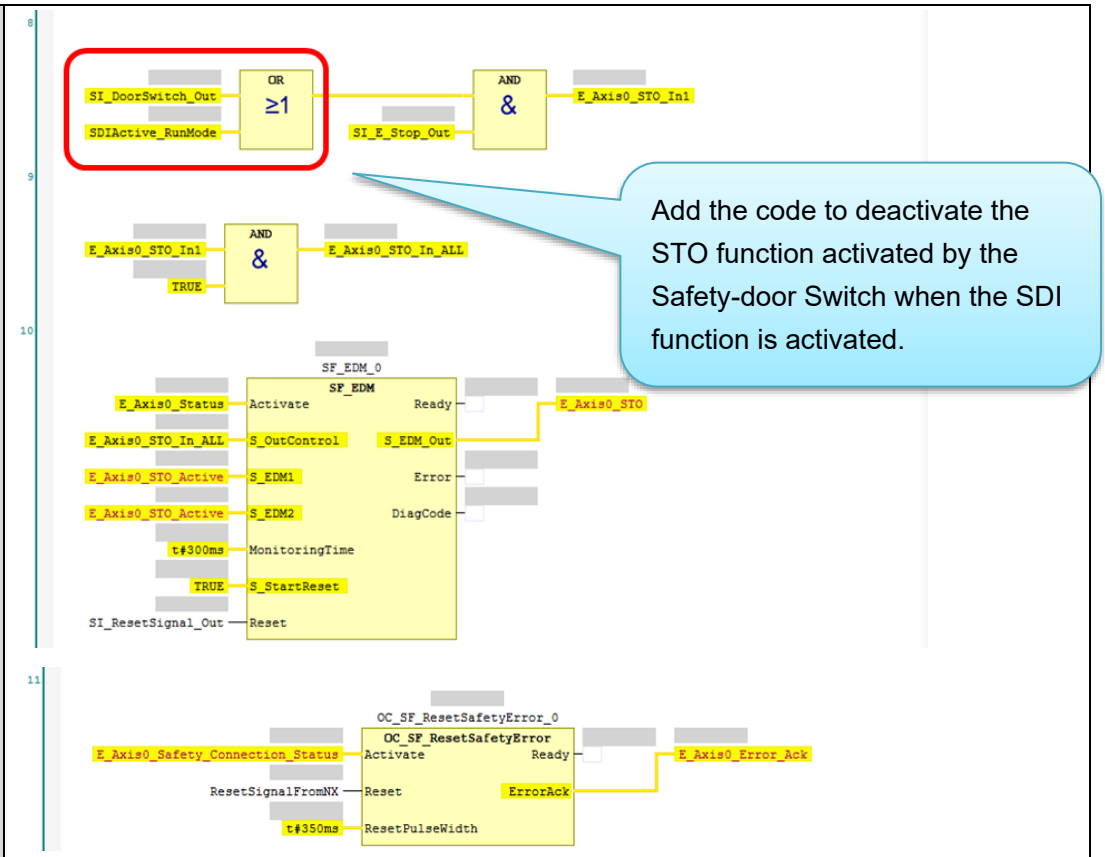
Port	Variable name
SDIn command for R88D-1SAN02H-ECT	**E_Axis0_SDIn_command1**



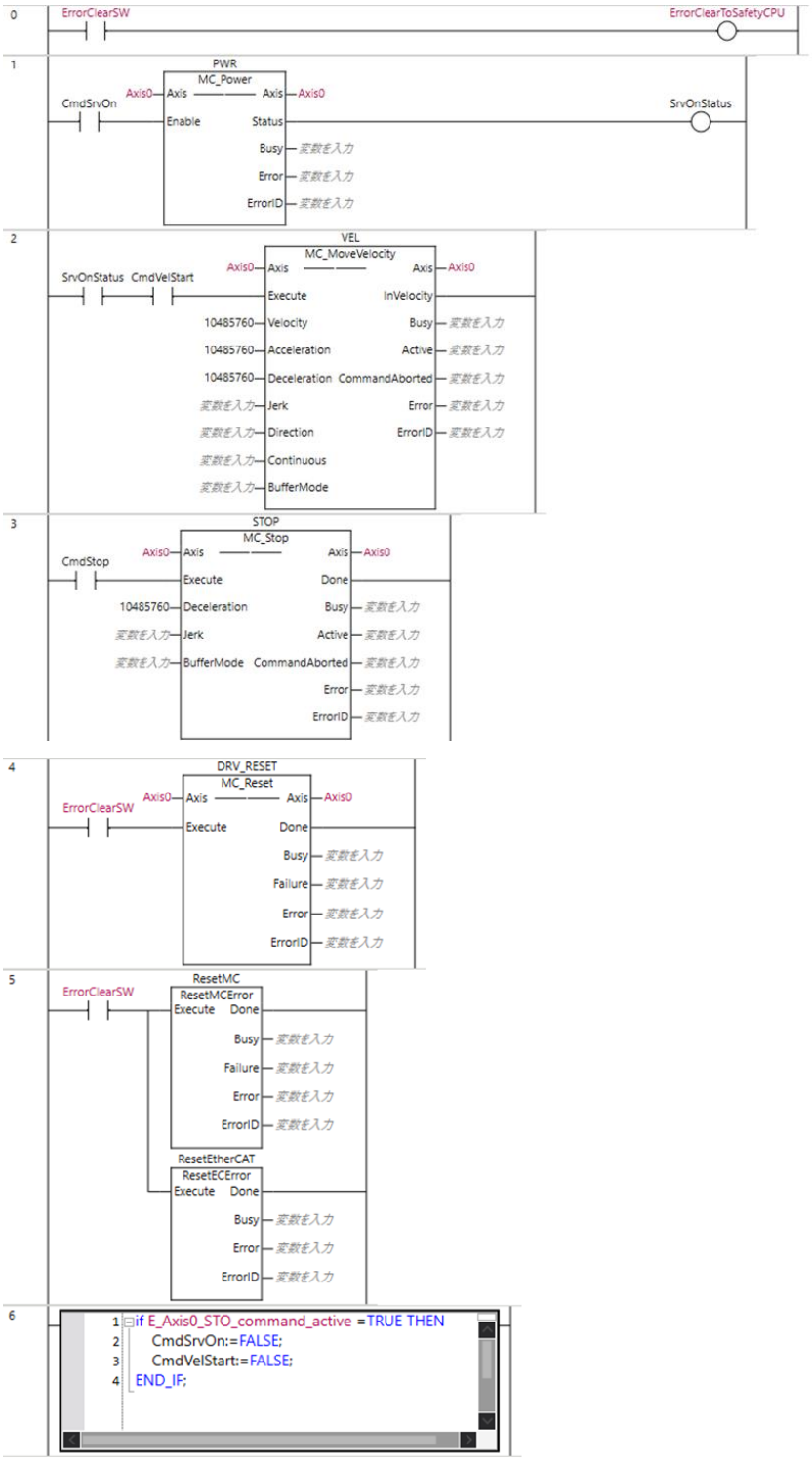
7.	**Create a safety program.** **Add the following code to AutoProgram1.**

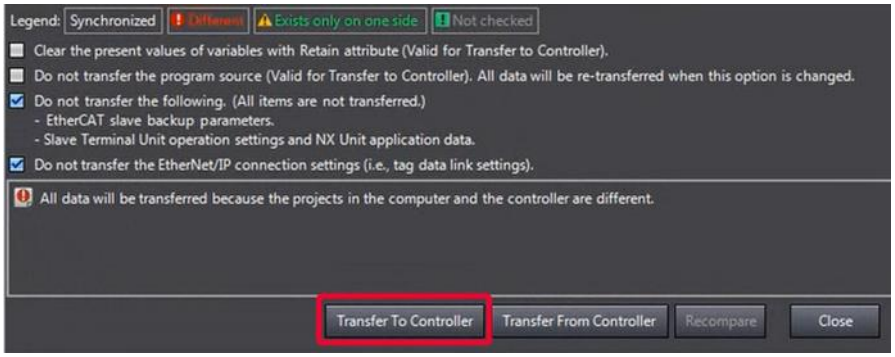
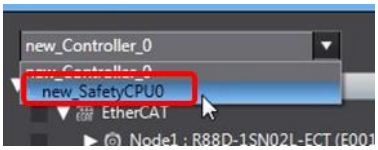
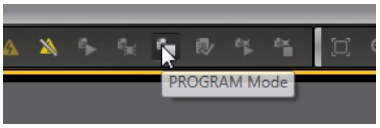
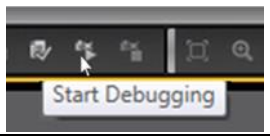


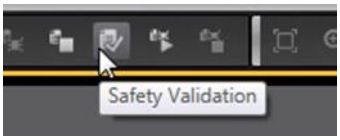
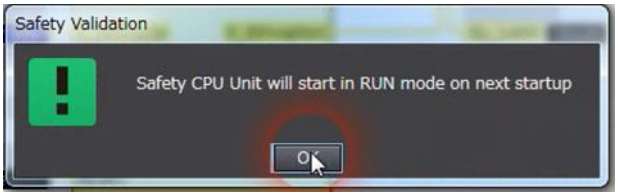
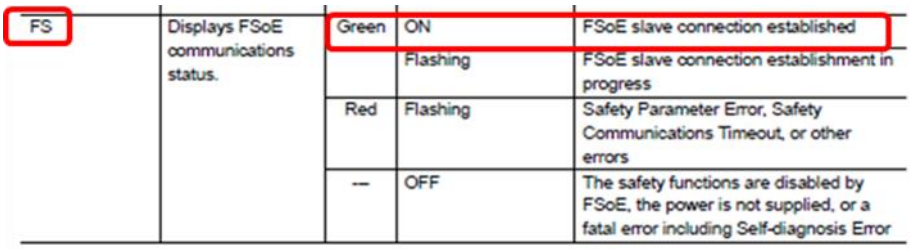
When change of the operating mode of the Safety Key Selector Switch to safety active mode is detected, the SDI function is activated.


8
OR
≥1
SI_DoorSwitch_Out
SDIActive_RunMode
AND
&
SI_E_Stop_Out
E_Axis0_STO_In1
9
AND
&
E_Axis0_STO_In1
TRUE
E_Axis0_STO_In_ALL
Add the code to deactivate the STO function activated by the Safety-door Switch when the SDI function is activated.
10
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
11
OC_SF_ResetSafetyError_0
OC_SF_ResetSafetyError
E_Axis0_Safety_Connection_Status
Activate
Ready
E_Axis0_Error_Ack
ResetSignalFromNX
Reset
ErrorAck
t#350ms
ResetPulseWidth

■ **Setting the Standard Controller**

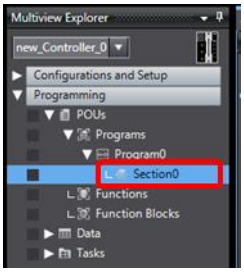
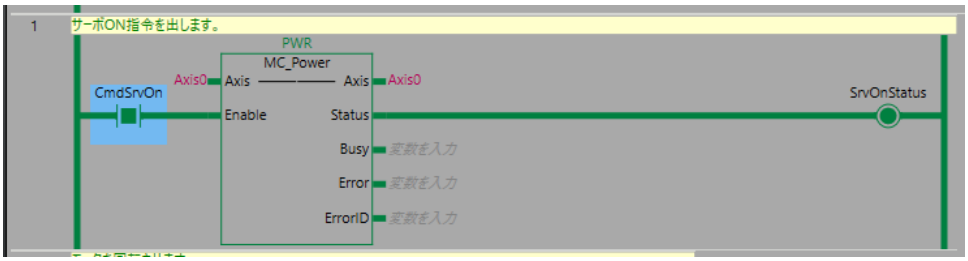
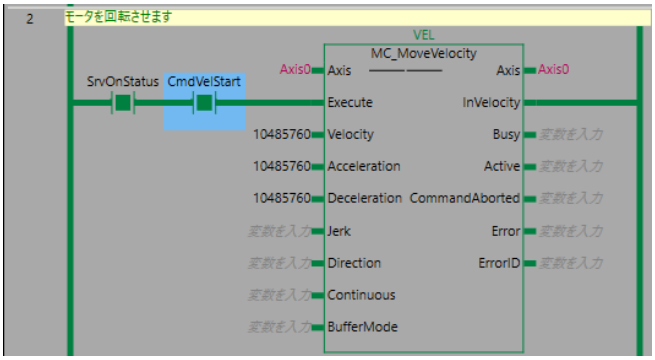
1.	**The program is the same as that of the STO function. For further details, refer to *3.6 Creating a Motor Control Program*.** **Confirm that the program is as follows.** 

2.	**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. 
3.	**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. 
4.	**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

■ Checking Operation of the SDI 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 600 r/min.

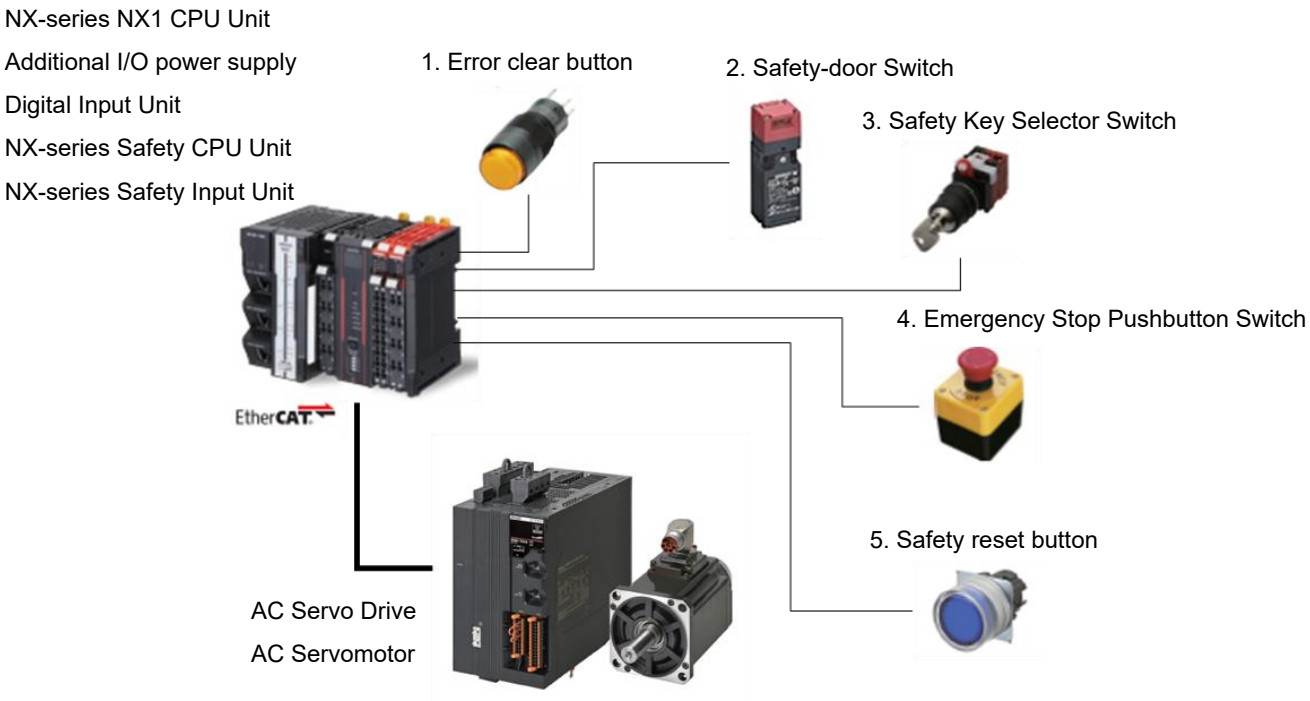
6.	**Operate the Safety Key Selector Switch to switch to safety active mode.**  Check that the 7-segment LED display shows ‘SF’. 
7.	**Open the guard with the Safety-door Switch.**  Check that the 7-segment LED display still shows ‘SF’.
8.	**Close the guard and press the safety reset switch.**
9.	**Operate the Safety Key Selector Switch to switch to normal operating mode.**  Check that the 7-segment LED display shows ‘oE.’. 

4.8. Adding Multiple Safety Functions (SS2 + SLS)

This section describes how to add the SS2 and SLS functions 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-door Switch is opened, the standard controller lets the Servomotor decelerate to a stop. The Servo Drive activates the SS2 and SLS functions and monitors the motor position and velocity.
3. When the Safety Key Selector Switch is operated to switch to safety inactive mode, the standard controller changes the velocity command value to low speed. The Servo Drive deactivates the SS2 function.
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.

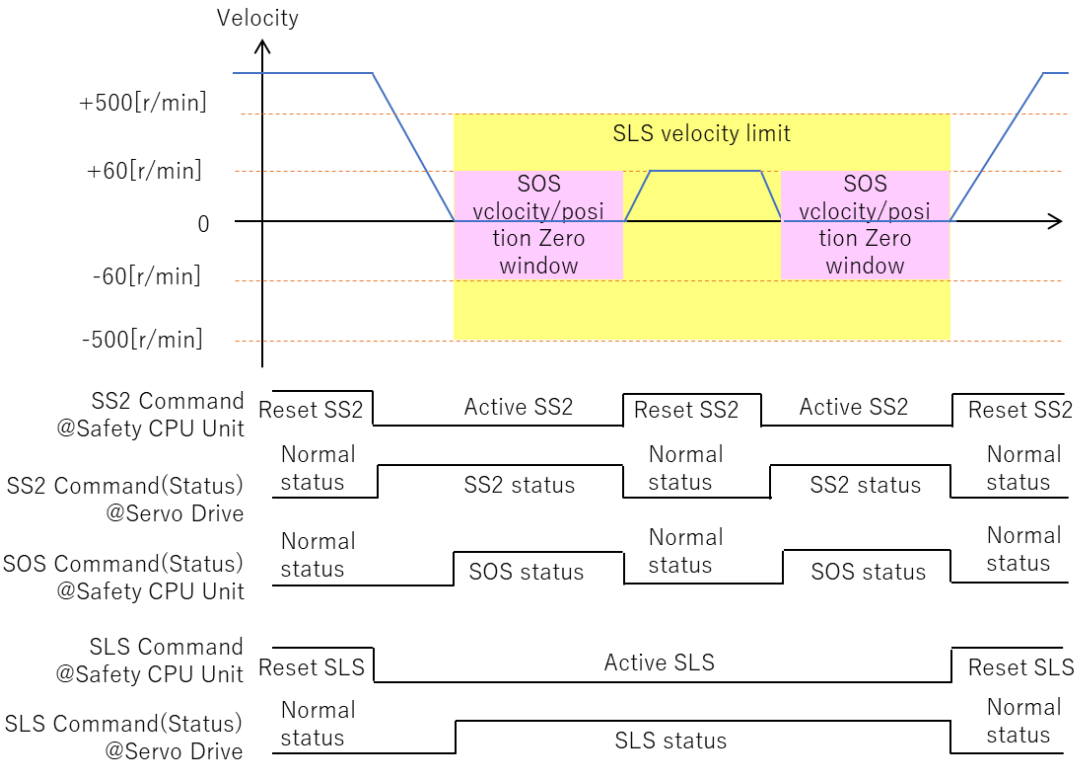


Input device	State	Operation
1. Error clear button	ON	Enable error reset command
	OFF	Disable error reset command
2. Safety-door Switch	Open	Make Servomotor decelerate to a stop and activate SOS function using SLS and SS2 functions. When SLS velocity limit or SOS position or velocity zero window is exceeded, Servo Drive goes into STO state and Excessive Limit Value Error occurs.
	Close	Deactivate SS2, SOS, and SLS functions with Servomotor set to run at normal velocity.

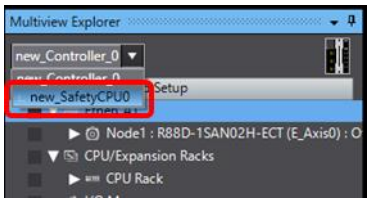
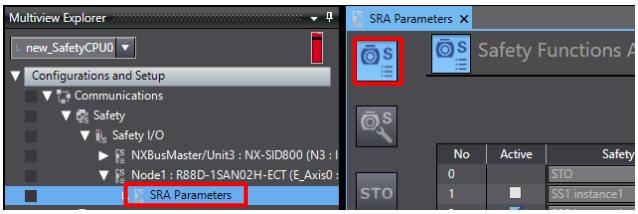
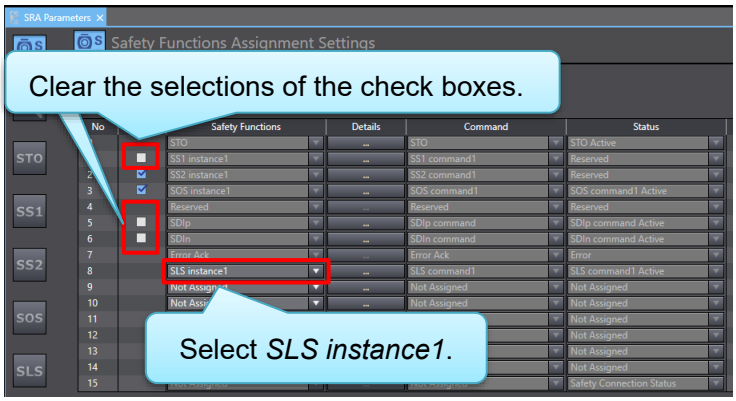
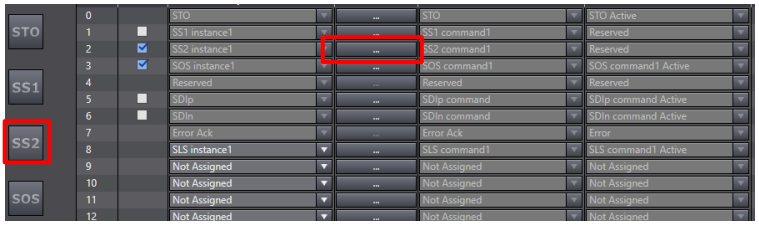
Input device	State	Operation
3. Safety Key Selector Switch	Normal operating mode	Safety-door Switch Open: Activate SS2 and SLS functions Safety-door Switch Closed: Deactivate SS2 and SLS functions
	Safety inactive mode	Deactivate SS2 function.
4. Emergency Stop Pushbutton Switch	ON	Enable STO command
	OFF	Disable STO command
5. Safety reset button	ON	Enable reset STO status command
	OFF	Disable reset STO status command

□ Operation of SS2 and SLS Functions 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 600 r/min.
3. When the SS2 function is executed, the Servo Drive shifts to the SOS state after the wait time (SS2 time to SOS 1) and monitors the motor position and velocity.
   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 lets the Servomotor decelerate to a stop.
4. The Servo Drive monitors the motor velocity by releasing only the SS2 or SOS function with the SLS state maintained.
   The standard controller sets the command velocity to the Servomotor to 60 r/min.
5. When the SS2 function is executed, the Servo Drive shifts to the SOS state after the wait time (SS2 time to SOS 1) and monitors the motor position and velocity.
   The standard controller lets the Servomotor decelerate to a stop.
6. When the SS2 or SLS function is released, the Servo Drive goes into the normal state and stops monitoring the motor position and velocity.
   The standard controller sets the command velocity to the Servomotor to 600 r/min.


Velocity
+500[r/min]
+60[r/min]
0
-60[r/min]
-500[r/min]
SLS velocity limit
SOS vclocity/posi tion Zero window
SOS vclocity/posi tion Zero window
SS2 Command @Safety CPU Unit
Reset SS2
Active SS2
Reset SS2
Active SS2
Reset SS2
SS2 Command(Status) @Servo Drive
Normal status
SS2 status
Normal status
SS2 status
Normal status
SOS Command(Status) @Safety CPU Unit
Normal status
SOS status
Normal status
SOS status
Normal status
SLS Command @Safety CPU Unit
Reset SLS
Active SLS
Reset SLS
SLS Command(Status) @Servo Drive
Normal status
SLS status
Normal status

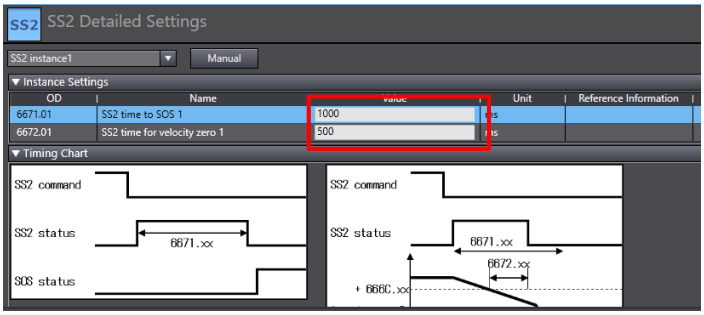
■ Setting the Safety Controller

1.	**Select *new_SafetyCPU0* from the list.** 
2.	**Click *SRA Parameters* and click the *Safety Function Assignment Settings* Button.** 
3.	**Assign STO, SS2/SOS instance1, and SLS instance1.** 
4.	**Click the SS2 Button to display the SS2 Detailed Settings view.** You can also use the ... Button to display the SS2 Detailed Settings view. 

5. **Set SS2 parameters.**

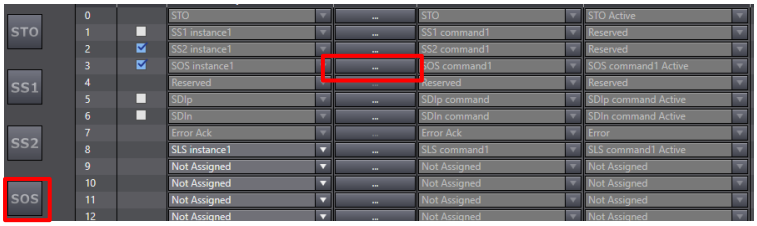
In this guide, set them as follows.

Name	Value	Unit
SS2 time to SOS 1	1000	ms
SS2 time for velocity zero 1	500	ms



6. **Click the SOS Button and then click the SOS Detailed Settings view.**

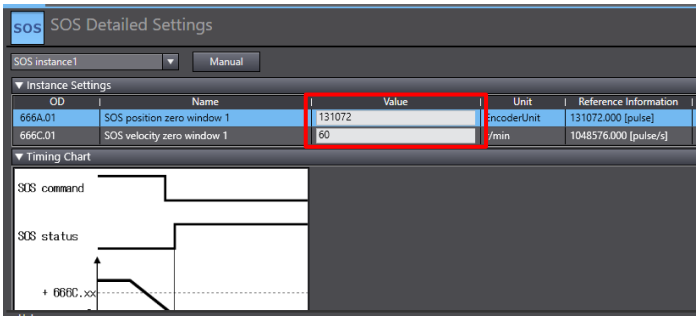
You can also use the ... Button to display the SOS Detailed Settings view.



7. **Set SOS parameters.**

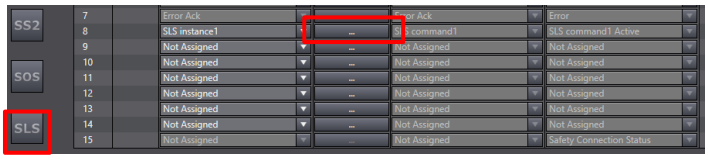
In this guide, set them as follows.

Name	Value	Unit
SOS position zero window 1	131072	EncoderUnit
SOS velocity zero window 1	60	r/min



8. **Click the SLS Button to display the SLS Detailed Settings view.**

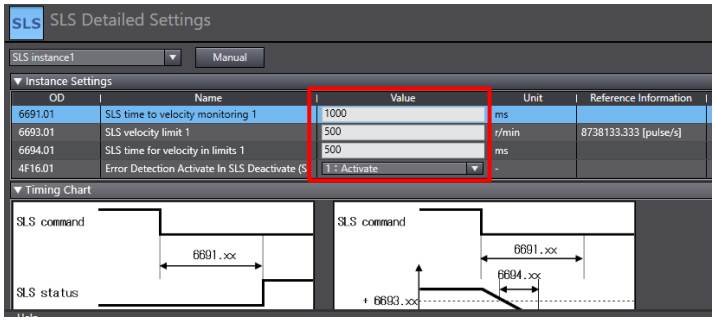
You can also use the ... Button to display the SLS Detailed Settings view.



9. **Set SLS parameters.**

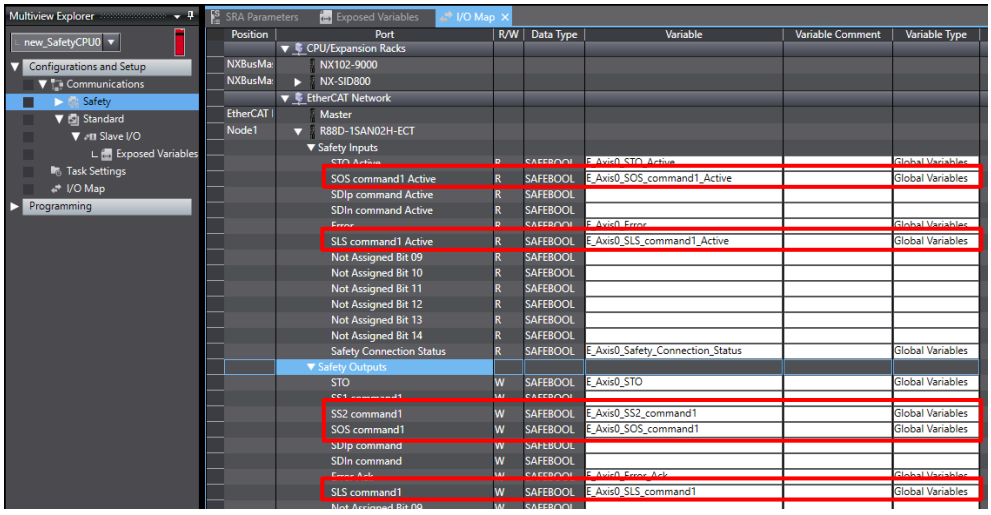
In this guide, set them as follows.

Name	Value	Unit
SLS time to velocity monitoring 1	1000	ms
SLS velocity limit 1	500	r/min
SLS time for velocity in limits 1	500	ms
Error Detection Activate In SLS Deactivate	Activate	-



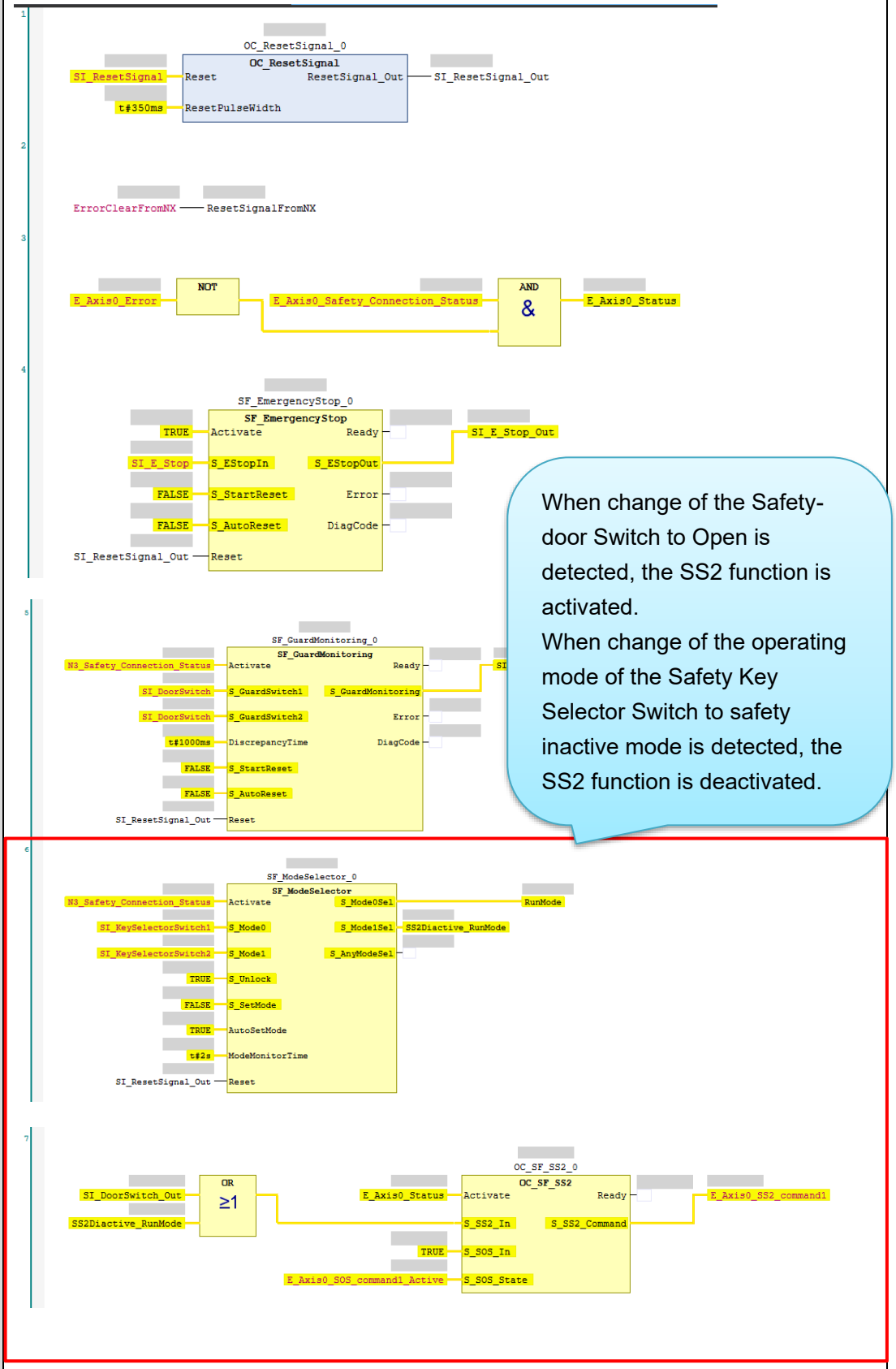
10. **Open the I/O Map and create device variables.**

Port	Variable name
SOS command1 Active for R88D-1SAN02H-ECT	**E_Axis0_SOS_command1_Active**
SLS command1 Active for R88D-1SAN02H-ECT	**E_Axis0_SLS_command1_Active**
SS2 command1 for R88D-1SAN02H-ECT	**E_Axis0_SS2_command1**
SOS command1 for R88D-1SAN02H-ECT	**E_Axis0_SOS_command1**
SLS command1 for R88D-1SAN02H-ECT	**E_Axis0_SLS_command1**

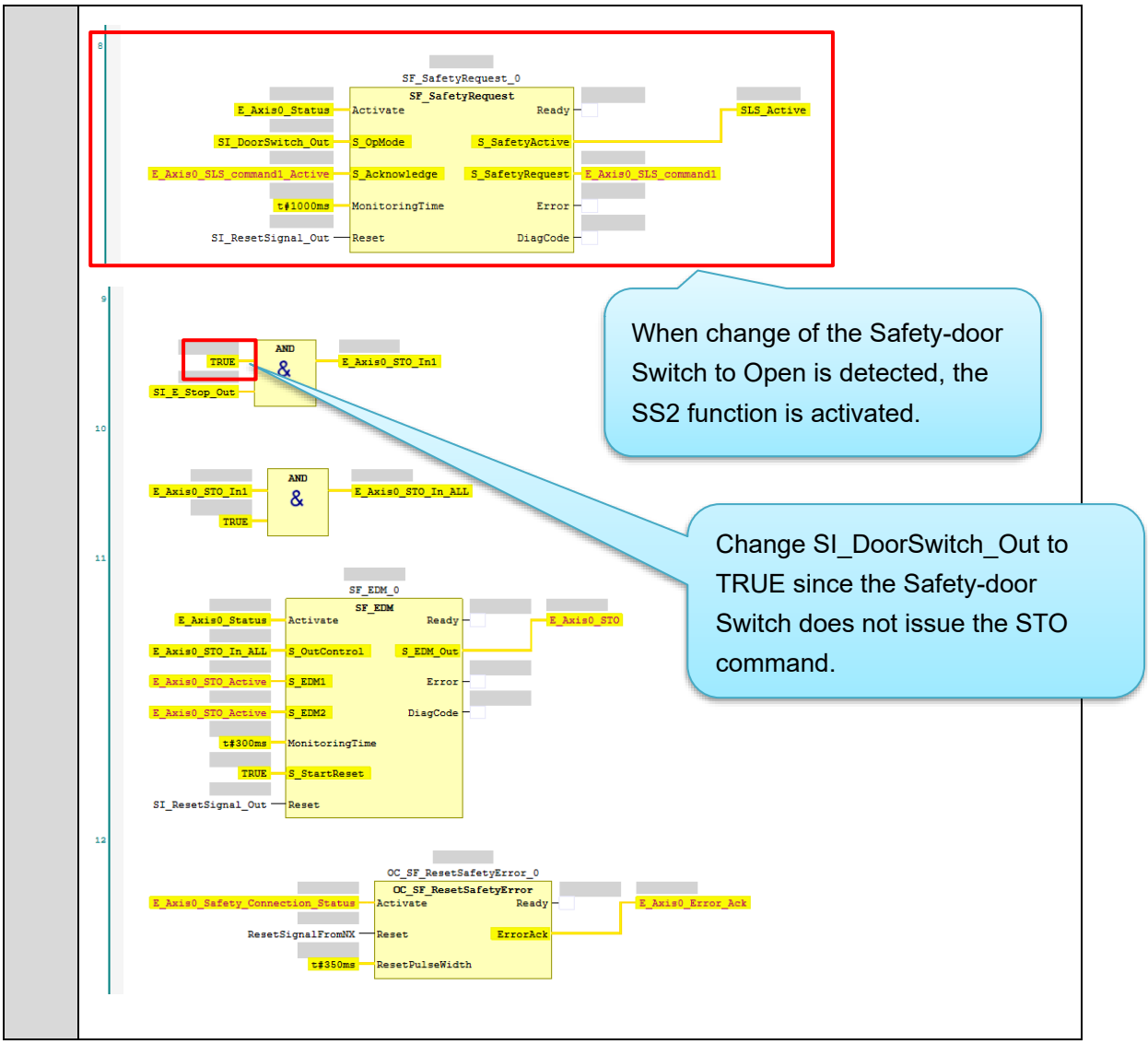


11. **Create a safety program.**

Add the following code to AutoProgram1.

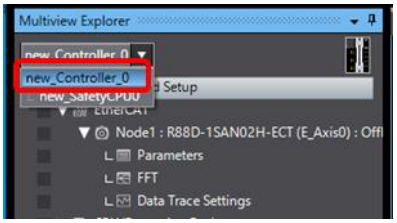


When change of the Safety-door Switch to Open is detected, the SS2 function is activated.
When change of the operating mode of the Safety Key Selector Switch to safety inactive mode is detected, the SS2 function is deactivated.

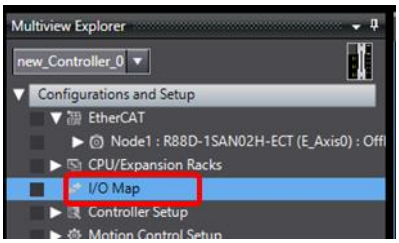

SF_SafetyRequest_0
SF_SafetyRequest
E_Axis0_Status
Activate
Ready
SLS_Active
SI_DoorSwitch_Out
S_OpMode
S_SafetyActive
E_Axis0_SLS_command1_Active
S_Acknowledge
S_SafetyRequest
E_Axis0_SLS_command1
t#1000ms
MonitoringTime
Error
SI_ResetSignal_Out
Reset
DiagCode
TRUE
AND
&
E_Axis0_STO_In1
SI_E_Stop_Out
E_Axis0_STO_In_ALL
SF_EDM_0
SF_EDM
E_Axis0_STO
S_OutControl
S_EDM_Out
S_EDM1
S_EDM2
t#300ms
S_StartReset
OC_SF_ResetSafetyError_0
OC_SF_ResetSafetyError
E_Axis0_Safety_Connection_Status
ResetSignalFromNX
ErrorAck
E_Axis0_Error_Ack
t#350ms
ResetPulseWidth
When change of the Safety-door Switch to Open is detected, the SS2 function is activated.
Change SI_DoorSwitch_Out to TRUE since the Safety-door Switch does not issue the STO command.

■ Setting the Standard Controller

1. **Select *new_Controller_0* from the list.**

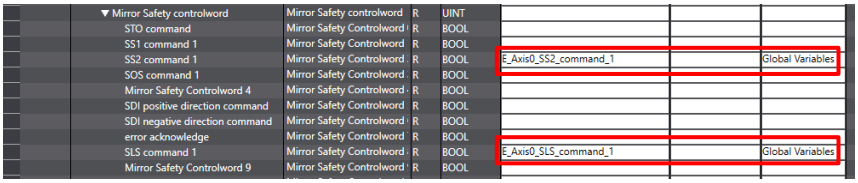


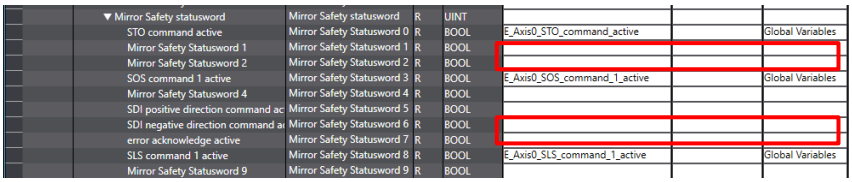
2. **Double-click *I/O Map*.**



3. **Create device variables.**

Port	Variable name
SS2 command1 for R88D-1SAN02H-ECT	**E_Axis0_SS2_command_1**
SLS command1 for R88D-1SAN02H-ECT	**E_Axis0_SLS_command_1**
SOS command1 active for R88D-1SAN02H-ECT	**E_Axis0_SOS_command_1_active**
SLS command1 Active for R88D-1SAN02H-ECT	**E_Axis0_SLS_command_1_Active**

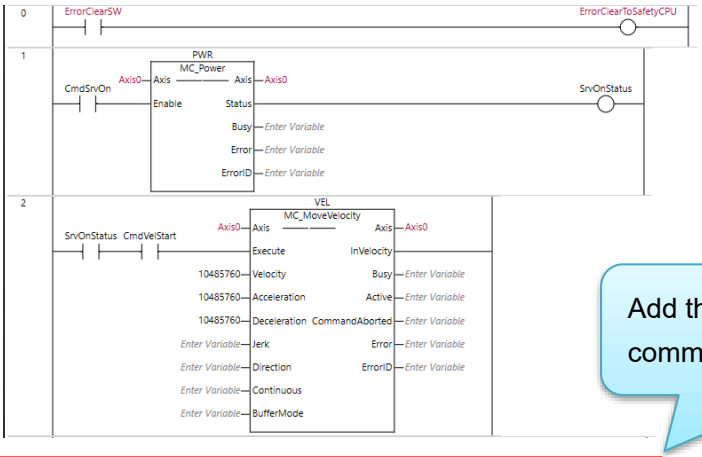




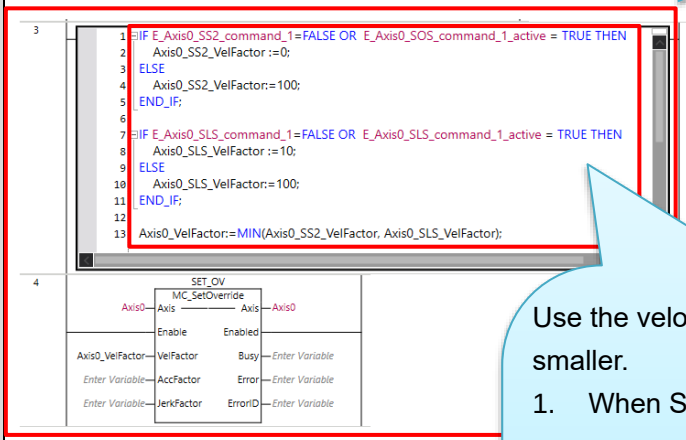
4. **Create code for the standard program.**

Add the code to change the command velocity.

- When the SS2 or SOS function is active, reduce the command velocity to 0 r/min.
- When the SLS function is active, reduce the command velocity to 60 r/min.
- When the SS2, SOS, and SLS functions are all inactive, increase the command velocity to 600 r/min.



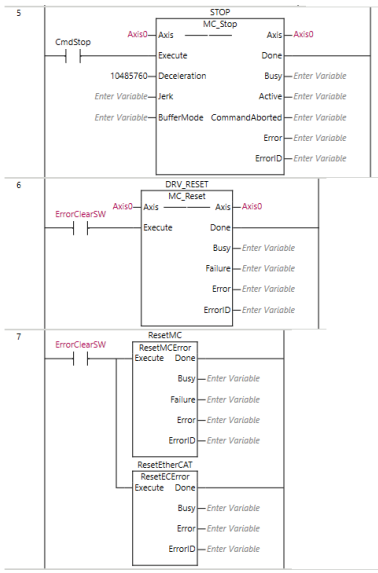
Add the code to change the command velocity here.

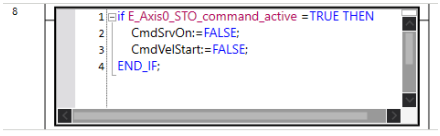


```
IF E_Axis0_SS2_command_1=FALSE OR  E_Axis0_SOS_command_1_active = TRUE THEN
    Axis0_SS2_VelFactor :=0;
ELSE
    Axis0_SS2_VelFactor:=100;
END_IF;

IF E_Axis0_SLS_command_1=FALSE OR  E_Axis0_SLS_command_1_active = TRUE THEN
    Axis0_SLS_VelFactor :=10;
ELSE
    Axis0_SLS_VelFactor:=100;
END_IF;

Axis0_VelFactor:=MIN(Axis0_SS2_VelFactor, Axis0_SLS_VelFactor);
```

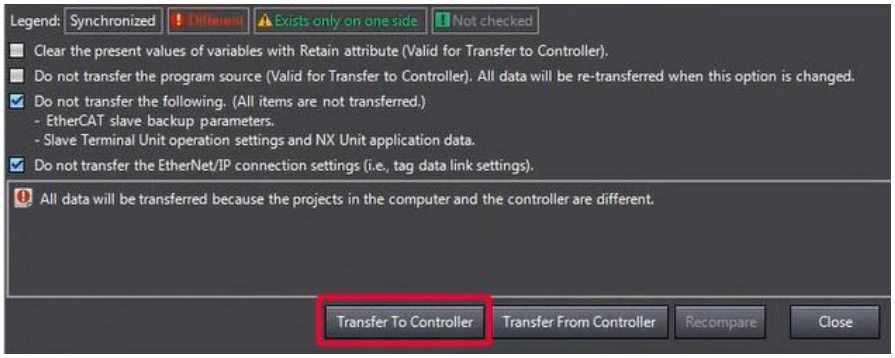
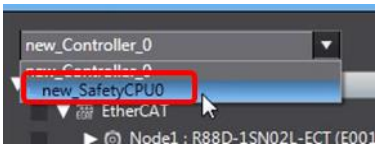
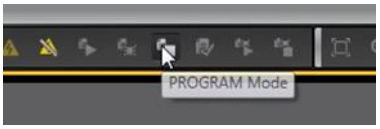
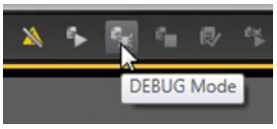
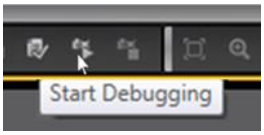

Use the velocity in 1 or 2, whichever is smaller.

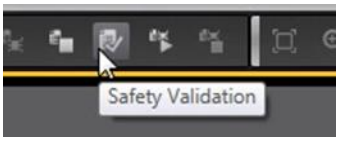
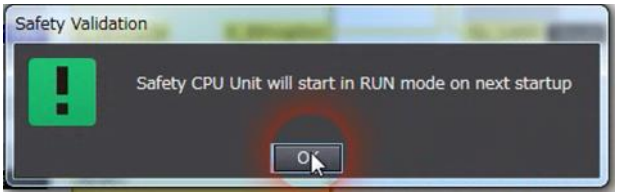
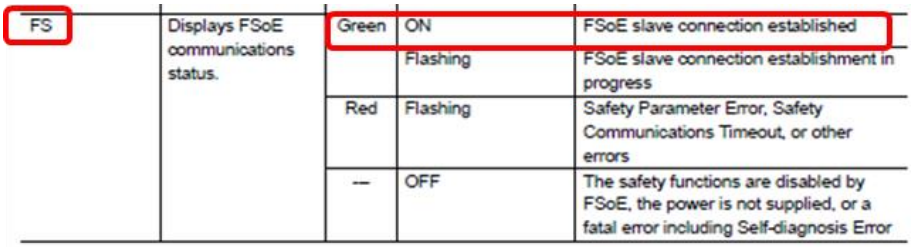
1. When SS2 or SOS function is active:
   0 [r/min] (0% of command velocity)
   When SS2 or SOS function is inactive:
   600 [r/min] (100% of command velocity)
2. When SLS function is active:
   60 [r/min] (10% of command velocity)
   When SLS function is inactive:
   600 [r/min] (100% of command velocity)





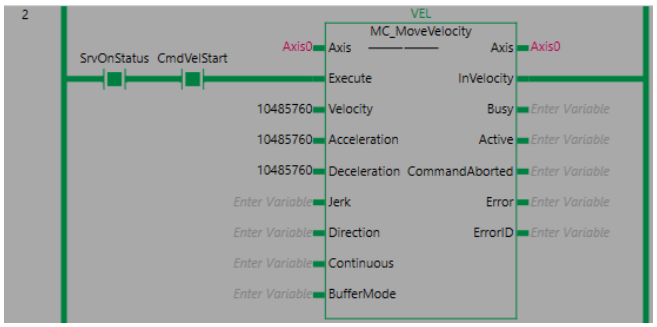
```
if E_Axis0_STO_command_active =TRUE THEN
    CmdSrvOn:=FALSE;
    CmdVelStart:=FALSE;
END_IF;
```

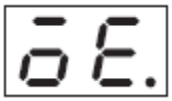
5.	**Transfer to the standard controller.** Select *new_Controller_0* from the list.  Connect to the standard controller.  Click the **Synchronization** Button to synchronize with the standard controller.  Transfer to the standard controller. 
6.	**Download the safety application.** Select *new_SafetyCPU0* 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

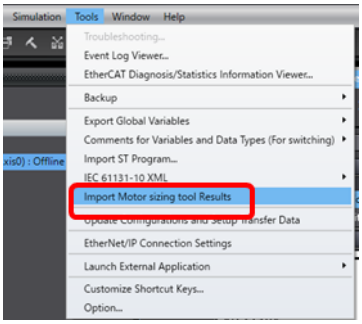
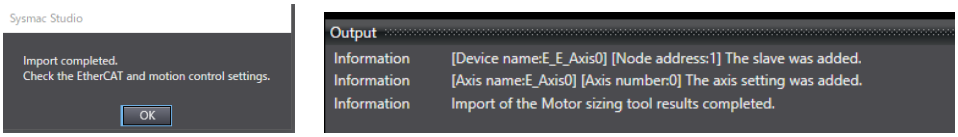
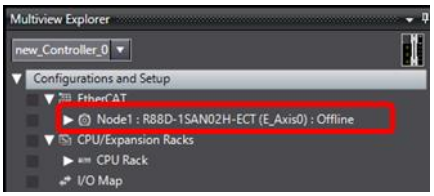
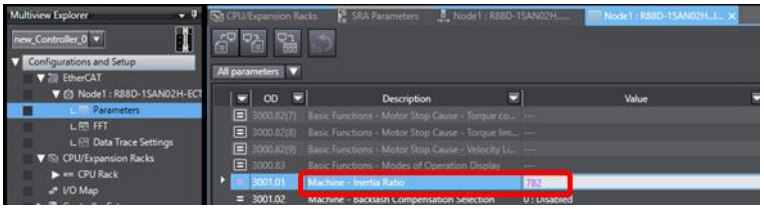
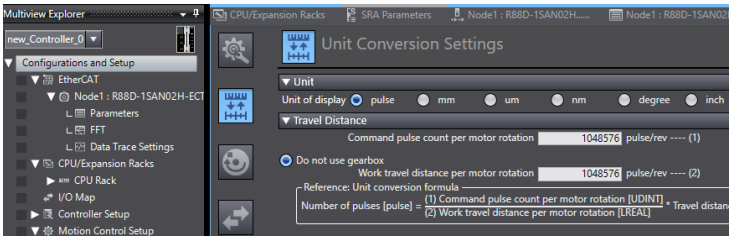
■ Checking Operation of the SS2 and SLS Functions

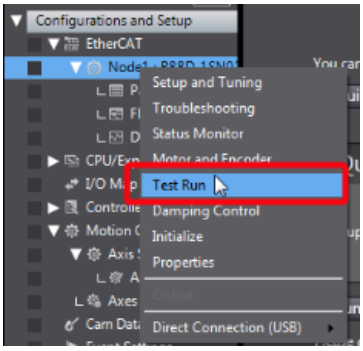
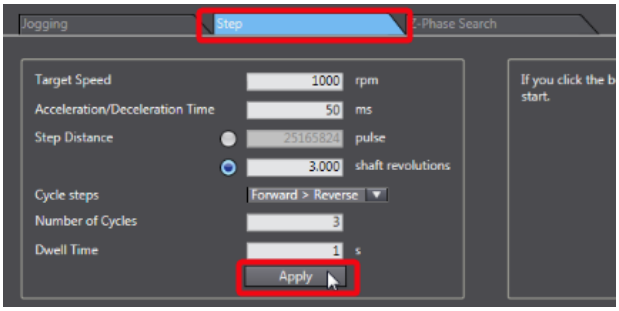
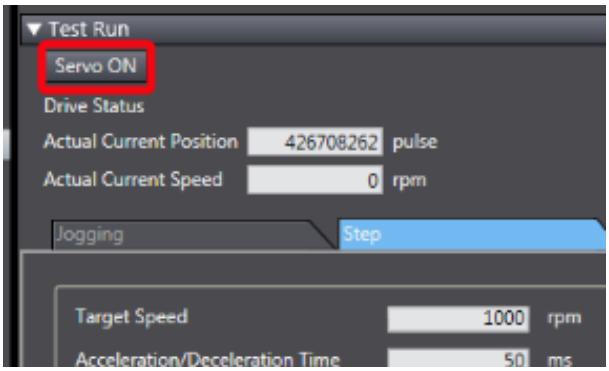
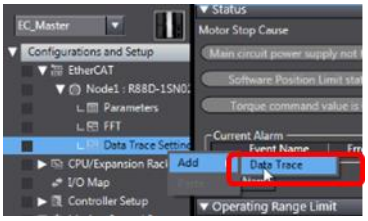
1.	**Check that the Safety Key Selector Switch is in normal operating mode.** 
2.	**Press the safety reset button.** 
3.	**Double-click *Section0* to open the section.** 
4.	**Right-click *CmdVelStart* and select *Set/Reset – Set*.**  Check that the Servomotor rotates at about 600 r/min.
5.	**Open the guard with the Safety-door Switch.**  Check that the Servomotor decelerates to a stop. Check that the 7-segment LED display shows ‘SF.’. 

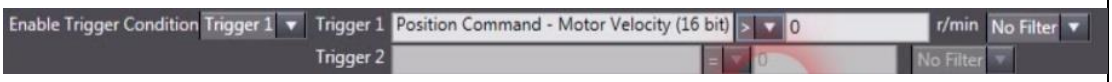
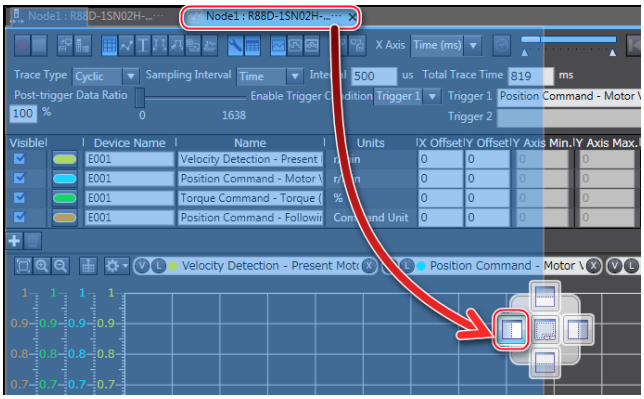
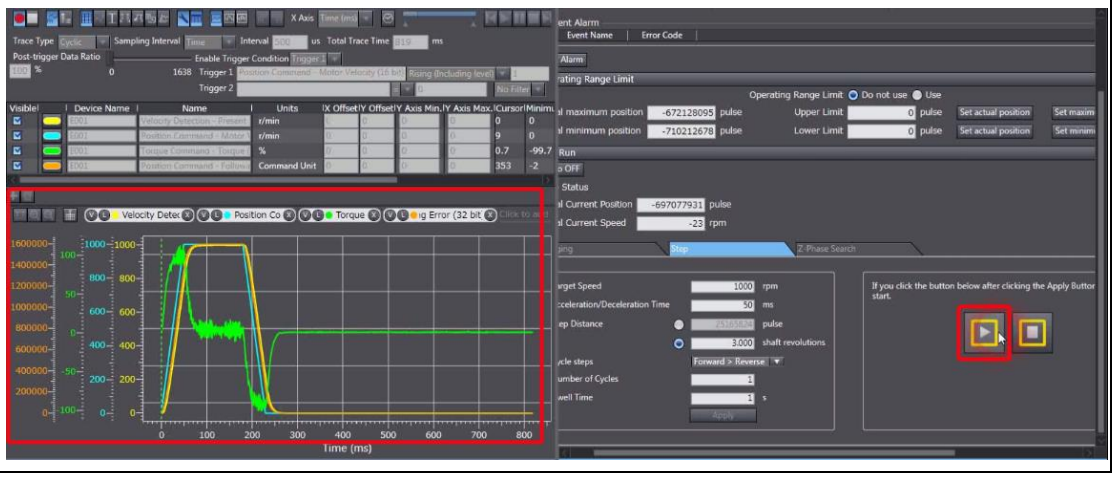
6.	**Operate the Safety Key Selector Switch to switch to safety inactive mode.**  Check that the Servomotor rotates at about 60 r/min. Check that the 7-segment LED display still shows ‘SF’. 
7.	**Operate the Safety key Selector Switch to switch to normal operating mode.**  Check that the Servomotor decelerates to a stop. Check that the 7-segment LED display still shows ‘SF.’. 
8.	**Close the guard and press the safety reset switch.** Check that the Servomotor rotates at about 600 r/min. Check that the 7-segment LED display shows ‘oE.’. 

Appendices

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.** 

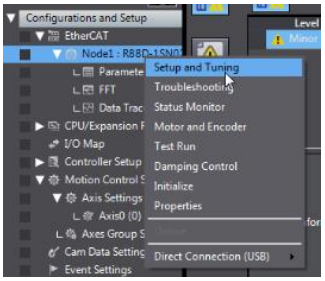
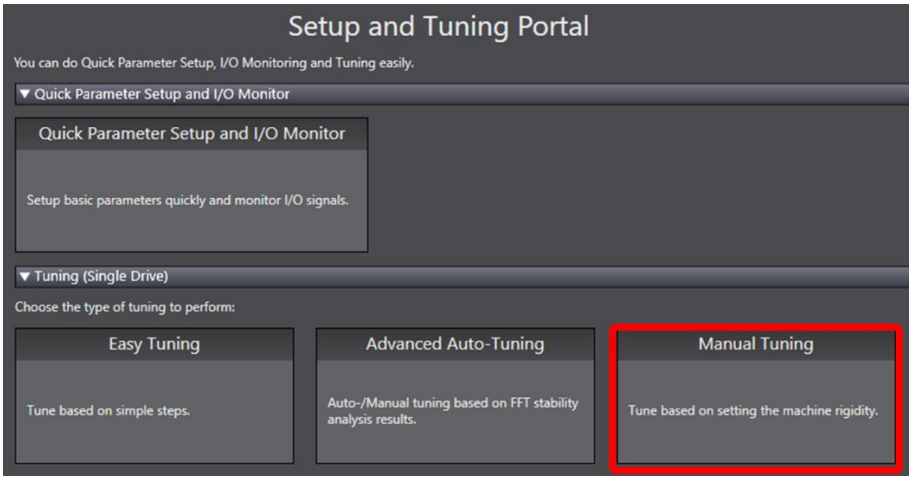
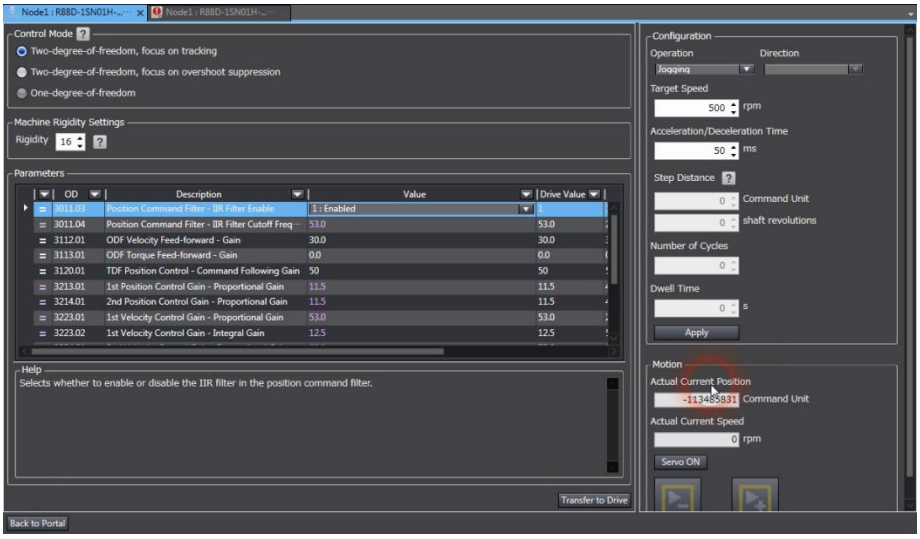
1.	**Right-click the Servo Drive and select *Test Run* from the menu.** 
2.	**Click the *Step* Tab.** Adjust the motion profile. Click the **Apply** Button. 
3.	**Click the *Servo ON* Button to turn ON the Servo.** 
4.	**Right-click *Data Trace Settings* and select *Add - Data Trace* from the menu to add a new data trace.** 

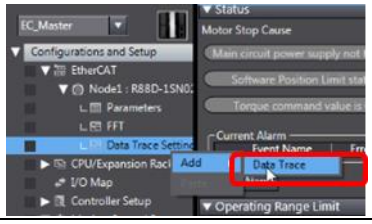
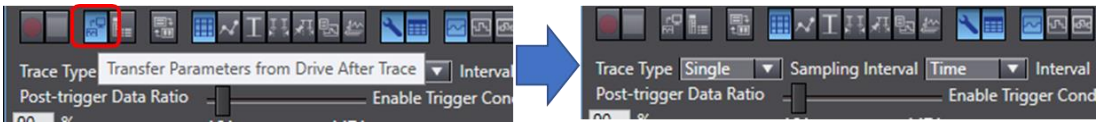
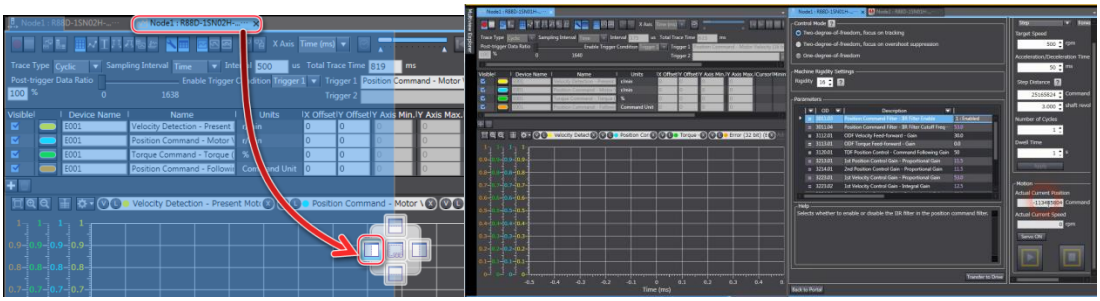
5.	**Select *Cyclic* for the trace type.** 
6.	**Specify the sampling interval.** 
7.	**Specify the enable trigger condition.** 
8.	**Click the *Execute* Button.** 
9.	**Align the Test Run Window and the Data Trace Window horizontally by docking them.**  Click the **Start** Button in the Test Run Window to run the Servomotor. **Traced data will appear cyclically.** 

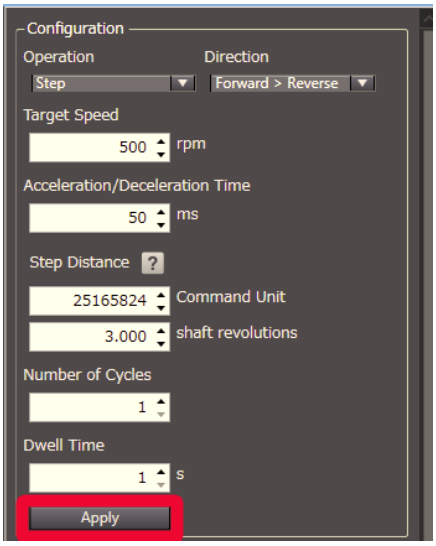
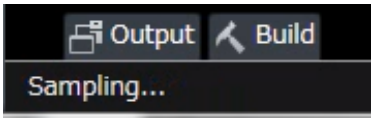
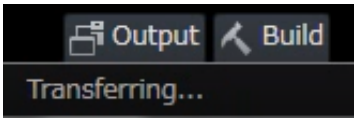
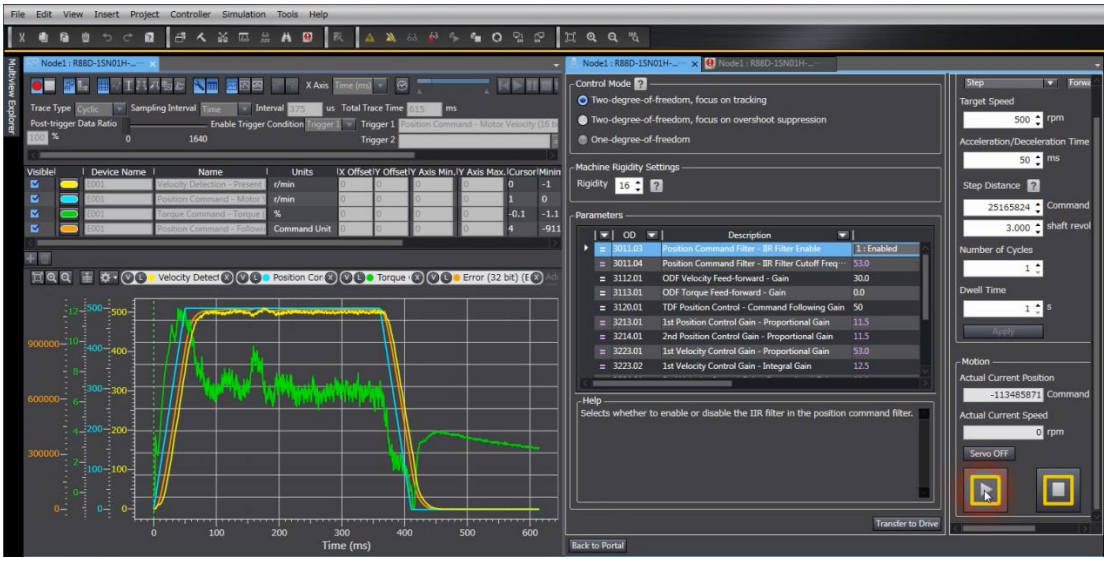
Manual Tuning

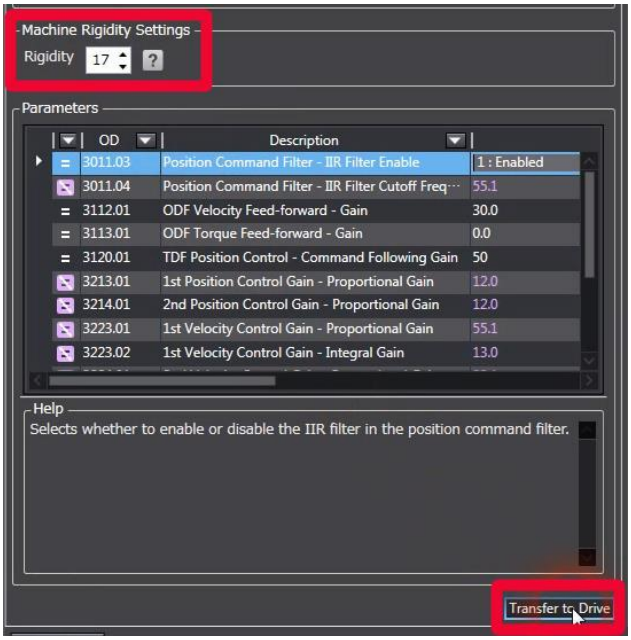
■ How to Perform Manual Tuning

This section describes how to change machine rigidity parameters for gain adjustment.

1.	**Right-click the Servo Drive and select *Setup and Tuning* from the menu.** 
2.	**Click the *Manual Tuning* Button.**  **The Manual Tuning Window is displayed.** It includes machine rigidity settings, gain parameters, and Servo Drive test run. 

3.	**In order to check the behavior of the Servomotor, right-click *Data Trace Settings* and select *Add - Data Trace* from the menu to add a new data trace.** 
4.	**Select *Cyclic* for the trace type.** 
5.	**Adjust the sampling interval.** 
6.	**Adjust the enable trigger condition.** 
7.	**Click the *Transfer Parameters from Drive after Trace* Button to disable uploading parameters.**  **Click the *Execute* Button.**  Sysmac Studio is now waiting for the trigger. 
8.	**Align the Test Run Window and the Data Trace Window horizontally by docking them.** 

9.	**Configure the motion profile and click the *Apply* Button.** 
10.	**Click the *Servo ON* Button to turn ON the Servo and then click the *Start* Button.**   **Be careful because the Servomotor will move in forward and reverse directions.**
11.	**Data trace is now triggered, and trace results are displayed.**   Each time the Servomotor moves, traced data will appear cyclically. 

12.	**It is possible to change gain values at once by changing the machine rigidity settings.**  Click the **Transfer to Drive** Button to transfer the gain parameters to the Servo Drive.
13.	**Repeat step 10, 11, and 12 until the desired performance is achieved.** If vibrations occur, reduce the rigidity settings. If required, it is possible to increase responsiveness by applying notch filters in Advanced Auto-Tuning and adjusting gains. Refer to the *Advanced Auto-Tuning*.

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

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