EPSON

Robot Controller
Safety Function Manual

Original instructions
Control Unit RC700-E

Rev.5
ENM23YS6209F

Table of Contents

1. Introduction

1.1 Introduction

Thank you for purchasing this Epson robot system.
This manual provides the information necessary for correctly using the Robot Controller safety functions.
Before using the system, please read this manual and related manuals to ensure correct use.
After reading this manual, store it in an easily accessible location for future reference.

Epson conducts rigorous testing and inspection to ensure that the performance of our robot systems meets our standards. Please note that if the Epson robot system is used outside the operating conditions described in the manual, the product will not perform up to its basic performance.

This manual describes potential hazards and problems that are foreseen. To use the Epson robot system safely and correctly, be sure to follow the safety information contained in this manual.

1.2 Trademarks

Microsoft, Windows, the Windows logo, Visual Basic, and Visual C++ are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries. All other company names, brand names, and product names are registered trademarks or trademarks of their respective companies.

1.3 Notation

Microsoft® Windows® 8 operating system Japanese version
Microsoft® Windows® 10 operating system Japanese version
Microsoft® Windows® 11 operating system Japanese version
In this manual, the above operating systems are referred to as Windows 8, Windows 10, and Windows 11, respectively.
Windows 8, Windows 10, and Windows 11 are sometimes collectively referred to as Windows.

1.4 Terms of Use

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1.5 Manufacturer

SEIKO EPSON CORPORATION

1.6 Contact Information

For contact information details, refer to the "Supplier" section in the following manual.
"Safety Manual"

1.7 Before Use

Before using this manual, be sure that you understand the following information.

Safety precautions
Only qualified personnel should transport and install the robot and the related equipment. Also, the laws and regulations of the

installation country must be followed.
Before use, please carefully read this manual and other related manuals to ensure correct use.
After reading this manual, store it in an easily accessible location for future reference.

Meaning of symbols

> ⚠ WARNING
>
> This symbol indicates an imminently hazardous situation which, if operation is not performed properly, will result in death or serious injury.

> ⚠ CAUTION
>
> This symbol indicates a potentially hazardous situation which, if operation is not performed properly, may result in an injury or in property damage only.

1.8 Training

Personnel using the safety functions of the Robot Controller must undergo the "installation training" or "maintenance training" conducted by Epson. To ensure that our customers understand our products, Epson provides training on a regular or ad hoc basis.
Undergoing formal training will allow you to properly use the product and increase productivity. For details on training, please contact the supplier.

2. Overview of the Robot Controller Safety Functions

2.1 Explanation of Robot Controller Safety Functions

The Robot Controller safety functions can be used to set safety inputs and safety outputs, and to create applications that link to safety devices.

Also, the safety function options support functions that safely control the operating speed and operating range of the robot. You can set the robot's Maximum Speed and monitoring area to achieve an application for safely controlling the robot.

> ⚠ CAUTION
>
> The safety performance of the Robot Controller safety functions is Category 3, PLd (Reference standard: ISO 13849-1: 2015).
> Please ensure the safety of the robot system in light of the safety performance of the Robot Controller safety functions. Also, please refer to and observe the safety standards of the respective country and region.

The following describes the types and characteristics of the Robot Controller safety functions.

Controller Safety Function standard functions:

- **Safe Torque OFF (STO)**
  A signal input from the Robot Controller opens a relay to cut off the power supply to the motors and stop the robot. This is a safe state for the Robot Controller.
  STO is operated indirectly from an emergency stop or protective stop. It cannot operate directly.

- **Emergency Stop**
  This function allows the robot to perform an emergency stop by a signal input from a safety relay or from an emergency stop switch attached to the emergency stop input connector or safety I/O connector. After the signal is input, an SS1 is executed, and after the motor stops, the robot is in an emergency stop status. During the emergency stop status, EP is displayed on the 7-segment LED of the Robot Controller.
  There are three emergency stop circuits for the Robot Controller:
  - Emergency stop input connector (E-Stop)
  - Port of the safety I/O connector configured for the emergency stop (Safety Input)
  - Emergency stop switch attached to Teach Pendant (E-Stop, TP)

- **Safeguard (SG) (protective stop)**
  This function allows the robot to perform a protective stop by a signal input from a safety peripheral device attached to the safety I/O connector. After the signal is input, the SS1 is executed, and after the motor stops, the robot is in a protective stop status. SO is displayed on the 7-segment LED of the Robot Controller.
  The Robot Controller safeguard (SG) circuit is as follow:
  - Port of the safety I/O connector configured for the safeguard (SG)

- **Enable**
  Enable is the path connected to the enable switch when the Teach Pendant is connected. Only Epson Teach Pendants can be connected, and customer enable switches cannot be connected.
  When the system detects that the enable switch of the Teach Pendant is not in the middle position, the SS1 is executed, and the robot is in an STO state.

- **Soft Axis Limiting**
  This monitors that each axis of the robot is within its operating range. If the system detects that an axis of the robot exceeded the limiting range, the robot emergency stop and STO are immediately executed, putting the Robot Controller in the emergency stop status.
  The restricted range for each axis of the robot is set in the dedicated software (Safety Function Manager).

- **Safety outputs**
  External safety devices can be connected to the safety outputs of the Robot Controller to perform notifications of the ON/OFF status of the safety functions.
  By assigning settings in the dedicated software (Safety Function Manager), the following safety signals can be output:
  - STO state
  - Status of the emergency stop switch
  - Status of the enable switch
  - Enabled/disabled status of the Safety Limited Speed (SLS)
  - Enabled/disabled status of the Safety Limited Position (SLP)

Controller Safety Function charged optional functions:

- **Safety Limited Speed (SLS)**
  This monitors the operating speed of the robot. If the system detects that the robot exceeded the Maximum Speed, the robot emergency stop and STO are immediately executed, putting the Robot Controller in the emergency stop status.
  The safety speed limit of the robot is set in the dedicated software (Safety Function Manager).

> **KEY POINTS**
>
> The speed monitoring function during teaching can be used as a standard function.

- **Safety Limited Position (SLP)**
  This monitors the robot's position and joint angles. If the system detects that the robot exceeded the monitored areas or joint angle limit, the robot emergency stop and STO are immediately executed, putting the Robot Controller in the emergency stop status.
  The Monitored Areas and Joint Angle Limit of the robot are set in the dedicated software (Safety Function Manager).

Reference
For details on each function, refer to the following sections.

Standard functions:

- **Safe Torque OFF (STO)**
- **Safe Stop 1 (SS1)**
- **Emergency Stop**
- **Enable**
- **Soft Axis Limiting**
- **Safety Inputs**
- **Safety Outputs**

Paid option functions:

- **Safety Limited Speed (SLS)**
- **Safety Limited Position (SLP)**
- **Joint Angle Limit**

> **KEY POINTS**
>
> For details on the "Safety Function Manager," refer to the following section.
> **Setting Safety Functions (Setting Software: Safety Function Manager)**

2.2 Required Knowledge

2.2.1 Undergoing Training

Personnel using the safety functions of the Robot Controller must undergo the "installation training" or "maintenance training" conducted by Epson.

2.2.2 Basic Knowledge of EPSON RC+

Use of the safety functions of the Robot Controller requires knowledge of the software used to develop programs for the Robot Controller, EPSON RC+, as well as EPSON robots. The contents of this manual are intended for persons who are knowledgeable about the following:

- Concept of EPSON RC+ project management, and how to use it
- How to create and edit SPEL+ programs in EPSON RC+
- How to execute the SPEL+ program from the Run window
- Basic language structure and functionality of SPEL+, and how to use it

KEY POINTS

Personnel using EPSON RC+ for the first time must undergo the "installation training" conducted by Epson.

2.3 Precautions for Using the Robot Controller Safety Functions

When using the Robot Controller safety functions, follow the safety precautions described below.

⚠ WARNING

- Be sure to check the safety function parameter settings when operating a Robot Controller in its initial state or when operating a Robot Controller with unknown safety function parameter settings. Also, operate the Manipulator after understanding the operation of the safety functions.
- Be sure to check that the intended operation is achieved when changing from the previous state of use, such as when safety function parameters are changed or when parts are replaced for maintenance.
- When checking operation, use low power mode.
  Reducing the motor output ensures operator safety and reduces the risk of destruction and damage to peripheral equipment due to careless operation.
- Before beginning full operation, check that the safety function parameters are set as intended.
  The parameter checksum of the safety functions is calculated from the safety function parameters. If the parameter checksum of the safety functions is changed, it means that the safety function parameters have been changed. Incorrectly set safety functions may cause serious safety problems.
- Before beginning full operation, make sure that the safety devices such as the emergency stop switch and safeguard switch operate. Operation without the switches functioning properly may result in the safety functions failing to operate during an emergency, which is extremely hazardous and may result in serious injury and/or severe damage to the robot system.

2.4 Terminology

Safety device
This refers to a device that is connected to a safety I/O connector of the Robot Controller.

Dry run
This refers to the status when a Robot Controller that is not connected to a Manipulator is used to check the operation of the robot program.

Operation mode
This refers to either AUTO mode (including PROGRAM mode), TEACH mode, TEST T1 mode, or TEST T2 mode. This can be changed using the Teach Pendant.

Hofs
This refers to the offset value of the robot's joint axes.

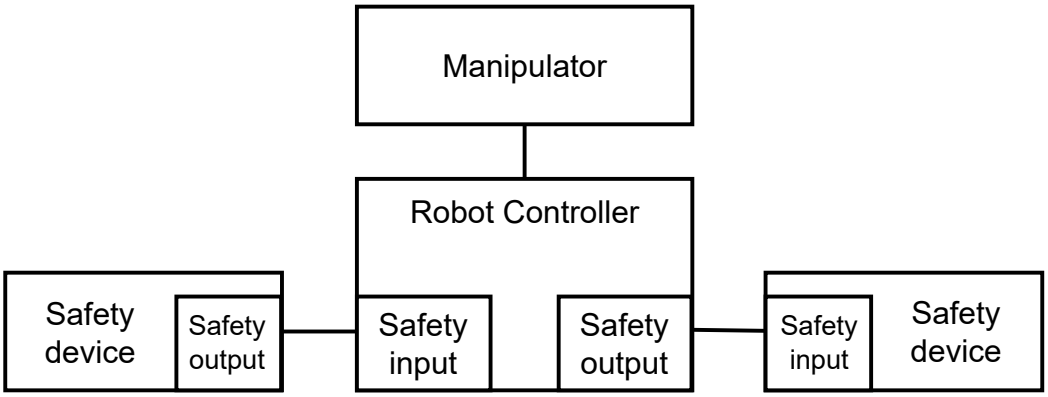
Safety board
This refers to the board for monitoring the robot system.
It is built into the Robot Controller.

Tool coordinate tip point (TCP)
This refers to the point of contact between the hand and the workpiece. Set this according to the hand.

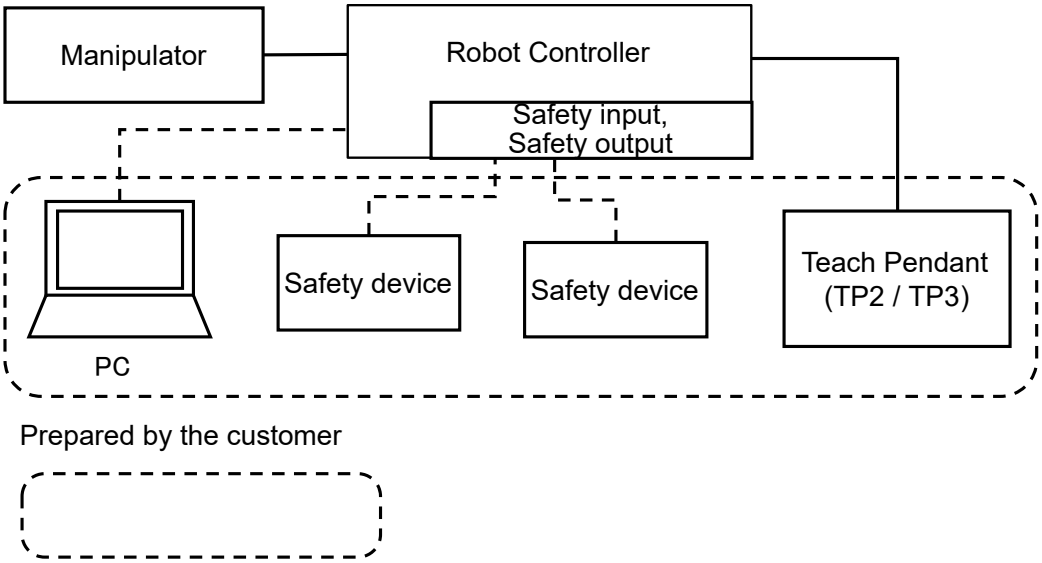
2.5 System Overview

Safety devices can be connected to the safety I/O connectors of the Robot Controller.

- Connect the safety outputs of safety devices to the safety inputs of the safety I/O connectors.
- Connect the safety inputs of safety devices to the safety outputs of the safety I/O connectors.



Example of system configuration using the Robot Controller safety functions:



KEY POINTS

For details on how to connect safety devices and the Robot Controller, refer to the following manual.
"Robot Controller RC700-E Manual"

3. Details of Robot Controller Safety Functions

3.1 Main Functions

Refer to the following section for details.
Explanation of Robot Controller Safety Functions

For details on each function, refer to the following sections.
Standard functions:

- **Safe Torque OFF (STO)**
- **Safe Stop 1 (SS1)**
- **Emergency Stop**
- **Enable**
- **Soft Axis Limiting**
- **Safety Inputs**
- **Safety Outputs**

Paid option functions:

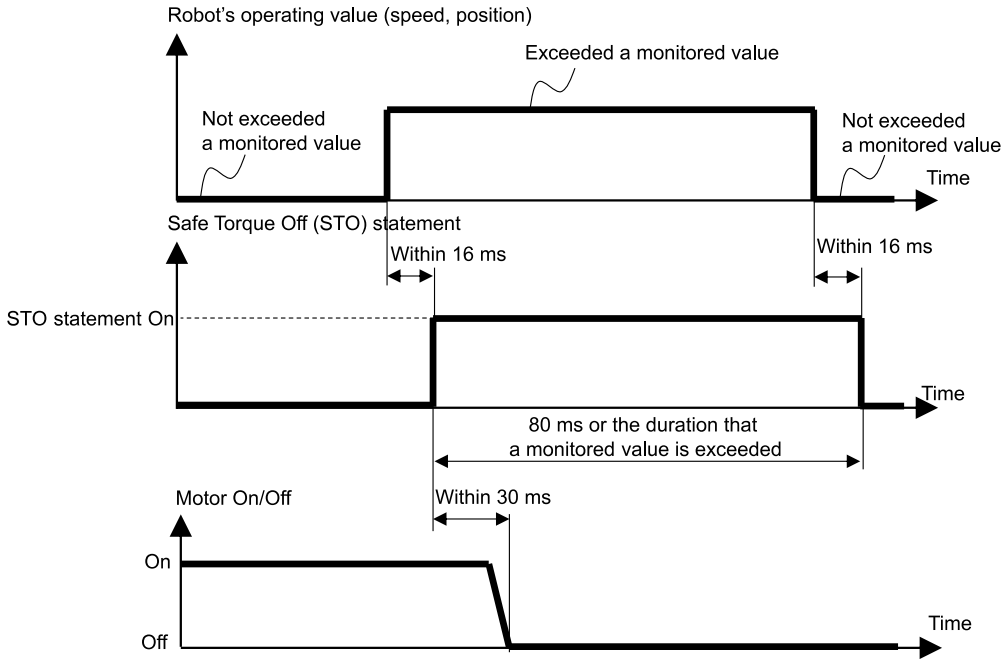
- **Safety Limited Speed (SLS)**
- **Safety Limited Position (SLP)**
- **Joint Angle Limit**

3.2 Safe Torque OFF (STO)

3.2.1 Outline and Operation Patterns for Safe Torque OFF (STO)

Safe Torque OFF (STO) is a function that opens the relay and disconnects the power supply to the motors when a monitoring value of a safety function is exceeded.

Safe Torque OFF (STO) is equivalent to stop category 0. (Reference standard: IEC 60204-1)



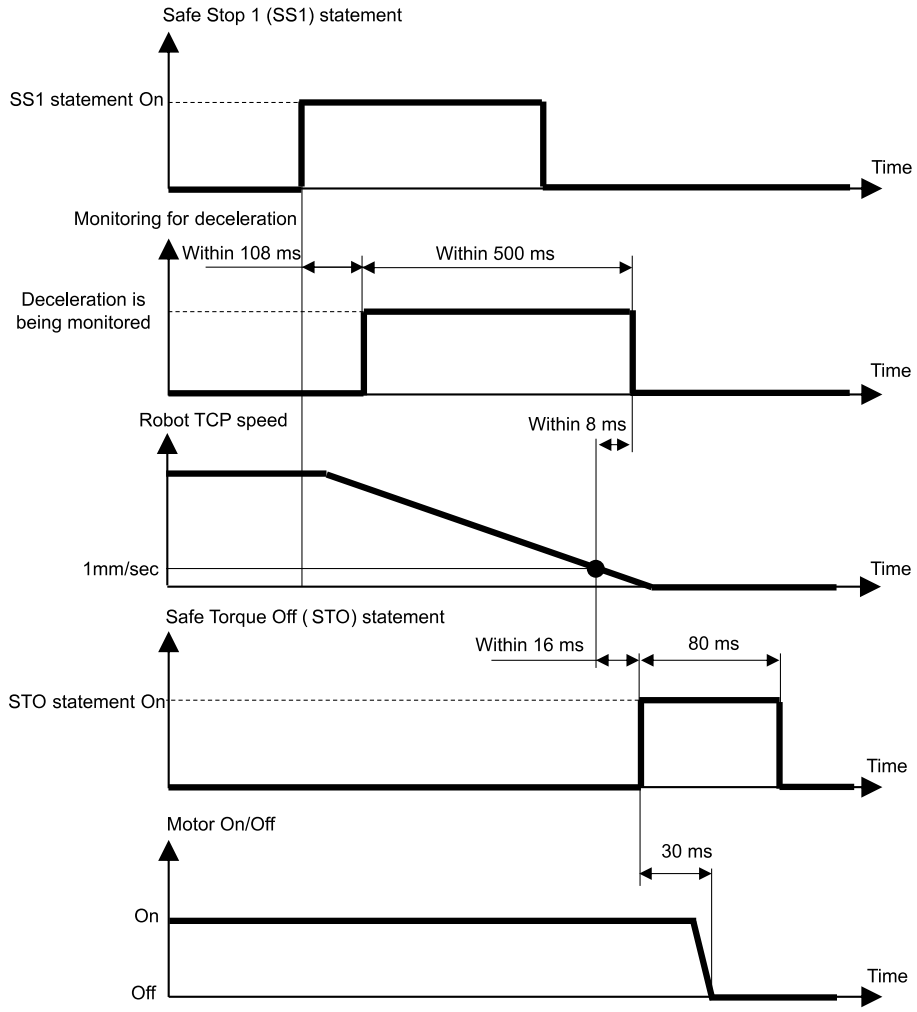
3.3 Safe Stop 1 (SS1)

3.3.1 Outline and Operation Patterns for Safe Stop 1 (SS1)

Safe Stop 1 (SS1) is a function that monitors whether the robot decelerates and stops normally when there is an emergency stop or a protective stop. If an abnormal deceleration of TCP speed is detected during stop control, Safe Torque OFF (STO) is immediately executed.

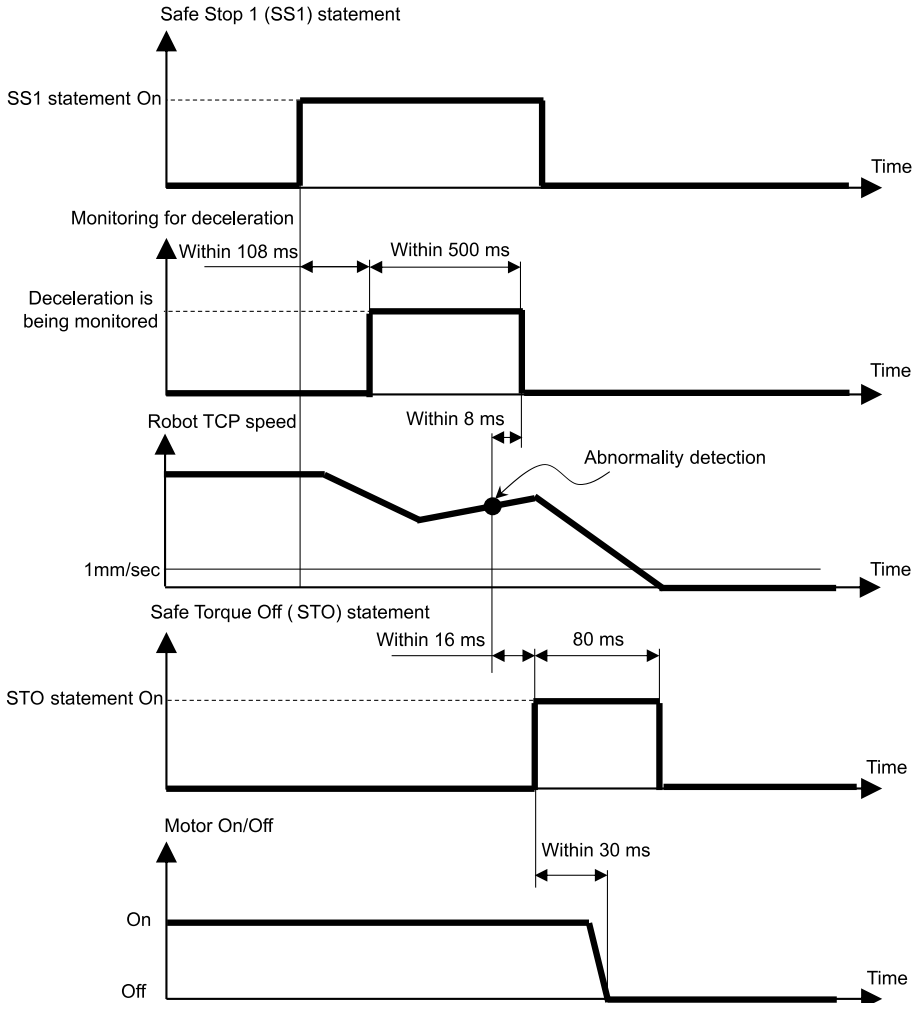
Safe Stop 1 is equivalent to stop category 1. (Reference standard: IEC 60204-1)

Relationship between Safe Stop 1 (SS1) and the STO statement (normal state)
If stop control is normal, Safe Torque OFF (STO) is executed after stop control is completed.



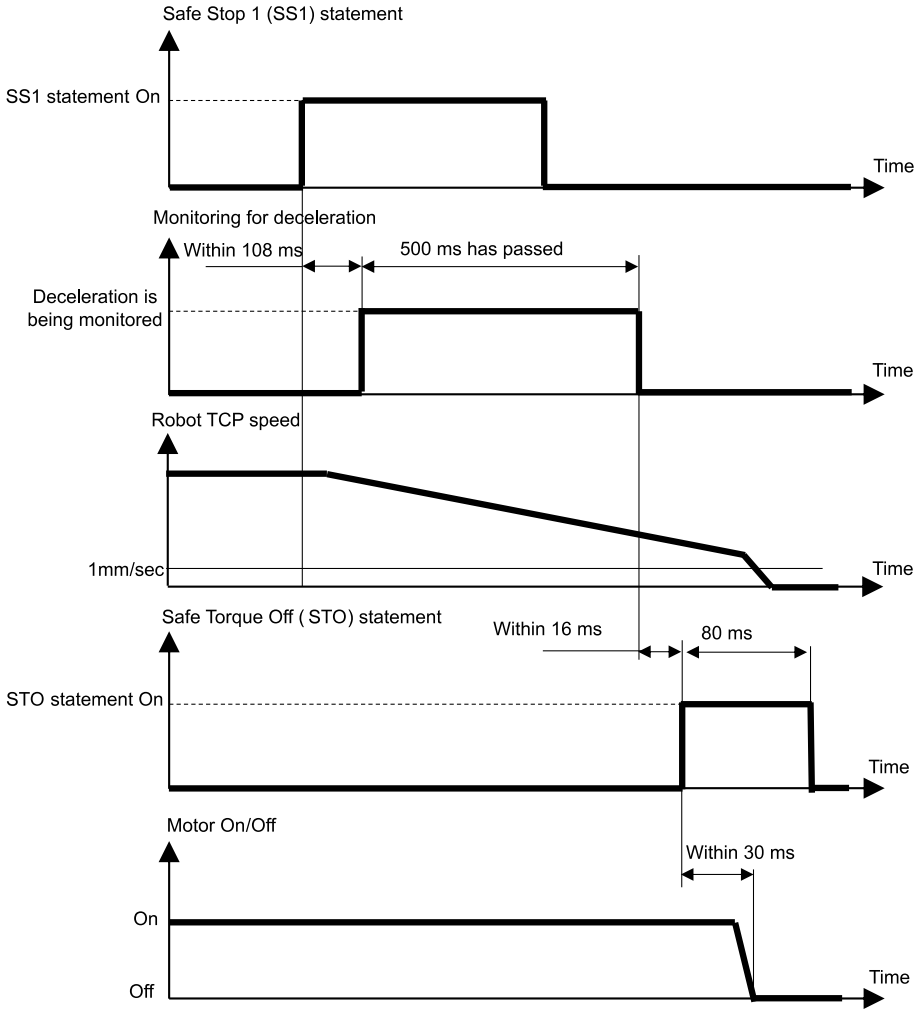
Relationship between Safe Stop 1 (SS1) and the STO statement (when deceleration abnormality is detected)

If an abnormal deceleration of TCP speed is observed during stop control, Safe Torque OFF (STO) is immediately executed.



Relationship between Safe Stop 1 (SS1) and the STO statement (after the monitoring time)

If the TCP speed does not decelerate to 1 [mm/sec] or less even after a certain period of time from the start of stop control, Safe Torque OFF (STO) is immediately executed.

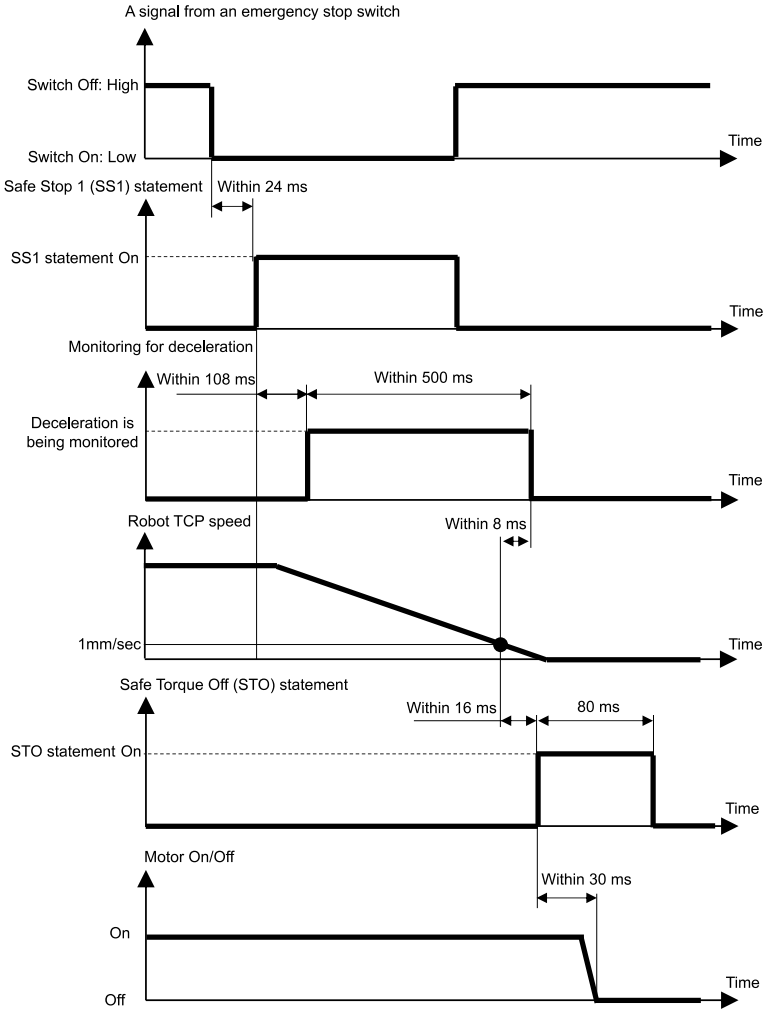


3.4 Emergency Stop

3.4.1 Outline and Operation Patterns for the Emergency Stop

When the emergency stop switch is turned ON (is pressed), Safe Stop 1 (SS1) is executed and then Safe Torque OFF (STO) is executed, putting the Robot Controller in the emergency stop status.

Relationship between the emergency stop and the STO statement

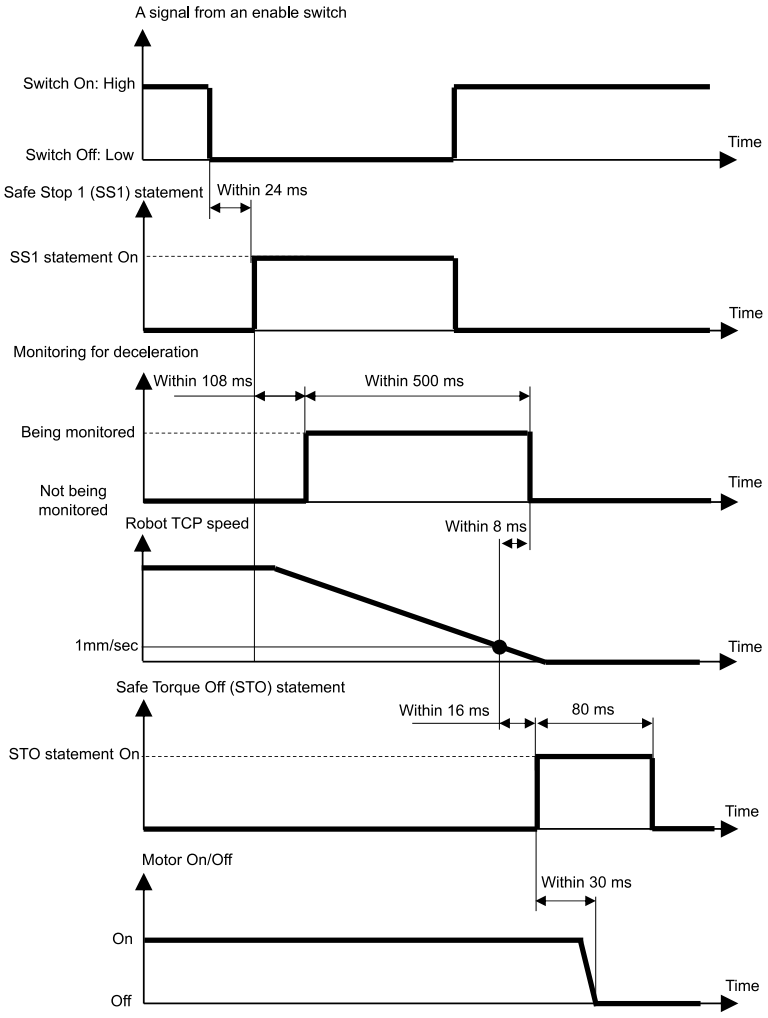


3.5 Enable

3.5.1 Outline and Operation Patterns for Enable

When the enable switch is OFF (is in a position other than the middle position), Safe Stop 1 (SS1) is executed and then Safe Torque OFF (STO) is executed, performing a protective stop.

Relationship between Enable and the STO statement



3.6 Safety Limited Speed (SLS)

3.6.1 Outline and Operation Patterns for Safety Limited Speed (SLS)

Safety Limited Speed (SLS) is a function that monitors the robot's operating speed. If, during operation, the robot exceeds the Maximum Speed, Safe Torque OFF (STO) is immediately executed, putting the Robot Controller in the emergency stop status.

⚠ WARNING

Please set the Maximum Speed considering the stopping distance. For the stopping distance, refer to the following manual.
"Manipulator Manual - Appendix B: Stopping Time and Stopping Distance at Emergency Stop"

Operation modes and enabling/disabling Safety Limited Speed (SLS)
When the operation mode is TEACH or TEST T1, the Safety Limited Speed pattern SLS_T is always enabled. Safety Limited Speed SLS_T is a standard function.

When the operation mode is TEST T2, the Safety Limited Speed pattern SLS_T2 is always enabled. Safety Limited Speed pattern SLS_T2 is a standard function.

When the operation mode is AUTO, TEST T1, or TEST T2, the safety inputs can be used to enable or disable Safety Limited Speed (SLS). In these operation modes, three patterns of Maximum Speeds, SLS_1, SLS_2, and SLS_3, can be set. Safety Limited Speed patterns SLS_1, SLS_2, and SLS_3 are safety function options.

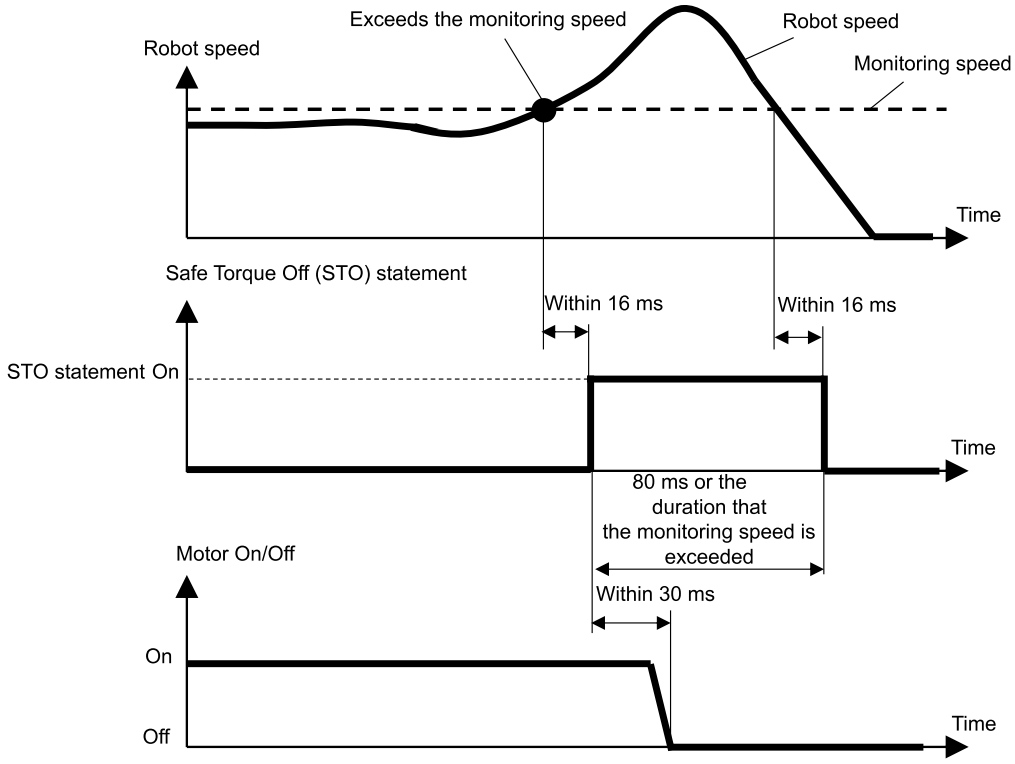
Safety Limited Speed (SLS) patterns		Enable or disable for each operation mode A: Always enable B: Enable or disable based on safety inputs -: Always disable			
		AUTO	TEACH	TEST T1	TEST T2
Standard functions	SLS_T*	-	A	A	-
	SLS_T2	-	-	-	A
Optional safety functions	SLS_1	B	-	B	B
	SLS_2	B	-	B	B
	SLS_3	B	-	B	B

*: For details on the Safety Limited Speed pattern SLS_T, refer to the following section.

- **Safety Limited Speed (SLS) for a SCARA Manipulator**
- **Safety Limited Speed (SLS) for a 6-Axis Manipulator**

Relationship between Safety Limited Speed (SLS) and the STO statement

If, during robot operation, the system detects that the Maximum Speed was exceeded, Safe Torque OFF (STO) is immediately executed, putting the Robot Controller in the emergency stop status.



3.6.2 Safety Limited Speed (SLS) for a SCARA Manipulator

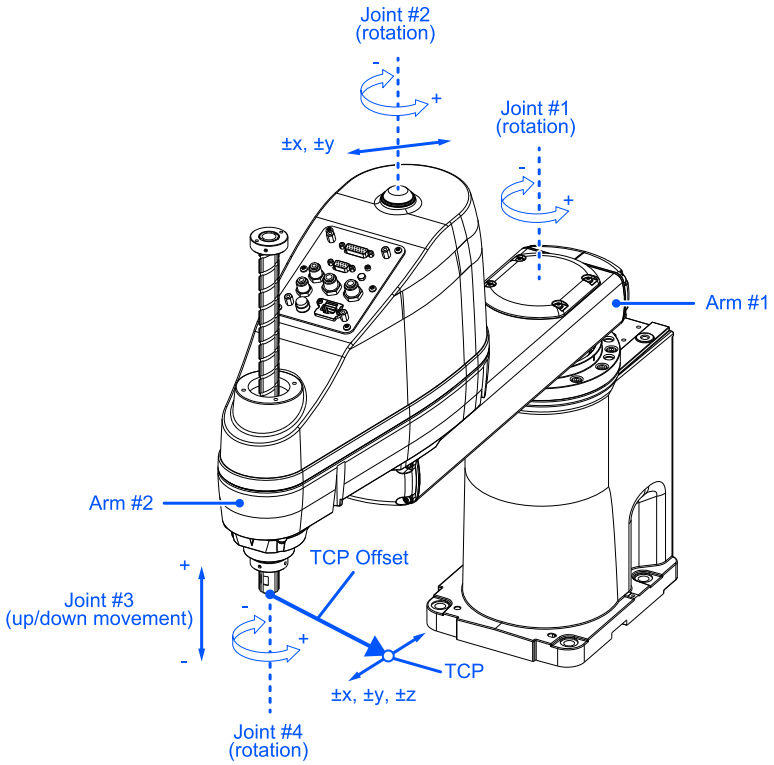
When using Safety Limited Speed (SLS) for a SCARA Manipulator, there are six locations that are monitored at the Maximum Speed. The speed (rotation or up/down) of each joint is expressed as a percentage of the maximum speed (rotation or up/down) of that joint.

- Speed (rotation) at Joints #1, #2, and #4 [%]
- Speed (up/down) of Joint #3 (ball screw linear motion mechanism) [%]
- Speed at Joint #2 (translation) [mm/sec]
- TCP speed [mm/sec]

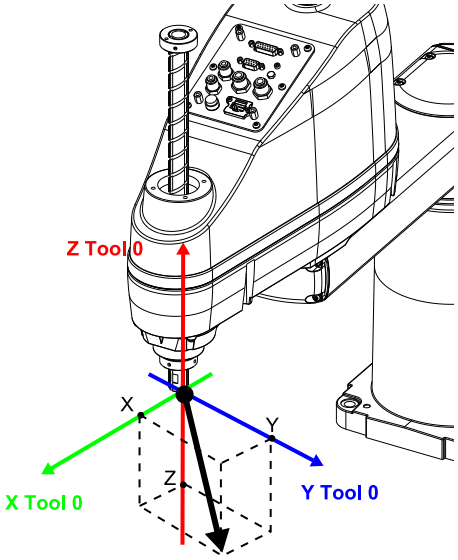
The TCP offset from the tip of the ball screw linear motion mechanism to the TCP is set in Safety Function Manager. With Safety Limited Speed (SLS) using the Safety Limited Speed pattern SLS_T, the TCP speed and Joint #2 speed (translation) limit is 250 [mm/sec].

⚠ CAUTION

The TCP offset setting set in Safety Function Manager is not linked to the setting parameters set in the “Tool Settings" section of the "EPSON RC+ User's Guide". Make sure that these settings are consistent.



The X, Y, and Z standards for the TCP offset are the Tool 0 coordinate system in EPSON RC+.

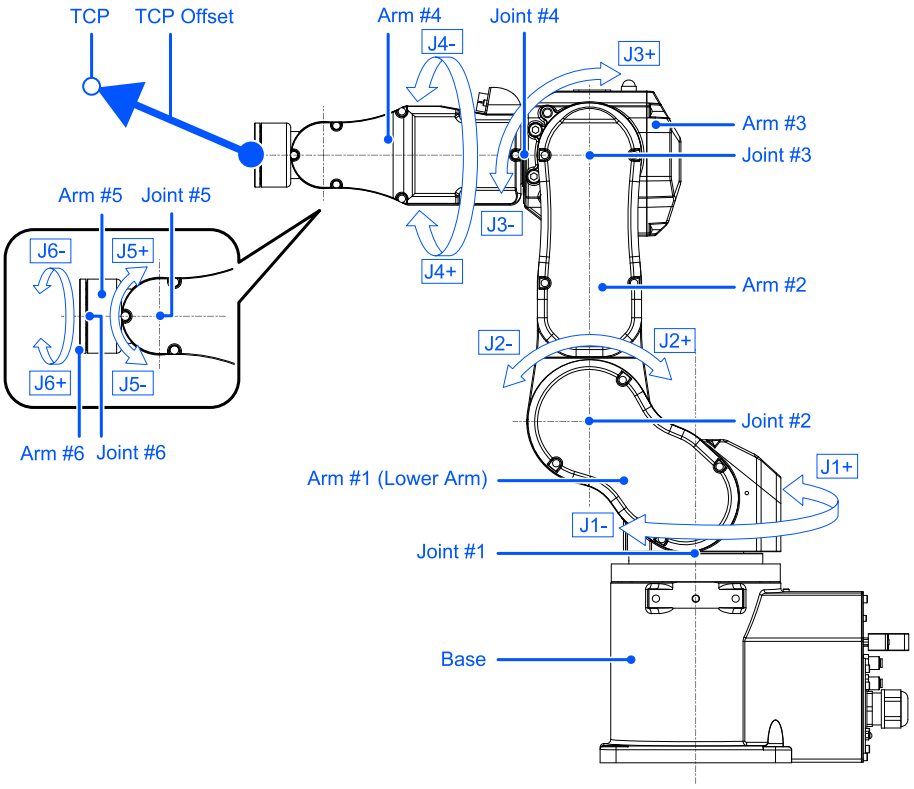


3.6.3 Safety Limited Speed (SLS) for a 6-Axis Manipulator

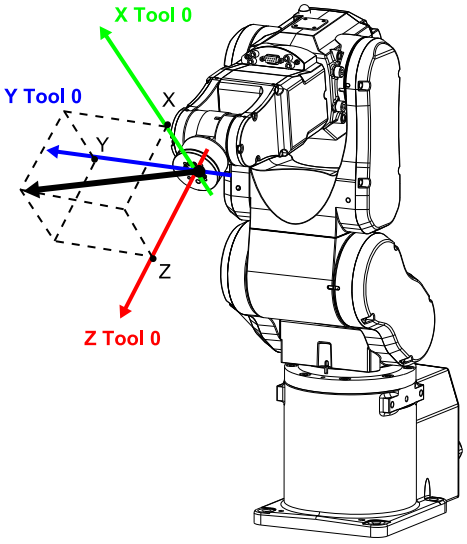
When using Safety Limited Speed (SLS) for a 6-Axis Manipulator, there are 10 locations that are monitored at the Maximum Speed. The rotation speed of each joint is expressed as a percentage of the maximum rotation speed of the corresponding joint.

- Speed at Joint (rotation) #1 to #6 [%]
- Speed at Joint #2 (translation) [mm/sec]
- Speed at Joint #3 (translation) [mm/sec]
- Speed at Joint #5 (translation) [mm/sec]
- TCP speed [mm/sec]

The TCP offset from the tip of Joint #6 to the TCP is set in Safety Function Manager. With Safety Limited Speed (SLS) using the Safety Limited Speed pattern SLS_T, the TCP speed and Joint #2, Joint #3, and Joint #5 speed (translation) limit is 250 [mm/sec].



The X, Y, and Z standards for the TCP offset are the Tool 0 coordinate system in EPSON RC+. For table top mounting, this is as follows.



For details on the Tool 0 coordinate system for a celling mounting or wall mounting, refer to the following manual.

"EPSON RC+ User's Guide - 6.16.4 Tool Coordinate System"

3.7 Safety Limited Position (SLP)

3.7.1 Outline and Operation Patterns for Safety Limited Position (SLP)

Safety Limited Position (SLP) is a function that monitors the robot's operating position. If the system detects that, during robot operation, the robot monitored range has entered the monitored area, then Safe Torque OFF (STO) is immediately executed, putting the Robot Controller in the emergency stop status.

Safety Limited Position (SLP) is a safety function option.

⚠ WARNING

- Please set the motion range considering the stopping distance. For the stopping distance, refer to the following manual.
  "Manipulator Manual - Appendix B: Stopping Time and Stopping Distance at Emergency Stop"
- If the robot speed is limited by the Safety Limited Speed (SLS), the restricted area can be determined based on the stopping distance calculated from the speed set by the Safety Limited Speed (SLS). If you are not using the Safety Limited Speed (SLS) function, determine the restricted area considering the stopping distance calculated from the robot's maximum speed.

Operation modes and enabling/disabling Safety Limited Position (SLP)
When the operation mode is AUTO, TEST T1, or TEST T2, the safety inputs can be used to enable or disable the Monitored Areas and Joint Angle Limit.

KEY POINTS

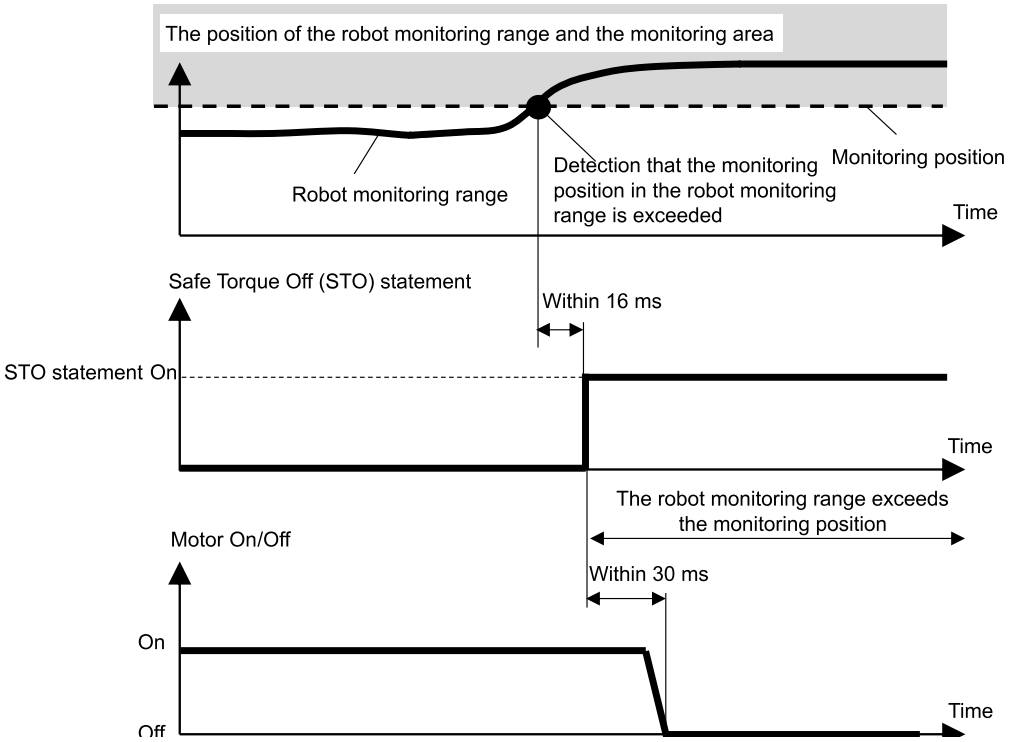
- For details on monitoring area, refer to the following section.
  - **Monitoring Areas for a SCARA Manipulator**
  - **Monitoring Areas for a 6-Axis Manipulator**
- For details on the Joint Angle Limit, refer to the following section.
  Joint Angle Limit

When the operation mode is TEACH, Safety Limited Position (SLP) is always disabled.

Safety Limited Position (SLP) patterns		Enable or disable for each operation mode B: Enable or disable based on safety inputs -: Always disable			
		AUTO	TEACH	TEST T1	TEST T2
Optional safety functions	SLP_A	B	-	B	B
	SLP_B	B	-	B	B
	SLP_C	B	-	B	B

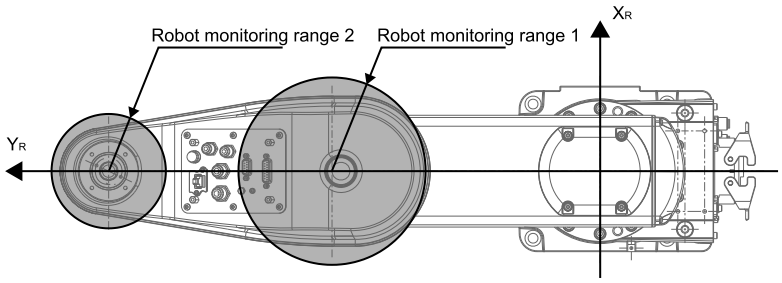
Relationship between Safety Limited Position (SLP) and the STO statement

If the system detects that, during robot operation, the robot monitored range has exceeded the monitored area, then Safe Torque OFF (STO) is immediately executed, putting the Robot Controller in the emergency stop status.

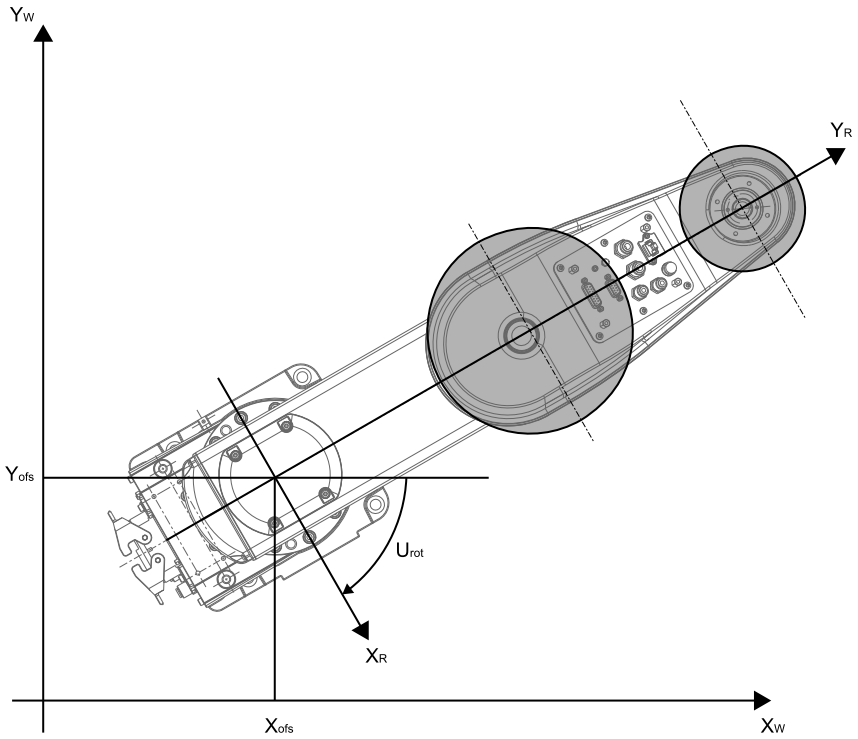


3.7.2 Robot Monitoring Range for a SCARA Manipulator

The robot monitoring ranges for the Safety Limited Position of a SCARA Manipulator are in two locations: a circle centered on Joint #2 (J2, Robot Monitored Range 1) and a circle centered on Joint #3 (J3, Robot Monitored Range 2). These robot monitoring ranges are set in Safety Function Manager. The minimum values that can be set are defined by the type of Manipulator.
Safety Limited Position (SLP) monitors whether the set monitoring range exceeds the Monitored Areas set by the coordinate system in which the robot is installed.

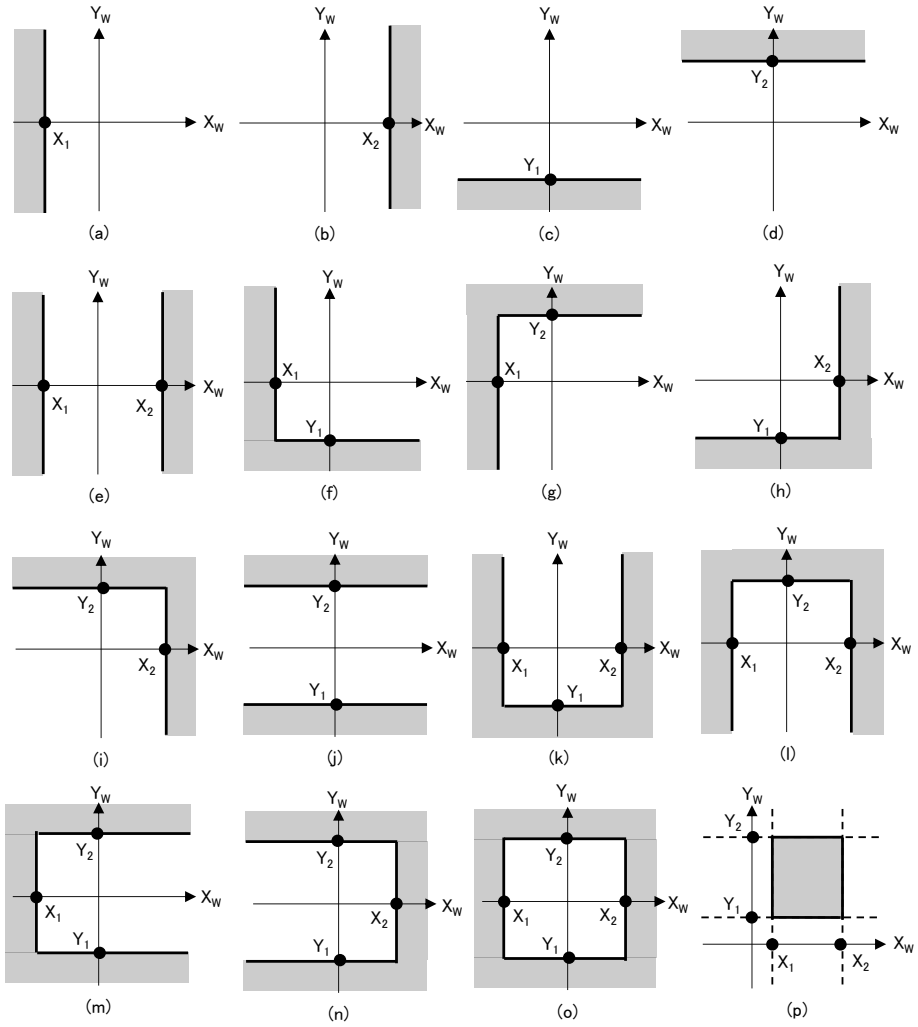


With Safety Limited Position (SLP) of a SCARA Manipulator, the robot installation position offset (X_{ofs}, Y_{ofs}) in the robot coordinate system X_R-Y_R and the robot installation plane rotation U_{rot} are set based on the coordinate system X_W-Y_W where the robot is installed.



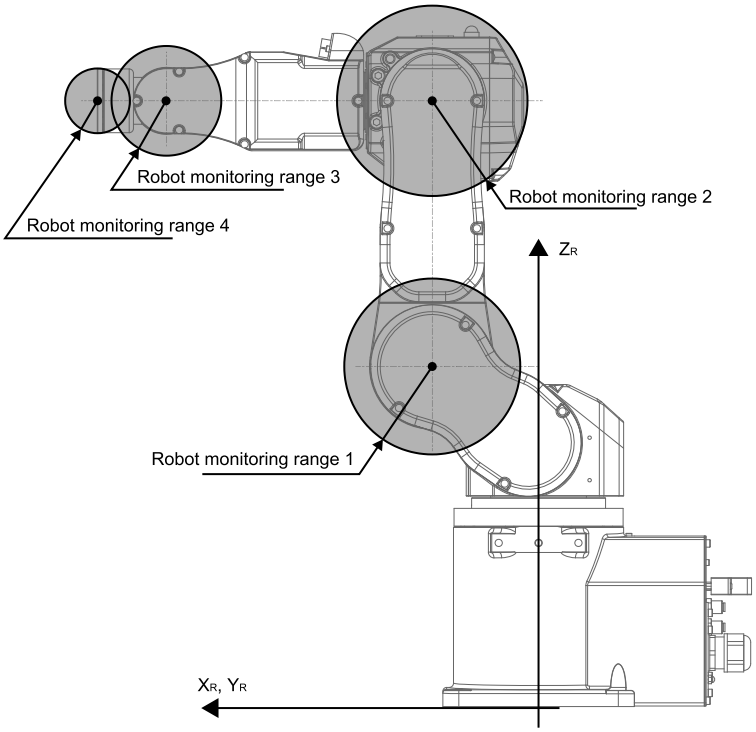
3.7.3 Monitoring Areas for a SCARA Manipulator

The monitoring areas for a SCARA Manipulator are specified within the restricted range of a X_W-Y_W plane in the coordinate system X_W-Y_W where the robot with Safety Limited Position is installed. There are 16 configurable restricted range patterns, (a) through (p).
These monitored areas are set as the positions (X_1, 0), (X_2, 0), (0, Y_1), (0, Y_2) that intersect with the coordinate system X_W-Y_W where the robot is installed. The robot monitoring range is monitored to ensure that it does not enter the monitoring areas.

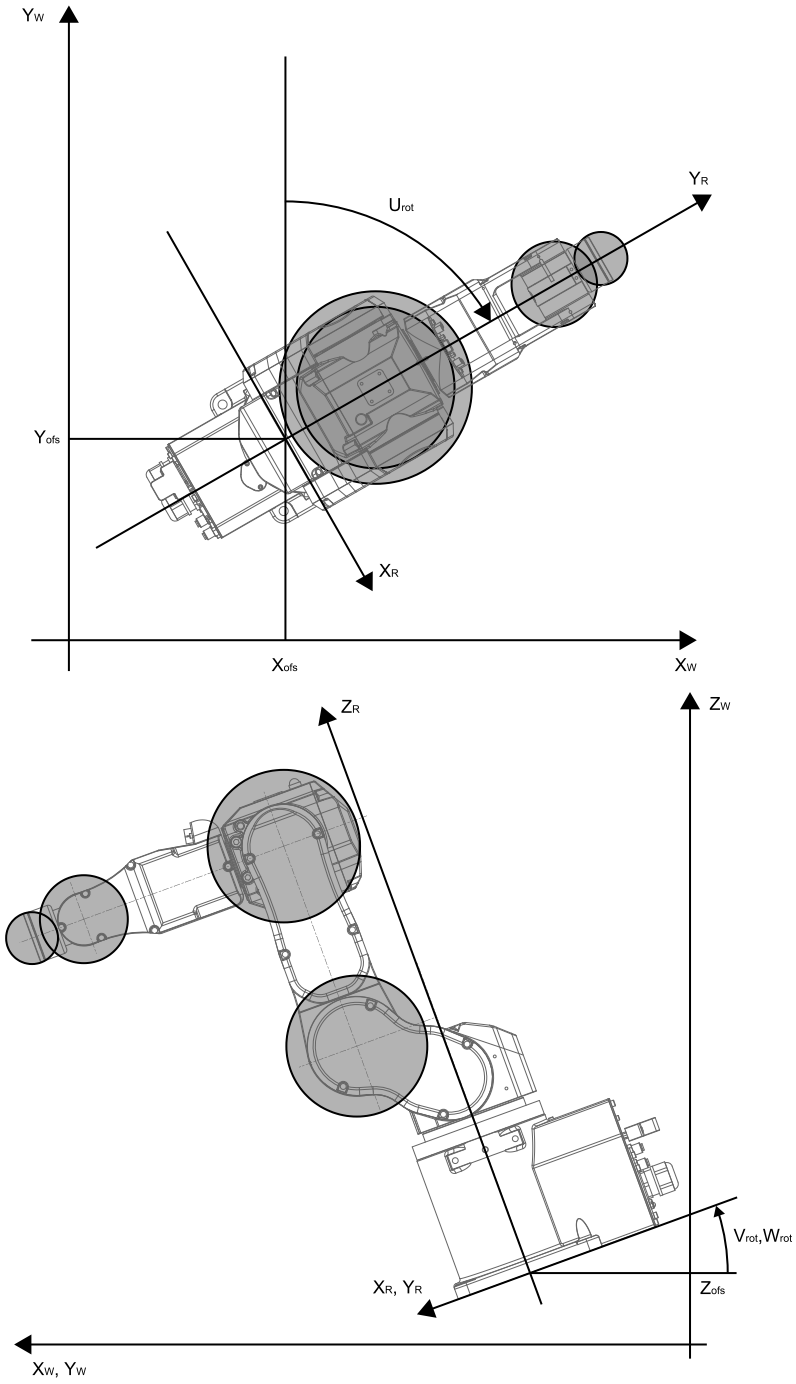


3.7.4 Robot Monitoring Range for a 6-Axis Manipulator

The robot monitoring ranges for the Safety Limited Position of a 6-Axis Manipulator are in four locations: a sphere centered on Joint #2 (J2, Robot Monitored Range 1), a sphere centered on Joint #3 (J3, Robot Monitored Range 2), a sphere centered on Joint #5 (J5, Robot Monitored Range 3), and a sphere centered on Joint #6 (J6, Robot Monitored Range 4). These robot monitoring ranges are set in Safety Function Manager. The minimum values that can be set are defined by the type of Manipulator.
Safety Limited Position (SLP) monitors whether the set monitoring range exceeds the Monitored Areas set by the coordinate system in which the robot is installed.

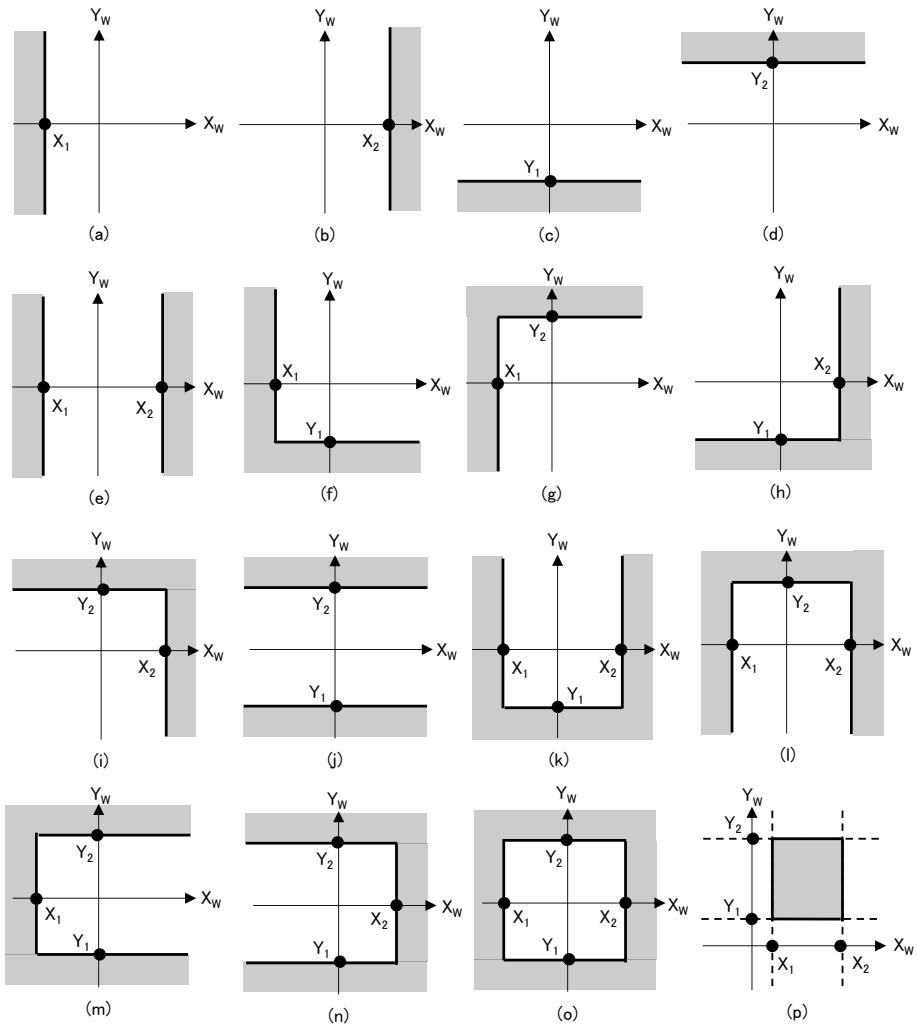


With Safety Limited Position (SLP) of a 6-Axis Manipulator, the robot installation position offset (X_{ofs}, Y_{ofs}, Z_{ofs}) in the robot coordinate system X_R-Y_R-Z_R and the robot installation plane rotation (U_{rot}, V_{rot}, W_{rot}) are set based on the coordinate system X_W, Y_W-Z_W where the robot is installed.

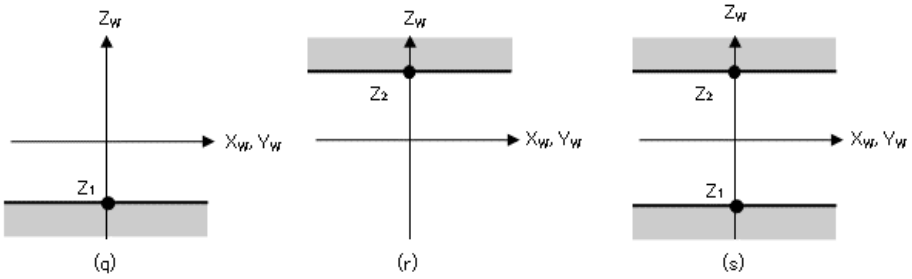


3.7.5 Monitoring Areas for a 6-Axis Manipulator

The monitoring areas for a 6-Axis Manipulator are specified based on a combination of the restricted range pattern of a X_W-Y_W plane and the restricted range pattern in the Z_W direction in the coordinate system X_W-Y_W-Z_W where the robot with Safety Limited Position is installed. There are 16 configurable restricted range patterns on a X_W-Y_W plane, (a) through (p). These monitored areas are set as the positions (X_1, 0), (X_2, 0), (0, Y_1), (0, Y_2) that intersect with the coordinate system X_W-Y_W where the robot is installed. The robot monitoring range is monitored to ensure that it does not enter the monitoring areas.



There are three configurable restricted range patterns in the Z_W direction, (q) through (s). These monitored areas are set as the positions (Z_1, Z_2) in the Z_W direction in the coordinate system where the robot is installed. The robot monitoring range is monitored to ensure that it does not enter the monitoring areas.



3.8 Joint Angle Limit

3.8.1 Outline and Operation Patterns for Joint Angle Limit

Joint Angle Limit is a function that monitors the robot's joint angles. If the system detects that the robot exceeded the motion range, Safe Torque OFF (STO) is immediately executed, putting the Robot Controller in the emergency stop status.

Joint Angle Limit is a safety function option.

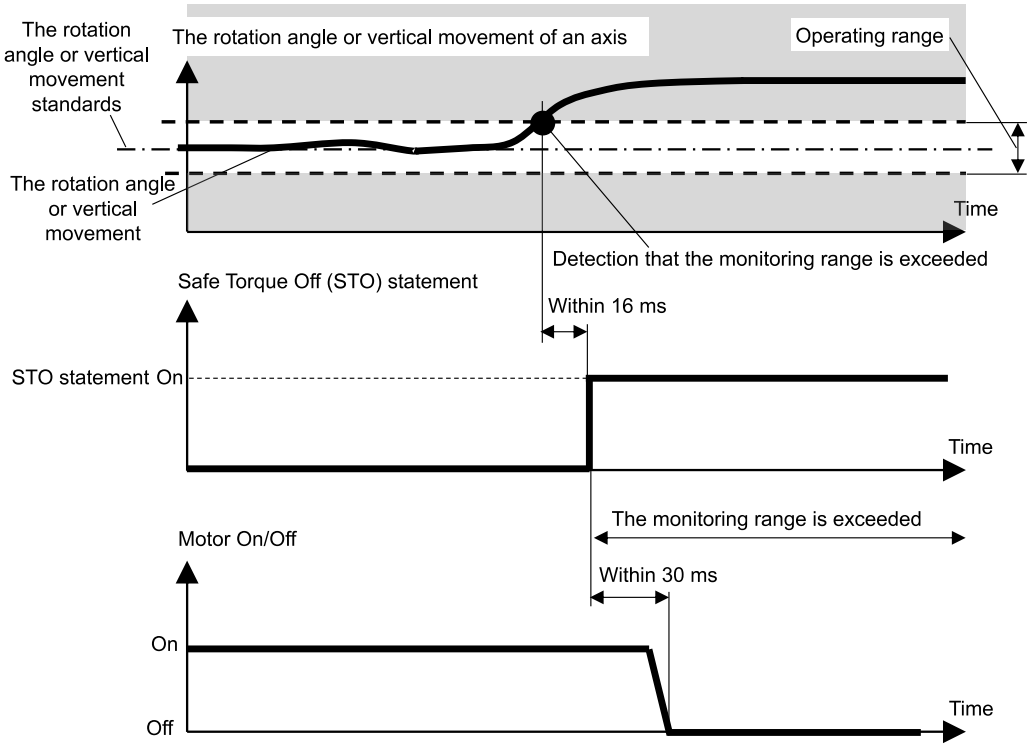
Operation modes and enabling/disabling Joint Angle Limit
When the operation mode is AUTO, TEST T1, or TEST T2, patterns* that use the narrow range based on the rotation angle or vertical movement of an axis of the robot as the operating range can be assigned.
*: When using SLS_1 as the Joint Angle Limit

When the operation mode is TEACH, Joint Angle Limit is always disabled.

Joint Angle Limit Pattern		Enable or disable for each operation mode B: Enable or disable based on safety inputs -: Always disable			
		AUTO	TEACH	TEST T1	TEST T2
Optional safety functions	SLS_1 *	B	-	B	B

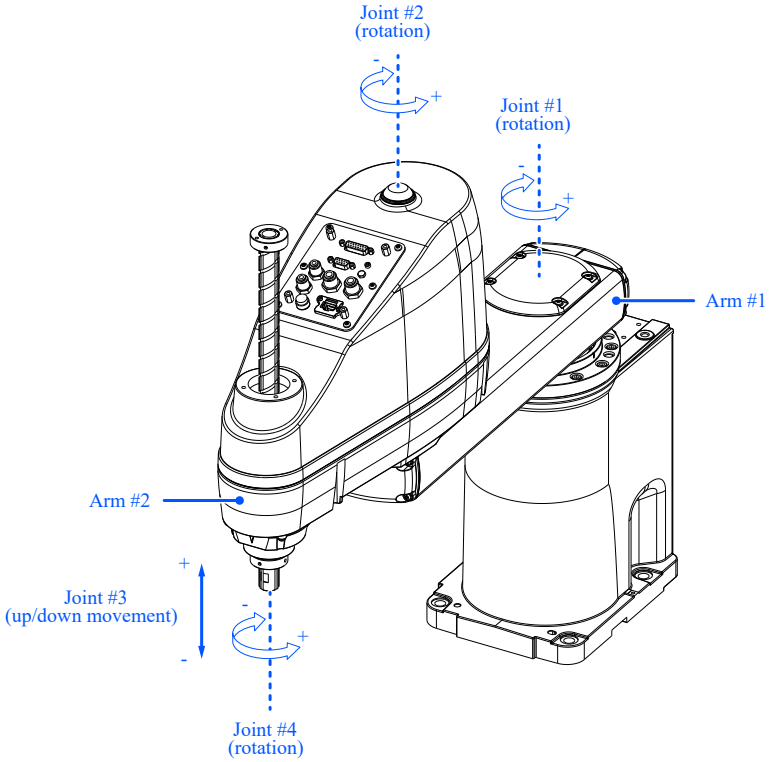
*: Case where a pattern setting the narrow range based on the rotation angle or vertical movement of an axis of the robot as the operating range for monitoring is assigned to SLS_1.

Relationship between Joint Angle Limit and the STO statement
If the system detects that either the rotation angle or vertical movement of an axis of the robot exceeded the motion range, Safe Torque OFF (STO) is immediately executed, putting the Robot Controller in the emergency stop status.

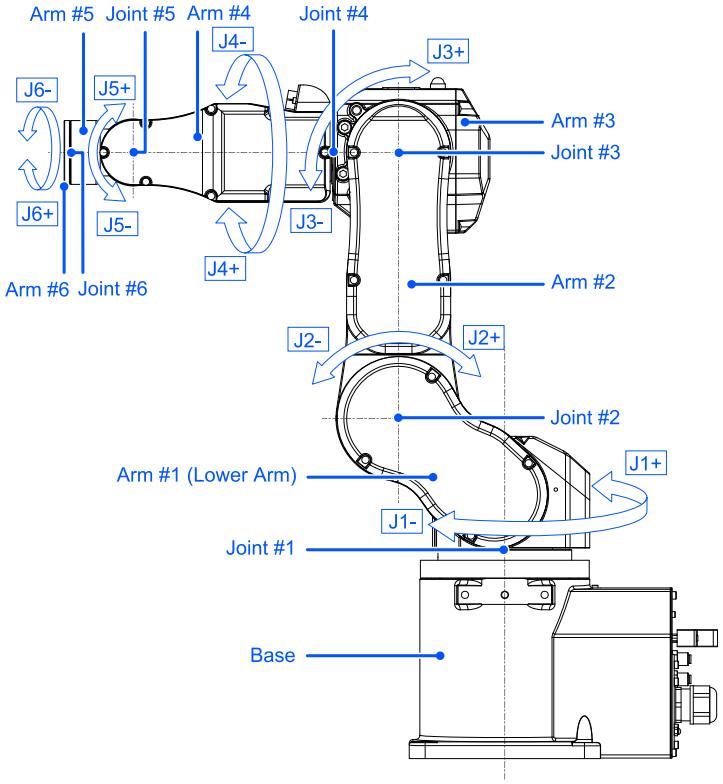


3.8.2 Joint Angle Limit for the Manipulator

With a SCARA Manipulator, Joint #1 (rotation), Joint #2 (rotation), Joint #3 (up/down), and Joint #4 (rotation) are all subject to the Joint Angle Limit, which sets the narrow range based on the rotation angle or vertical movement of an axis of the robot as the operating range.



With a 6-Axis Manipulator, Joint #1 (rotation), Joint #2 (rotation), Joint #3 (rotation), Joint #4 (rotation), Joint #5 (rotation), and Joint #6 (rotation) are all subject to the Joint Angle Limit, which sets the narrow range based on the rotation angle of an axis of the robot as the operating range.



3.9 Soft Axis Limiting

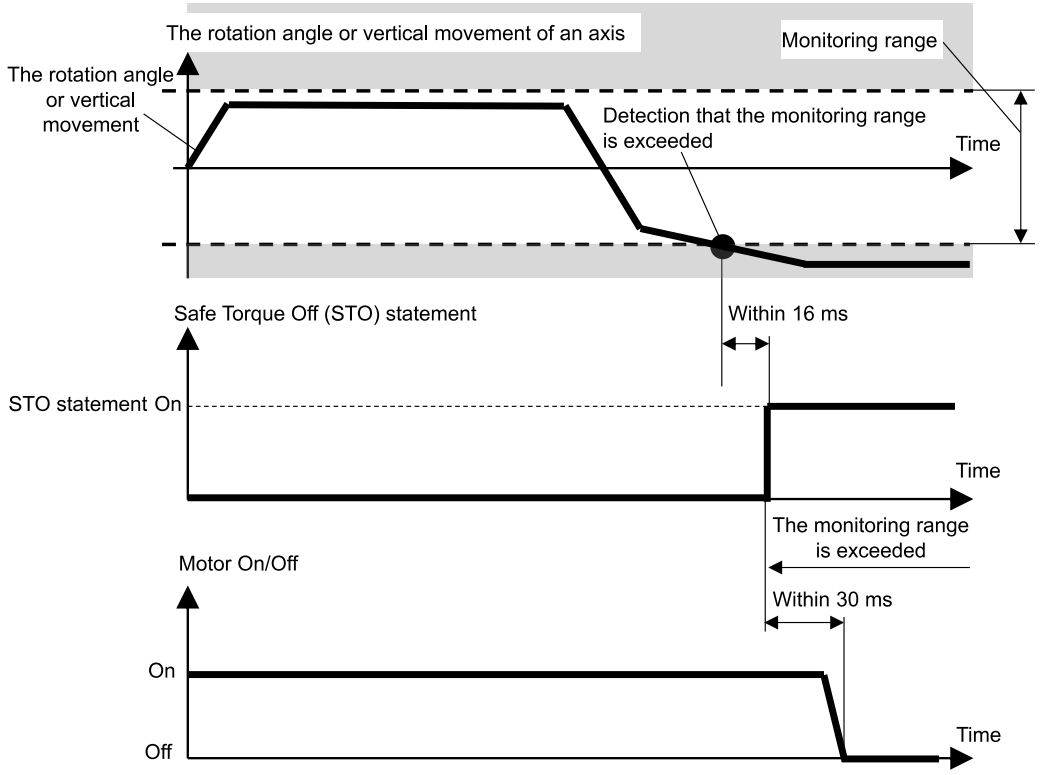
3.9.1 Outline and Operation Patterns for Soft Axis Limiting

Soft Axis Limiting is a function that monitors the robot's joint operating range. If the system detects that either the rotation angle or vertical movement of an axis of the robot exceeded the motion range of an axis, the robot emergency stop and STO are executed, putting the Robot Controller in the emergency stop status.

Operation modes and enabling/disabling Soft Axis Limiting
When the operation mode is AUTO, TEST T1, or TEST T2, Soft Axis Limiting is always enabled.
When the operation mode is TEACH, Soft Axis Limiting is always disabled.

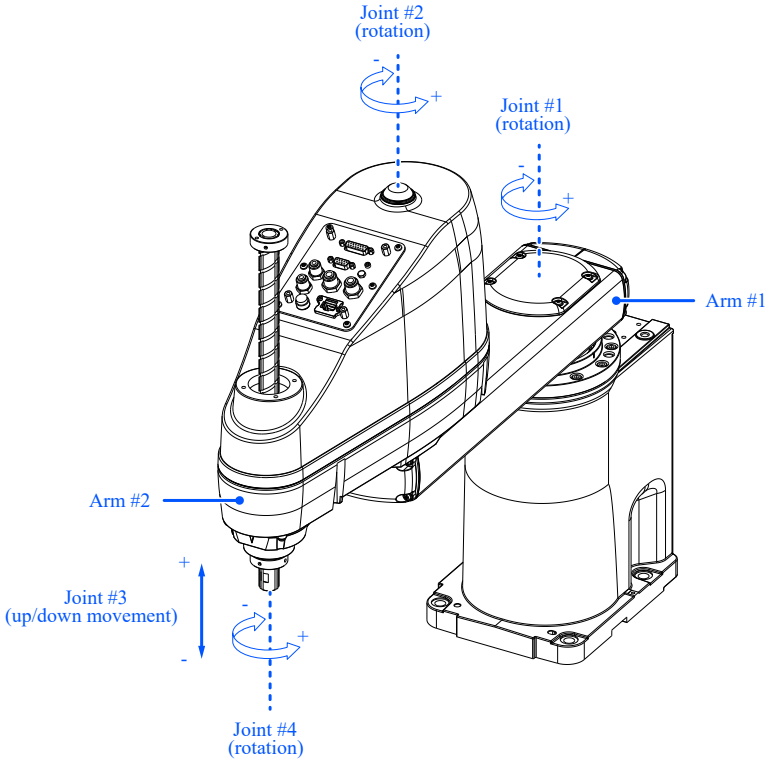
Soft Axis Limiting	Enable or disable for each operation mode A: Always enable -: Always disable			
	AUTO	TEACH	TEST T1	TEST T2
Standard functions	A	-	A	A

Relationship between Soft Axis Limiting and the STO statement
If the system detects that either the rotation angle or vertical movement of an axis of the robot exceeded the motion range, the robot emergency stop and STO are immediately executed, putting the Robot Controller in the emergency stop status.

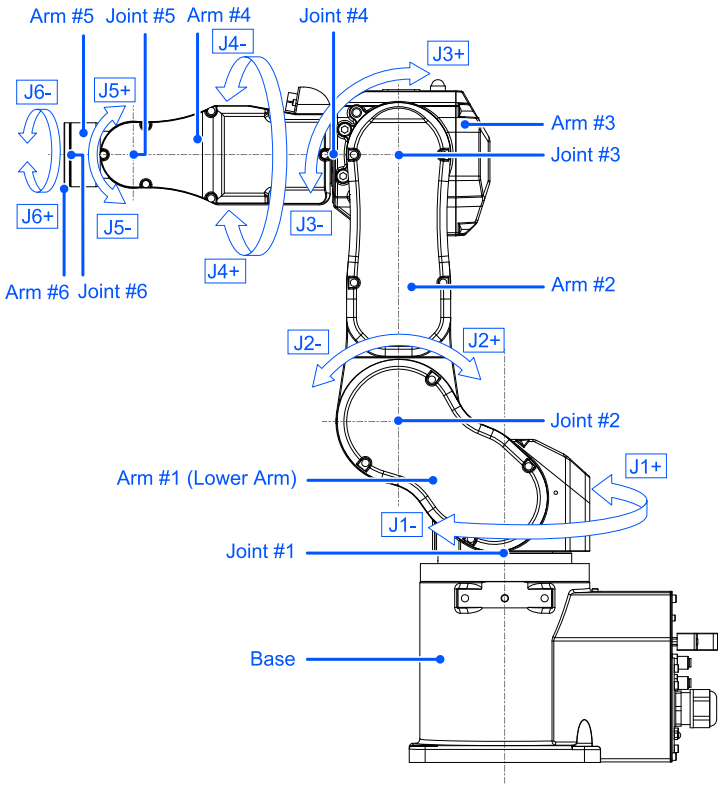


3.9.2 Manipulator Operating Range

With a SCARA Manipulator, Joint #1 (rotation), Joint #2 (rotation), Joint #3 (up/down), and Joint #4 (rotation) are all subject to monitoring by Soft Axis Limiting.



With a 6-Axis Manipulator, Joint #1 (rotation), Joint #2 (rotation), Joint #3 (rotation), Joint #4 (rotation), Joint #5 (rotation), and Joint #6 (rotation) are all subject to monitoring by Soft Axis Limiting.

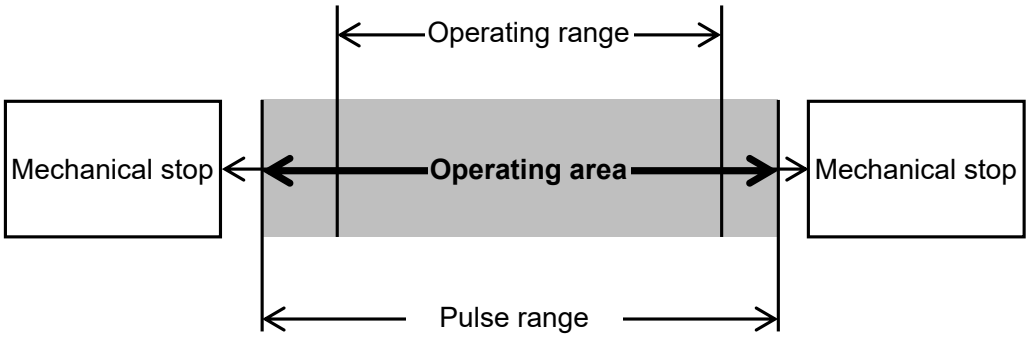


The rotation angle or motion range for vertical motion of an axis of the robot can be set to a value at or below the pulse range set for each robot model. For details on the configurable pulse range, refer to the following manual.
"Manipulator Manual - Operation Area Settings"
Motion range settings are made in Safety Function Manager.

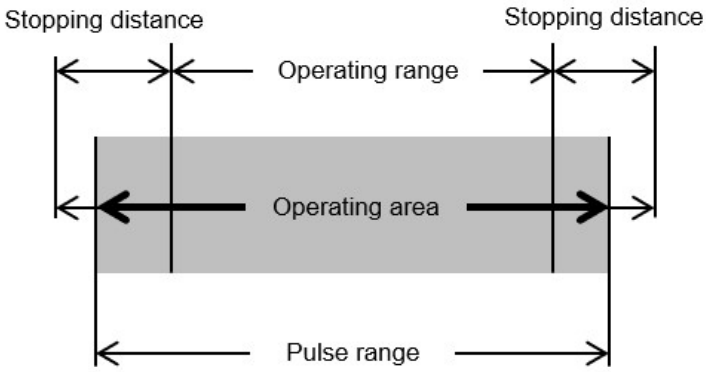
⚠ CAUTION

The operating range set in Safety Function Manager is not linked to the setting parameters set in the "Tool Settings" section of the "EPSON RC+ User's Guide". Make sure that these settings are consistent.

When using the mechanical stop and Soft Axis Limiting together



When using only Soft Axis Limiting



⚠ WARNING

- When designing a robot system and restricting the robot motion area, perform restrictions using Soft Axis Limiting or the mechanical stop. However, due to robot safety standard requirements, a single-axis mechanical stop cannot be replaced by Soft Axis Limiting. For details on restriction using a mechanical stop, refer to the following manual.
  "Manipulator Manual"
- If the robot speed is limited by the Safety Limited Speed (SLS), the restricted area can be determined based on the stopping distance calculated from the speed set by the Safety Limited Speed (SLS). If you are not using the Safety Limited Speed (SLS) function, determine the restricted area considering the stopping distance calculated from the robot's maximum speed.
- When using the mechanical stop and Soft Axis Limiting together, there is no need to set the motion range considering the stopping distance, because the mechanical stop is the limit.
- If using only the Soft Axis Limiting, set the motion range considering the stopping distance. For the stopping distance, refer to the following manual.
  "Manipulator Manual - Appendix B: Stopping Time and Stopping Distance at Emergency Stop"

3.10 Safety Inputs

3.10.1 Outline and Operation Patterns for Safety Inputs

The safety inputs are functions that execute safety functions assigned to the safety inputs according to the output signal of the safety device connected to the safety inputs of safety I/O connectors.
The safety I/O connectors have five ports for safety inputs.
The safety functions that can be assigned to the safety inputs are as follows:

- Emergency Stop (ESTOP)
- Safeguard (SG)
- Safety Limited Speeds (SLS) SLS_1, SLS_2, and SLS_3
  Refer to the following section for details.
  Safety Limited Speed (SLS)
- Safety Limited Positions (SLP) SLP_A, SLP_B, SLP_C, and SLS_1*
  Refer to the following section for details.
  Safety Limited Position (SLP)

  *: Case where Joint Angle Limit is enabled in SLS_1 settings. Refer to the following section for details.
  Joint Angle Limit

Operation modes and enabling/disabling safety inputs
Emergency Stop (ESTOP) can be executed in any operation mode.
Safeguard (SG) can be executed in the AUTO operation mode.

Safe Stop 1 by Safety Input 1		Enable or disable for each operation mode B: Enable or disable based on safety inputs -: Always disable			
		AUTO	TEACH	TEST T1	TEST T2
Standard functions	ESTOP	B	B	B	B
	SG	B	-	-	-

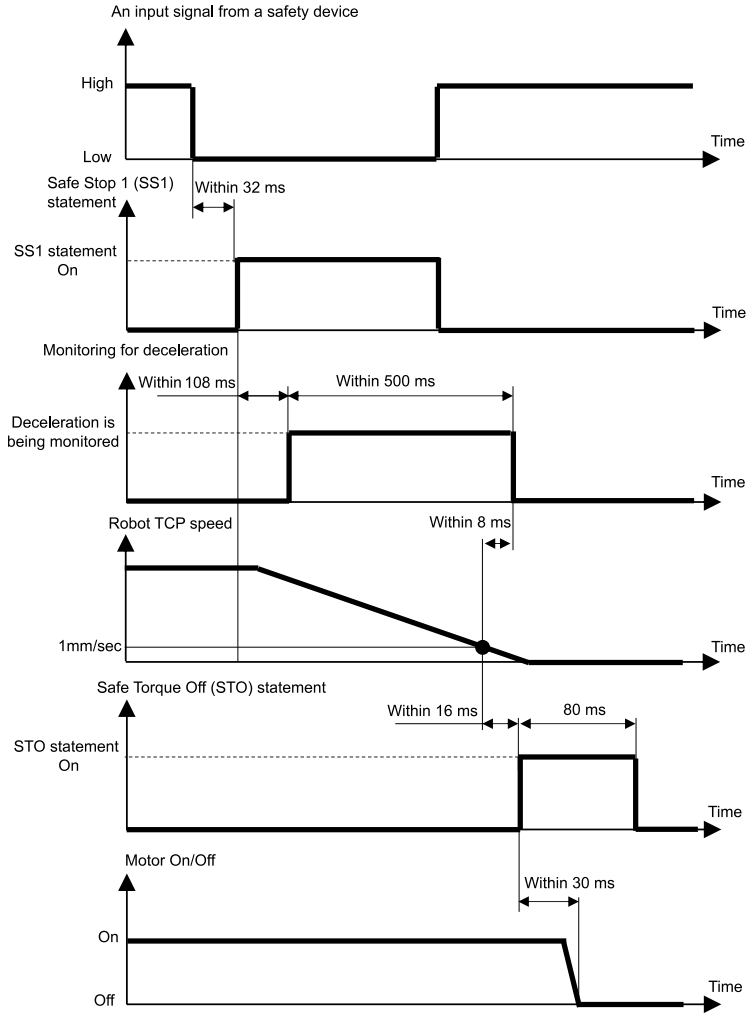
Multiple safety functions can be assigned to a single safety input port. Multiple safety functions are prioritized in the following order:

- Priority: High
  Emergency Stop (ESTOP)
  Safeguard (SG)
- Priority: Low
  Safety Limited Speed (SLS)
  Safety Limited Position (SLP)
  Joint Angle Limit

Relationship between safety inputs and the STO statement (when ESTOP or SG is assigned)

Safety inputs to which the Emergency Stop (ESTOP) or Safeguard (SG) are assigned execute Safe Stop 1 (SS1) when the signal level is "Low."

Safety Input Signal Level	Safety Function Operation
High	Does not execute Safe Stop 1 (SS1)
Low	Executes Safe Stop 1 (SS1)

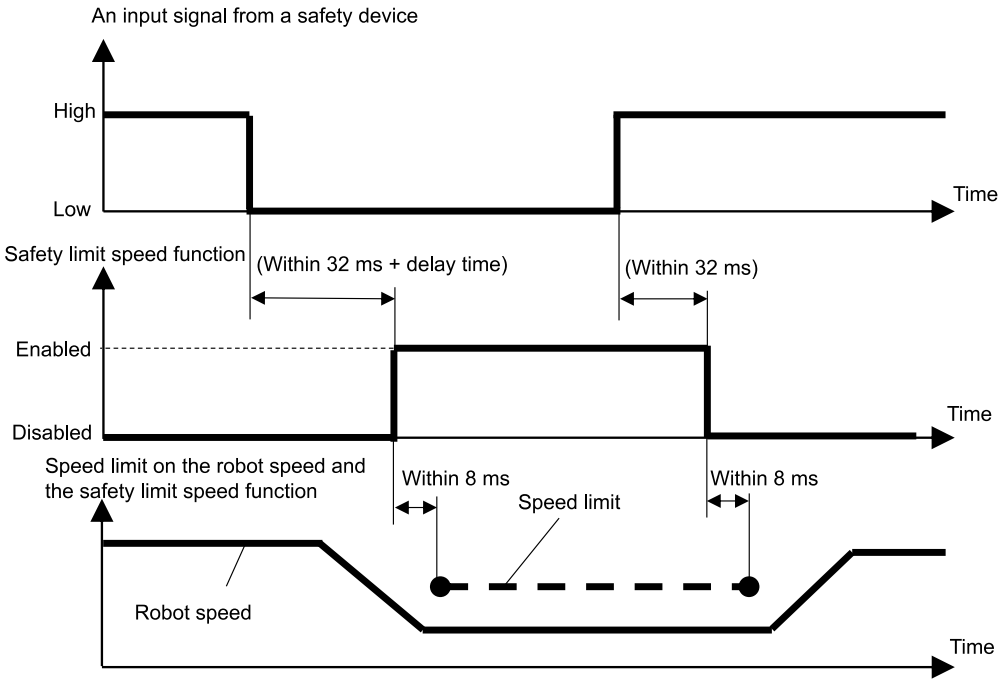


Relationship between safety inputs and the STO statement (when SLS is assigned)

The safety input to which Safety Limited Speed (SLS) is assigned disables Safety Limited Speed (SLS) when the signal level is "High" and enables Safety Limited Speed (SLS) when the signal level is "Low."

The delay time for enabling/disabling Safety Limited Speed (SLS) is set in Safety Function Manager.

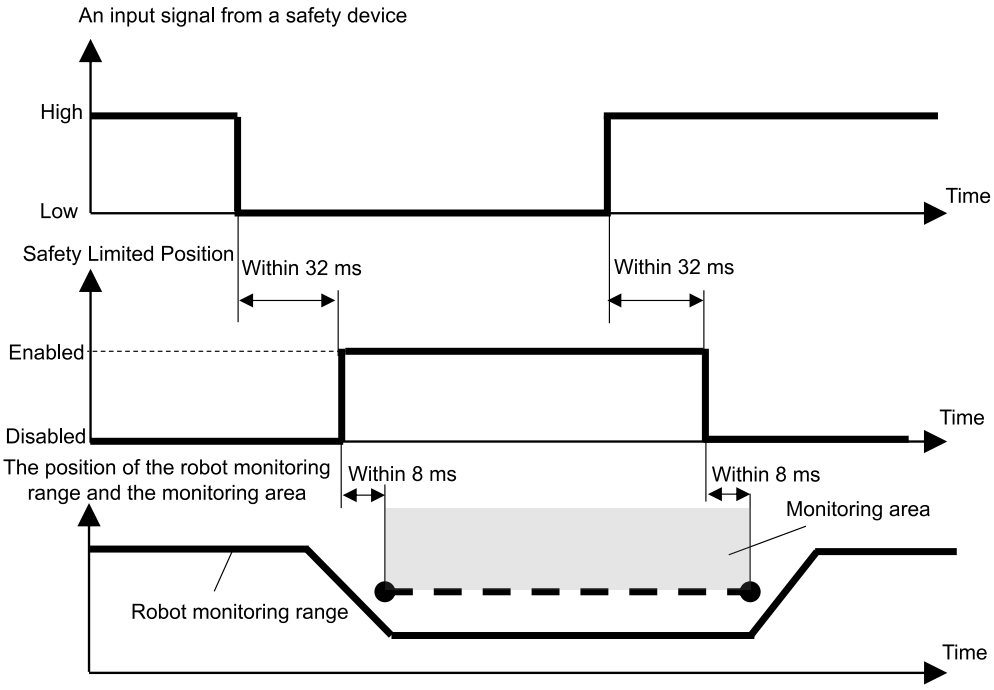
Safety Input Signal Level	Safety Function Operation
High	Disables Safety Limited Speed (SLS)
Low	Enables Safety Limited Speed (SLS)



Relationship between safety inputs and the STO statement (when SLP is assigned)

The safety input to which Safety Limited Position (SLP) is assigned disables Safety Limited Position (SLP) when the signal level is "High" and enables Safety Limited Position (SLP) when the signal level is "Low."

Safety Input Signal Level	Safety Function Operation
High	Disables Safety Limited Position (SLP)
Low	Enables Safety Limited Position (SLP)



3.11 Safety Outputs

3.11.1 Outline and Operation Patterns for Safety Outputs

Safety outputs are functions that output information related to the safety functions of the Robot Controller to the safety devices connected to the safety outputs of the safety I/O connectors.
The Robot Controller has three ports for safety outputs.
The information that can be assigned to safety outputs is as follows:

- Whether the STO statement is being issued or not
- Whether the emergency stop switch is On or Off (emergency stop switch connected to the EMERGENCY connector, emergency stop switch attached to Teach Pendant)
- Whether the enable switch is on or off
- Whether Safety Limited Speed (SLS) is enabled or disabled (SLS_1, SLS_2, SLS_3, SLS_T, and SLS_T2)
- Whether Safety Limited Position (SLP) is enabled or disabled (SLP_A, SLP_B, and SLP_C)

Multiple pieces of information related to safety functions can be assigned to a single safety output port. When making multiple assignments, the signal level of the safety outputs becomes Low if the STO statement is issued (signal level is Low), the emergency stop is turned on (signal level is Low), the enable switch is turned off (signal level is Low), the Safety Limited Speed (SLS) is enabled (signal level is Low), or the Safety Limited Position (SLP) is enabled (signal level is Low).

Safety output status and output signal level
The safety output to which whether the STO statement is being issued or not is assigned outputs a signal on the Low level if the STO statement is being issued, and a signal on the High level if the STO statement is not being issued.

Assignment to Safety Outputs		Output Signal Level	
STO Statement		High	Low
Standard functions	STO	Statement not being issued	Statement being issued

The safety output to which whether the emergency stop switch is on or off is assigned outputs a signal on the Low level if the switch is on, and a signal on the High level if the switch is off.

Assignment to Safety Outputs		Output Signal Level	
Emergency Stop Switch		High	Low
Standard functions	EP_RC *	Switch off	Switch on
	EP_TP*	Switch off	Switch on

*: EP_RC: Emergency stop switch connected to the EMERGENCY connector, EP_TP: Emergency stop switch attached to Teach Pendant

The safety output to which whether the enable switch is on or off is assigned outputs a signal on the Low level if the switch is off, and a signal on the High level if the switch is on.

Assignment to Safety Outputs		Output Signal Level	
Enable Switch		High	Low
Standard functions	EN_SW	Switch on (Middle position)	Switch off (Not middle position)

⚠ CAUTION

SLS and SLP output whether the monitoring function is enabled.
The signal does not switch even if the Manipulator exceeds speed limits or enters a restricted area. Therefore, to make a trigger when the Manipulator exceeds speed limits or enters a restricted area, use the STO output signal as well.

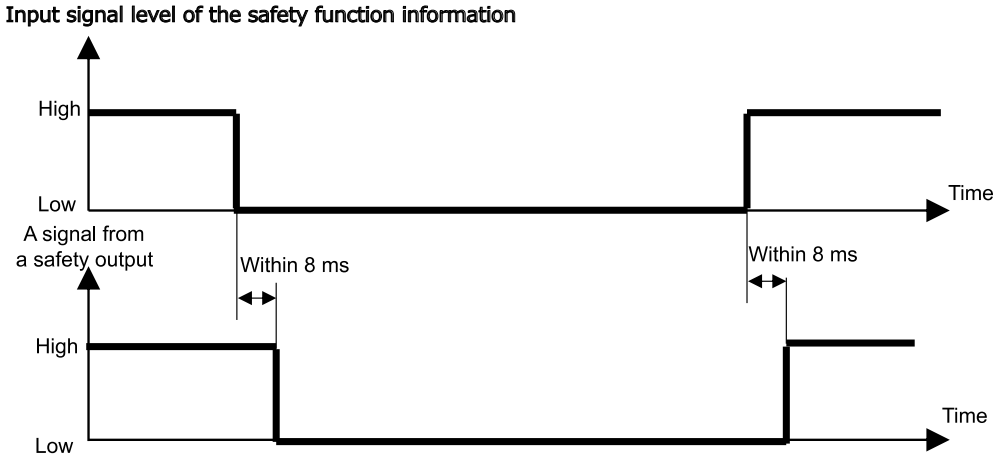
The safety output to which whether the Safety Limited Speed (SLS) is enabled or disabled is assigned outputs a signal on the Low level if the Safety Limited Speed (SLS) is enabled, and a signal on the High level if it is disabled.

Assignment to Safety Outputs		Output Signal Level	
Safety Limited Speed (SLS)		High	Low
Standard functions	SLS_T	Limitation disabled	Limitation enabled
	SLS_T2		
Optional safety functions	SLS_1	Limitation disabled	Limitation enabled
	SLS_2		
	SLS_3		

The safety output to which whether the Safety Limited Position (SLP) is enabled or disabled is assigned outputs a signal on the Low level if the Safety Limited Position (SLP) is enabled, and a signal on the High level if it is disabled.

Assignment to Safety Outputs		Output Signal Level	
Safety Limited Position (SLP)		High	Low
Optional safety functions	SLP_A	Limitation disabled	Limitation enabled
	SLP_B		
	SLP_C		

Time from safety function information input until safety output signal is issued



4. Setting Safety Functions (Setting Software: Safety Function Manager)

4.1 What is Safety Function Manager?

4.1.1 What Safety Function Manager Can Do

Safety Function Manager allows you to check and change the following settings related to Robot Controller safety functions:

- Making dry run settings
  Refer to the following section for details.
  Making Dry Run Settings
- Checking the robot model, Hofs data, and safety board setting change dates
- Checking and changing safety function parameters (Robot Controller safety function parameters)
- Changing the password for the safety board

The language displayed is automatically switched according to the language of EPSON RC+.

> ⚠ WARNING
>
> If you change the safety parameters for a safety function in the Safety Function Manager, be sure to verify that function and check its validity before use.

4.1.2 Operating Environment

Safety Function Manager can be used in the following operating environment:

EPSON RC+ 7.0: Ver. 7.5.4 or later
Robot Controller: RC700-E
Manipulator/Application:

- For GX4-B/GX8-B:
  PC with EPSON RC+7.0 Ver. 7.5.4 or later installed
- For GX10-B/GX20-B:
  PC with EPSON RC+7.0 Ver.7.5.4 A or later installed
- For C4-B/C8-B/C12-B:
  PC with EPSON RC+7.0 Ver.7.5.4 C or later installed

4.1.3 Installation

Safety Function Manager is installed automatically when installing EPSON RC+.

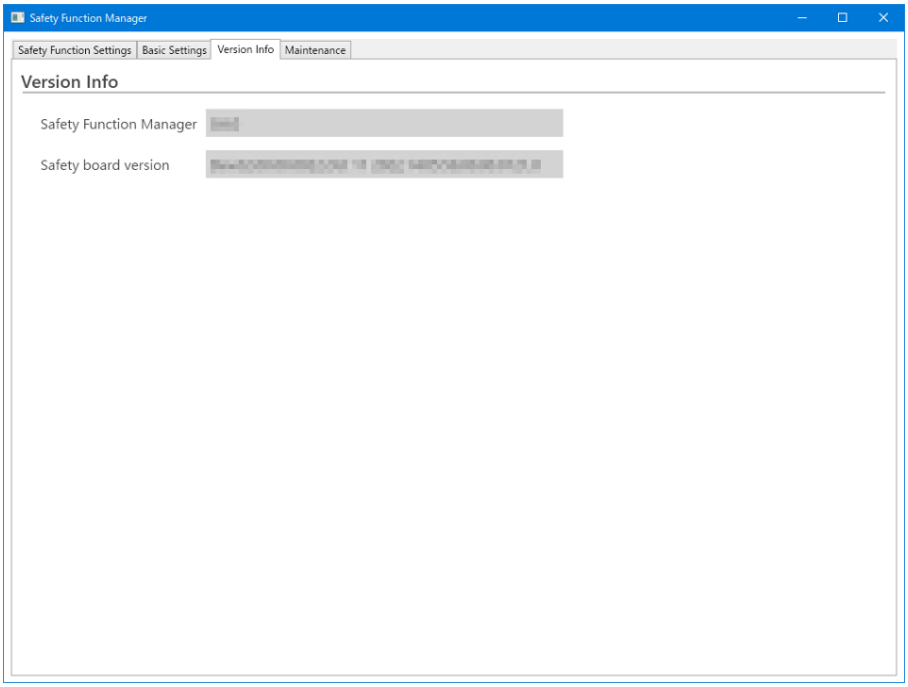
For the supported versions of EPSON RC+, refer to the following section.
Operating Environment

4.1.4 How to Check the Version (Version Info)

You can check the versions of Safety Function Manager and the safety board firmware.

Select the [Version Info] tag and check the displayed versions.

Safety Function Manager: 1.0.0 or later
Safety board version: Rel. 02.00.00.0031 or later


Safety Function Manager
Safety Function Settings
Basic Settings
Version Info
Maintenance
Version Info
Safety Function Manager
Safety board version

4.1.5 Settable Items for Safety Function Options

Some of the settings in Safety Function Manager are safety function options.
Please contact the supplier if you require safety function options.

✓ : Available for use
-: Not available for use

Setting		Standard Functions	Safety Function Options
Dry Run Settings	-	✓	✓
Safety Inputs	ESTOP SG SLS_1 SLS_2 SLS_3 SLP_A SLP_B SLP_C	✓ ✓ - - - - - -	✓
Safety Outputs	STO EP_RC EP_TP EN_SW SLS_T SLS_T2 SLS_1 SLS_2 SLS_3 SLP_A SLP_B SLP_C	✓ ✓ ✓ ✓ ✓ ✓ - - - - - -	✓
Safety Limited Speed (SLS)	SLS_T SLS_T2 SLS_1 SLS_2 SLS_3	✓ ✓ - - -	✓
Safety Limited Position (SLP)	SLP_A SLP_B SLP_C SLS_1 *	-	✓
Soft Axis Limiting	-	✓	✓
Factory Settings	-	✓	✓
Password Management	-	✓	✓

*: Case where Joint Angle Limit is enabled in SLS_1 settings.

4.2 Flow from Startup to Finish

4.2.1 Operation Flow

Changes to the safety function parameters of the safety board are performed as follows:

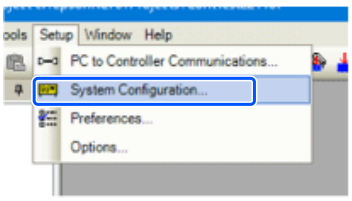
1. Start "Safety Function Manager"
   Refer to the following section for details.
   Starting Safety Function Manager

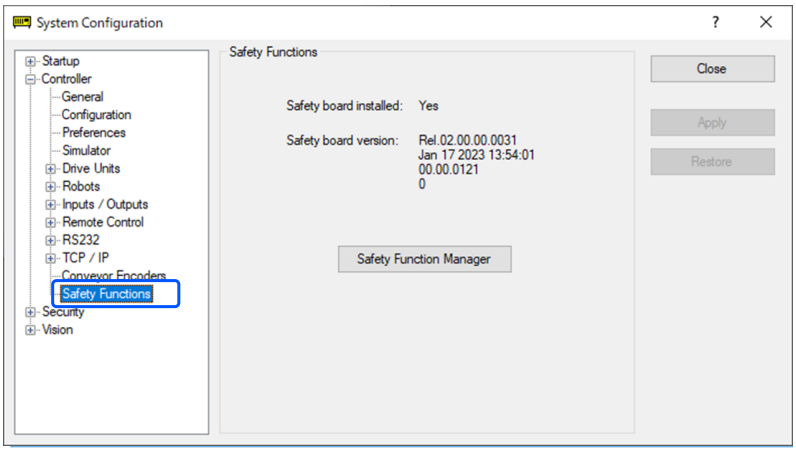
2. Change settings
   Refer to the following section for details.
   Changing Settings

3. Apply settings
   Refer to the following section for details.
   Applying Settings

4.2.2 Starting Safety Function Manager

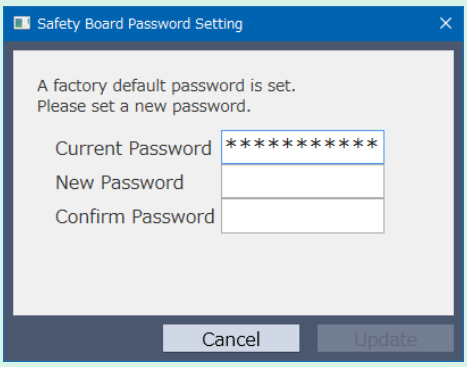
In EPSON RC+, select [Setup] - [System Configuration], and then under [Controller] - [Safety Functions], click [Safety Function Manager].





KEY POINTS

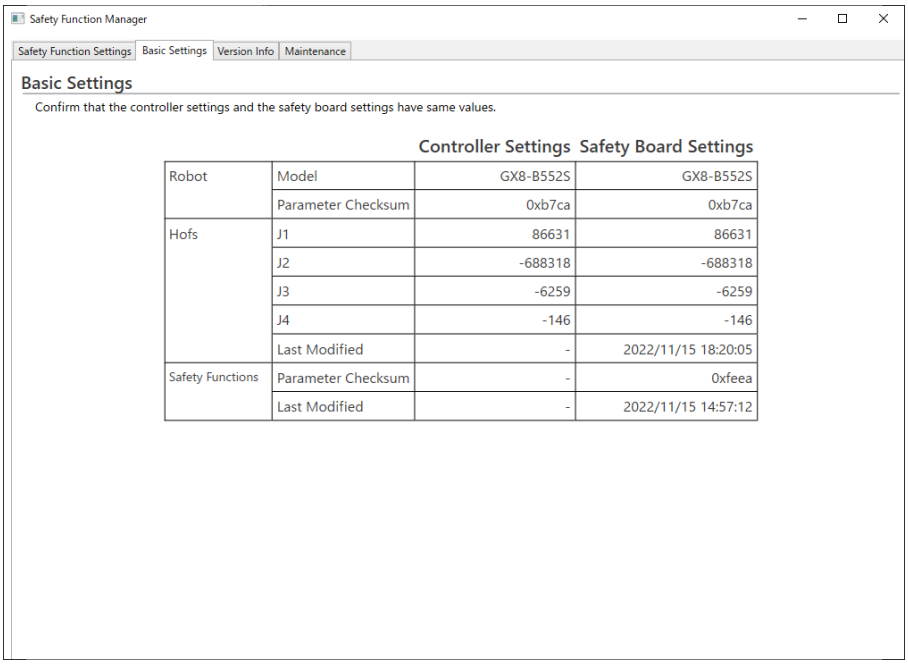
- Safety Function Manager must be started for the first time by the safety manager.
- The following dialog box appears when starting up for the first time. Follow the on-screen instructions and change the password. The initial password is "EpsonSafety."



- The display language of Safety Function Manager is automatically switched according to the language set in the EPSON RC+.
- If you cannot perform startup, check the following conditions:
  - A Robot Controller equipped with safety functions must be connected.
  - The EPSON RC+ start mode must be in program mode.
  - The control device for the Robot Controller must be a PC.

4.2.2.1 Checking Settings When Starting up Safety Function Manager

When starting up Safety Function Manager, in the [Basic Settings] tab, check the settings of the safety board and make sure that they are the same as those of the Robot Controller.
It is recommended to keep a record of the [Parameter Checksum] of [Robot] and the [Parameter Checksum] of [Safety Functions] as displayed in the Safety Function Manager.



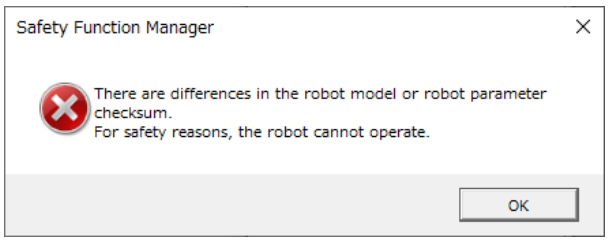
		Controller Settings	Safety Board Settings
Robot	Model	GX8-B552S	GX8-B552S
	Parameter Checksum	0xb7ca	0xb7ca
Hofs	J1	86631	86631
	J2	-688318	-688318
	J3	-6259	-6259
	J4	-146	-146
	Last Modified	-	2022/11/15 18:20:05
Safety Functions	Parameter Checksum	-	0xfeea
	Last Modified	-	2022/11/15 14:57:12

Setting Item		Function	Remarks
Robot	Model	Robot model name	-
	Parameter Checksum	Parameter checksum for robot settings (hidden)	Robot model specific values.
Hofs	J1	Hofs value for Joint #1	Value for correcting the origin of the joint axis. These values may vary by individual machine even within the same model. (Unit: Pulse) The Hofs value for Joint #5 and Joint #6 are only displayed for a 6-Axis robot.
	J2	Hofs value for Joint #2	
	J3	Hofs value for Joint #3	
	J4	Hofs value for Joint #4	
	J5	Hofs value for Joint #5	
	J6	Hofs value for Joint #6	
	Last Modified	Date and time Hofs was modified	-
Safety Functions	Parameter Checksum	Parameter checksum for safety function parameters	Specific value calculated from the safety function parameters for safety inputs, safety outputs, Safety Limited Speed (SLS), Safety Limited Position (SLP), Joint Angle Limit, Soft Axis Limiting, and Dry Run, as well as the safety function parameters last modified value.
	Last Modified	Date and time safety parameters were modified	-

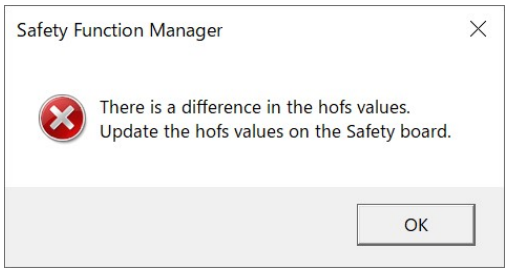
If an error is displayed when starting up Safety Function Manager

An error screen may be displayed when Safety Function Manager is started. Follow the instructions on each screen and take the following measures.

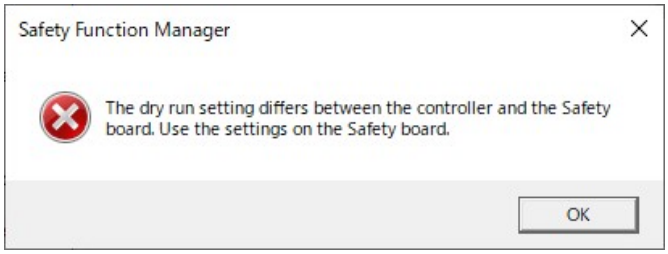
- If the robot model or robot parameter checksum is different
  Click the [OK] button.
  Click [Send robot parameters to the Safety Board].
  Follow the on-screen instructions and change the settings.



- If the Hofs value is different
  Click the [OK] button.
  Click [Send Hofs to the Safety Board].
  Follow the on-screen instructions, enter the [Password], and change the settings.

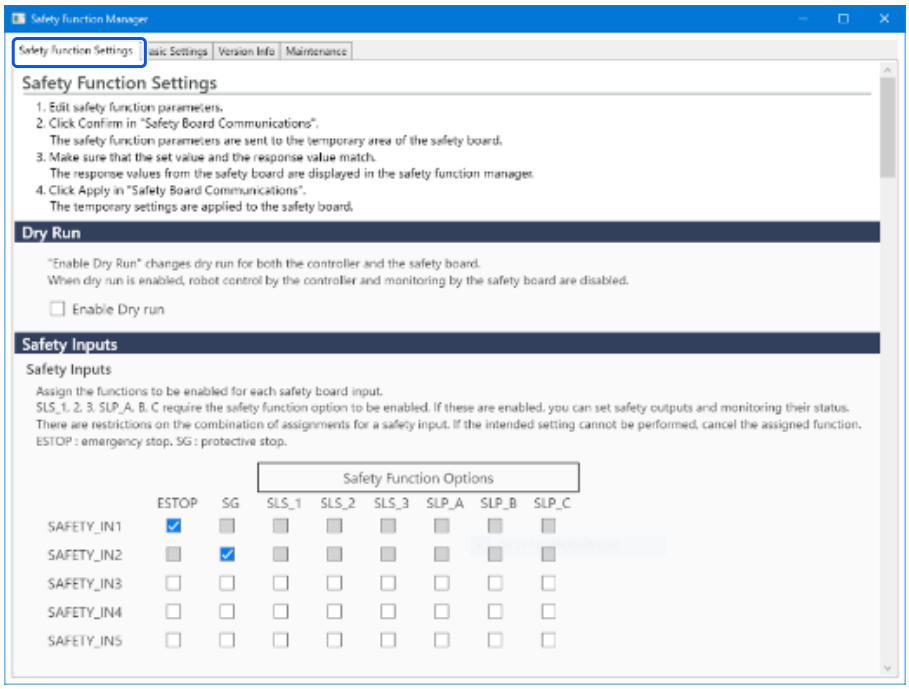


- If the Dry Run settings are different
  Click the [OK] button to restart the Robot Controller.

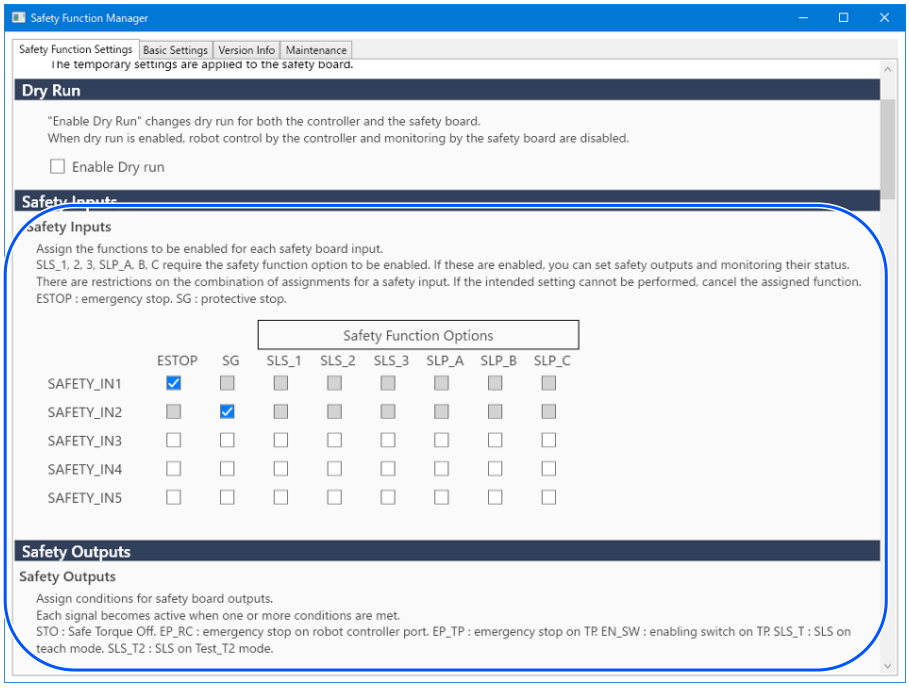


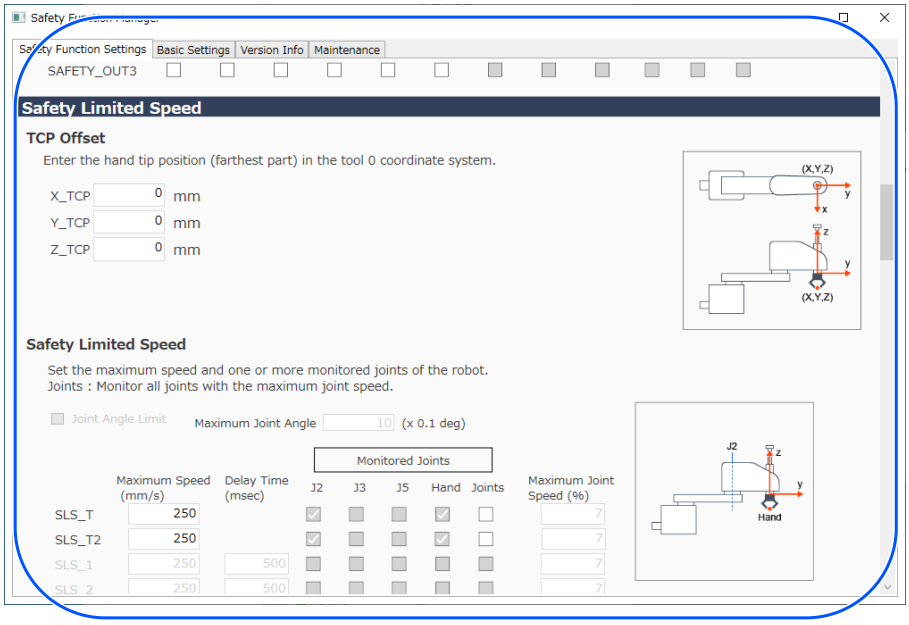
4.2.3 Changing Settings

1. Select the [Safety Function Settings] tab to display the [Safety Function Settings] screen.



2. Select the items for which you want to change the settings.





For details on settings, refer to the following section.

Safety Function Parameters

KEY POINTS

Parameters whose settings have been changed are displayed with a blue background. After applying the settings to the safety board, the display returns to normal.

KEY POINTS

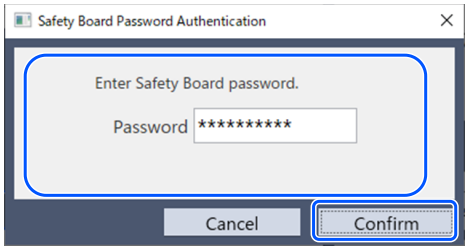
If the set value of a safety function parameter is outside the input range, the background is displayed in yellow and the setting range is displayed in a pop-up. In this case, re-enter the value in the appropriate range.

4.2.4 Applying Settings

Finish editing the safety function parameters and display the confirmation screen.

1. Click the [Confirm] button.

2. Enter the password on the password entry screen and then click the [Confirm] button.



KEY POINTS

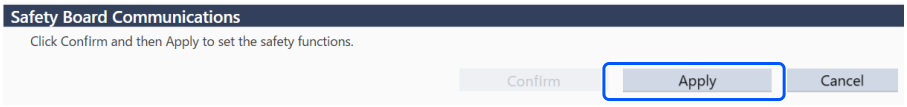
- If an incorrect password is entered three times, Safety Function Manager shuts down and the Robot Controller is restarted. Settings are not changed.

3. On the confirmation screen that appears, confirm the changed safety function parameters.

KEY POINTS

- Settings cannot be changed on the confirmation screen. If you need to continue to make changes, click the [Cancel] button.
- If a setting item is displayed in yellow after clicking the [Confirm] button, an error in communication with the safety board has occurred. Restart both the Robot Controller and the PC on which Safety Function Manager is operating, and then perform the setting again. If the problem is still not improved, stop use of the robot system and contact the supplier.

4. Click the [Apply] button.
   Safety Function Manager shuts down and the Robot Controller is restarted.



5. After the Robot Controller restarts, EPSON RC+ will connect automatically.

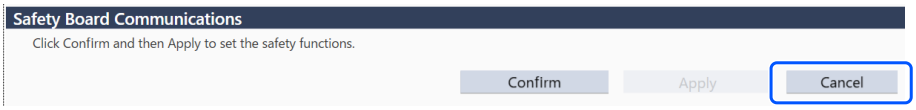
6. Start Safety Function Manager and check to see if the parameters you changed have been applied.

KEY POINTS

- Safety function parameters should be applied to the safety board only after the safety manager has thoroughly checked the contents.

Cancelling

This cancels changes to safety function parameters.



Canceling before clicking the [Confirm] button will close Safety Function Manager without changing the safety function parameters of the safety board. The Robot Controller is not restarted at this time.

Canceling after clicking the [Confirm] button will close Safety Function Manager without changing the safety function parameters of the safety board. The Robot Controller is also restarted.

4.2.5 Saving Settings (Performing a Backup)

The settings of Safety Function Manager can be saved using "Controller Backup" in EPSON RC+. Backing up your settings allows you to restore the saved settings if you make a mistake when performing settings or if the safety board malfunctions. Be sure to perform a backup when changing the safety board settings, after teaching, and before performing maintenance.

KEY POINTS

Depending on the status of the device, backing up may not be available before maintenance. Be sure to always back up your latest settings.

Data that can be backed up

The backup saves the safety function parameters and the safety parameter last modified value.

- Safety inputs
- Safety outputs
- Safety Limited Speed (SLS)
- Safety Limited Position (SLP)
- Joint Angle Limit
- Soft Axis Limiting
- Dry Run

KEY POINTS

For details on backup data other than the safety function parameters, refer to the following manual.
"EPSON RC+ User's Guide"

Backup procedure

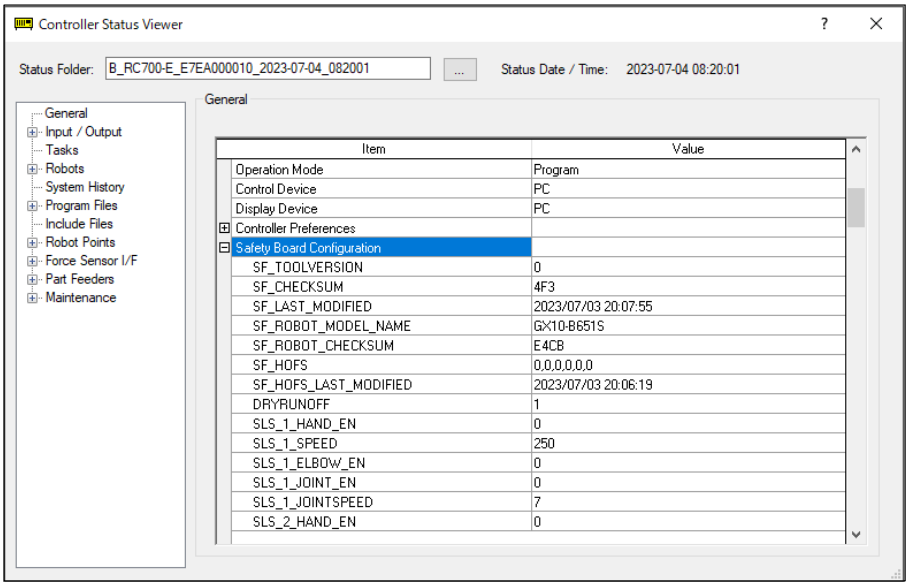
The backup is performed using "Controller Backup" in EPSON RC+. For details, refer to the following manual.
"EPSON RC+ User's Guide"

For the restoration method, refer to the following section.
Restoring Saved (Backed-up) Settings

4.2.6 Confirming Saved Information (Saved States Viewer)

You can refer to Safety Function Manager settings using the backup data saved with "Controller Backup" in EPSON RC+. In EPSON RC+ 7.0, open the [Controller] dialog box, and then select [View Controller Status]. For details, refer to the following manual.
"EPSON RC+ User's Guide"

Refer to the SF_GetParam function in the manual below for an explanation of the displayed setting values.
"EPSON RC+ SPEL+ Language Reference"

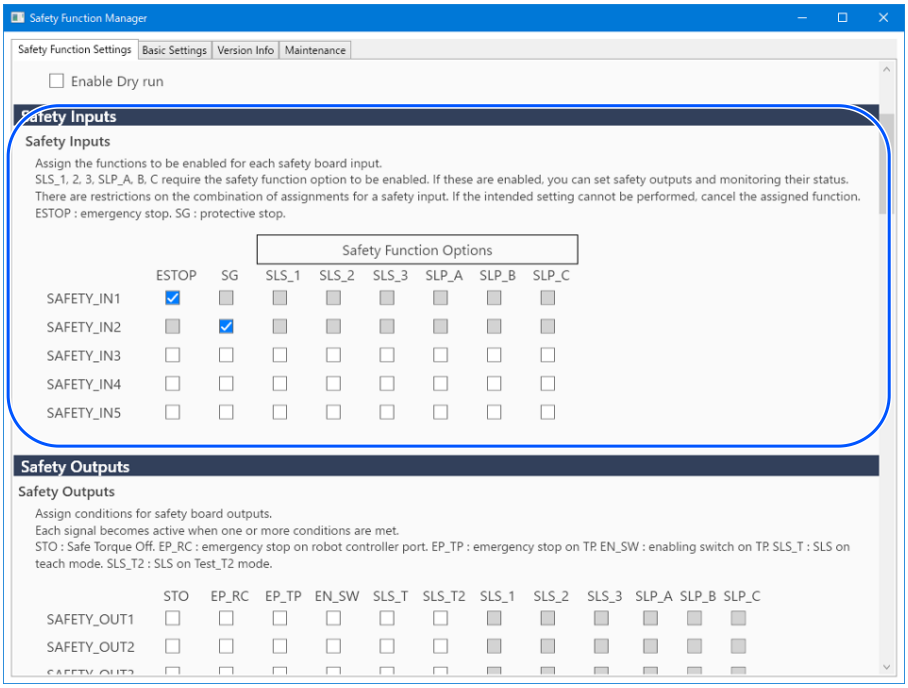


4.3 Safety Function Parameters

This section describes the safety function parameters that set the Robot Controller safety functions.

4.3.1 Setting Safety Function Parameters Related to Safety Inputs and Safety Outputs

These settings are used by the safety input and safety output functions.



Safety input settings

These settings assign a function to be enabled for the safety inputs. For example, if you want to perform an emergency stop when a signal is input to SAFETY_IN1, enable the checkbox at the intersection of SAFETY_IN1 and ESTOP.

No	Name	Function	Notes
1. Safety Input Settings			
1.1	SAFETY_IN1	Function setting for SAFETY_IN1	Set the function for each safety input by assigning one of the "A. Safety Functions That Can Be Assigned" in the table below.
1.2	SAFETY_IN2	Function setting for SAFETY_IN2	
1.3	SAFETY_IN3	Function setting for SAFETY_IN3	
1.4	SAFETY_IN4	Function setting for SAFETY_IN4	
1.5	SAFETY_IN5	Function setting for SAFETY_IN5	

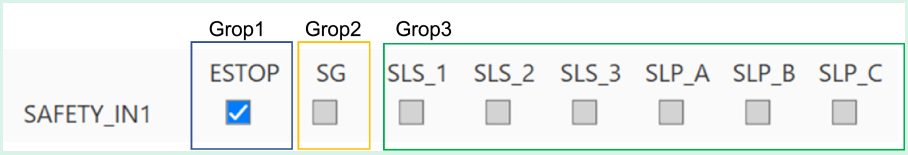
No	Name	Function	Notes
A. Safety Functions That Can Be Assigned			
Standard Functions	ESTOP	Emergency stop	ESTOP is assigned to SAFETY_IN1 by factory default.
	SG	Protective stop	SG is assigned to SAFETY_IN2 by factory default.
Safety Function Options	SLS_1, SLS_2, SLS_3	Safety Limited Speed (SLS)	SLS_1, 2, and 3 can be assigned to safety inputs to set the safety outputs and the safety speed limit. Refer to the following section for details. **Setting Safety Function Parameters Related to Safety Limited Speed (SLS)** SLS_T and SLS_T2 monitoring is enabled in the prescribed operation modes without having to be assigned to a safety input. Refer to the following section for details. **Safety Limited Speed (SLS)**
	SLP_A, SLP_B, SLP_C	Safety Limited Position (SLP)	SLP_A, B, and C can be assigned to safety inputs to set the safety outputs and monitored areas. Refer to the following section for details. **Robot Installation Position Settings for Safety Limited Position (SLP)**

⚠ CAUTION

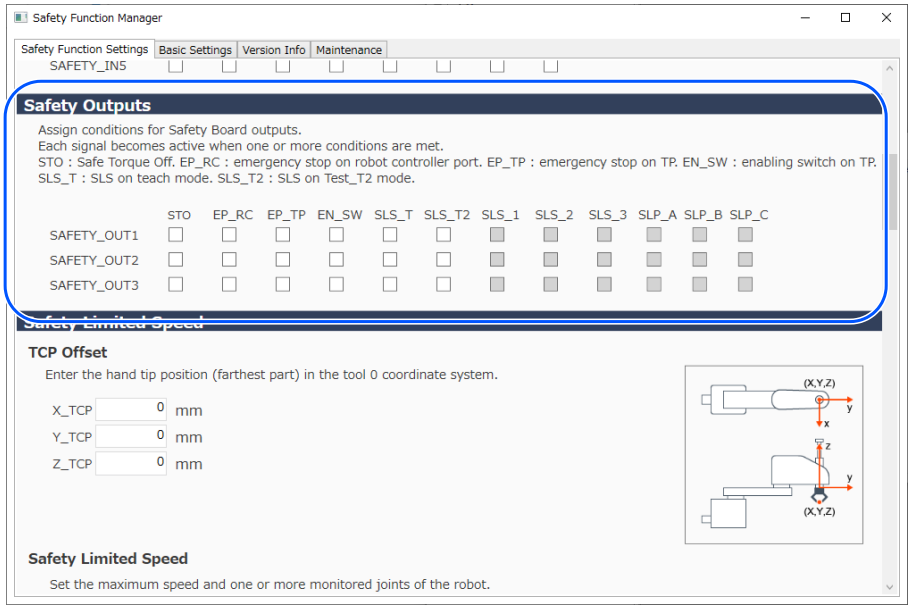
- If ESTOP is not set for SAFETY_IN, an emergency stop switch must be connected to the emergency stop input connector or a Teach Pendant must be connected.
- SG should be set to one or more SAFETY_IN.

KEY POINTS

Settings for the safety inputs are divided into three groups.



- Any single group of safety functions can be selected for one SAFETY_IN.
- Group 3 allows a combination of functions to be selected.
  - For SLS options, one can be selected.
  - For SLP options, an arbitrary combination can be selected. When SAFETY_IN is turned ON, all combined functions will be enabled.



Safety outputs settings

These settings assign conditions for when the safety outputs output a signal. For example, if you want to output a signal from SAFETY_OUT1 when STO is executed, enable the checkbox at the intersection of SAFETY_OUT1 and STO.

No	Name	Function	Notes
2. Safety Output Ports			
2.1	SAFETY_OUT1	Function setting for SAFETY_OUT1	Set the function for each safety output port by assigning one of the "B. Safety Functions That Can Be Assigned" in the table below.
2.2	SAFETY_OUT2	Function setting for SAFETY_OUT2	
2.3	SAFETY_OUT3	Function setting for SAFETY_OUT3	

No	Name	Function	Notes
B. Safety Functions That Can Be Assigned			
Standard functions	STO	Outputs a signal when a Safe Torque OFF is executed.	Refer to the following section for details. **Safe Torque OFF (STO)**
	EP_RC	Outputs whether the emergency stop button connected to the emergency stop input connector of the Robot Controller is On or Off.	Refer to the following section for details. **Emergency Stop**
	EP_TP	Outputs whether the emergency stop button on the Teach Pendant is On or Off.	Refer to the following section for details. **Emergency Stop**
	EN_SW	Outputs whether the enable switch on the Teach Pendant is On or Off.	Refer to the following section for details. **Enable**
	SLS_T	Outputs whether Safety Limited Speed (SLS_T) is enabled or disabled.	Refer to the following section for details. **Safety Limited Speed (SLS)**
	SLS_T2	Outputs whether Safety Limited Speed (SLS_T2) is enabled or disabled.	
Optional safety functions	SLS_1,SLS_2,SLS_3	Outputs whether Safety Limited Speed (SLS) is enabled or disabled.	Safety Function options. A function can only be assigned to a safety output if it is assigned to a safety input. Refer to the following section for details. **Safety Limited Speed (SLS)**
	SLP_A,SLP_B,SLP_C	Outputs whether Safety Limited Position (SLP) is enabled or disabled.	Safety Function options. A function can only be assigned to a safety output if it is assigned to a safety input. Refer to the following section for details. **Safety Limited Position (SLP)**

KEY POINTS

Multiple functions can be selected. When even one of the selected functions operates, a signal is output from the SAFETY_OUT.

4.3.2 Setting Safety Function Parameters Related to Safety Limited Speed (SLS)

These settings are used by the Safety Limited Speed (SLS) function. Set the following items:

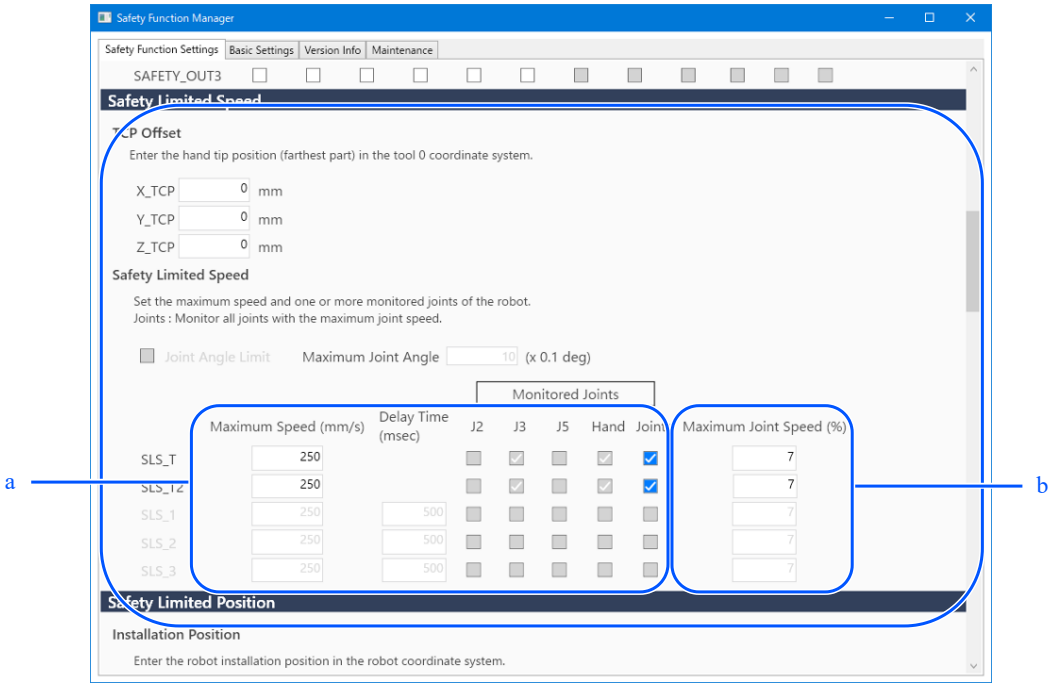
- TCP Offset
- Safety Limited Speed

⚠ WARNING

Be sure to set TCP Offset to properly operate Safety Limited Speed.
The TCP offset setting set in Safety Function Manager is not linked to the setting parameters set in the “Tool Settings" section of the "EPSON RC+ User's Guide". Make sure that these settings are consistent.

KEY POINTS

- SLS_1, SLS_2, and SLS_3 can be edited only when a function is assigned to the safety input.
- The TCP Offset should be set to the hand tip position* using the Tool 0 coordinate system as a reference.
  *: The position where the hand moves at its fastest during robot operation. Or, the position farthest from the tip of the ball screw linear motion mechanism.
- To achieve control that does not exceed the Safety Limited Speed (SLS), it must be explicitly set using the SPEL+ command.
  The robot makes an emergency stop if Safety Limited Speed (SLS) is enabled and the robot speed exceeds the monitoring speed.
- If SLS_1, SLS_2, and SLS_3 are enabled, the next SPEL+ command is automatically set when the controller starts up.
  - SLS number set in SF_LimitSpeedS, 0
  - SLS number set in SF_LimitSpeedSEnable, On
- SF_LimitSpeedS and SF_LimitSpeedSEnable are functions that adjust the speed at the tool position selected by the Tool command. For details, refer to the following manual.
  "SPEL+ Language Reference"
- The speed of Monitored Joints can be acquired with SF_PeakSpeedS/SF_RealSpeedS. In addition, the joint speed of Monitored Joints can be acquired with PeakSpeed. For details, refer to the following manual.
  "SPEL+ Language Reference"



a: Control using SPEL+ to ensure that the Maximum Speed (mm/s) is not exceeded referring to the SF_PeakSpeedS command value.
b: Referring to the PeakSpeed command values, control with SPEL+ to avoid exceeding the Maximum Joint Speed (%).

No	Name	Function	Notes
1. TCP Offset Settings		These set the TCP Offset [mm].	
1.1	X_TCP	Setting for the offset position [mm] of the X axis	-
1.2	Y_TCP	Setting for the offset position [mm] of the Y axis	-
1.3	Z_TCP	Setting for the offset position [mm] of the Z axis	-

No	Name	Function	Notes
2. Joint Angle Limit		These configure settings related to the Joint Angle Limit.	
2.1	Check box	Setting for whether to execute Joint Angle Limit	This is a function of SLS_1 (safety function option). To use this, enable SLS_1 in the safety input settings.
2.2	Maximum Joint Angle	Setting for the limit angle [× 0.1 deg]	

No	Name	Function	Notes
3	SLS_T Settings	Setting for Maximum Speed in TEACH mode and TEST T1 mode	The following settings are available: - Maximum Speed setting (required) Set at 250 [mm/sec] or less. - Maximum Joint Speed setting (optional) This is always enabled for the Monitored Joints other than the Maximum Joint Speed. This cannot be disabled.
4	SLS_T2 Settings	Setting for Maximum Speed in TEST T2 mode	The following settings are available: - Maximum Speed setting (required) - Maximum Joint Speed setting (optional) This is always enabled for the Monitored Joints other than the Maximum Joint Speed. This cannot be disabled.
5	SLS_1 Settings	Setting for Maximum Speed in SLS_1	Safety Function options. The following settings are available: - Maximum Speed setting (required) - Delay Time (optional) - Monitored Joints (At least one must be selected, including the Maximum Joint Speed) - Maximum Joint Speed setting (required)
6	SLS_2 Settings	Setting for Maximum Speed in SLS_2	
7	SLS_3 Settings	Setting for Maximum Speed in SLS_3	

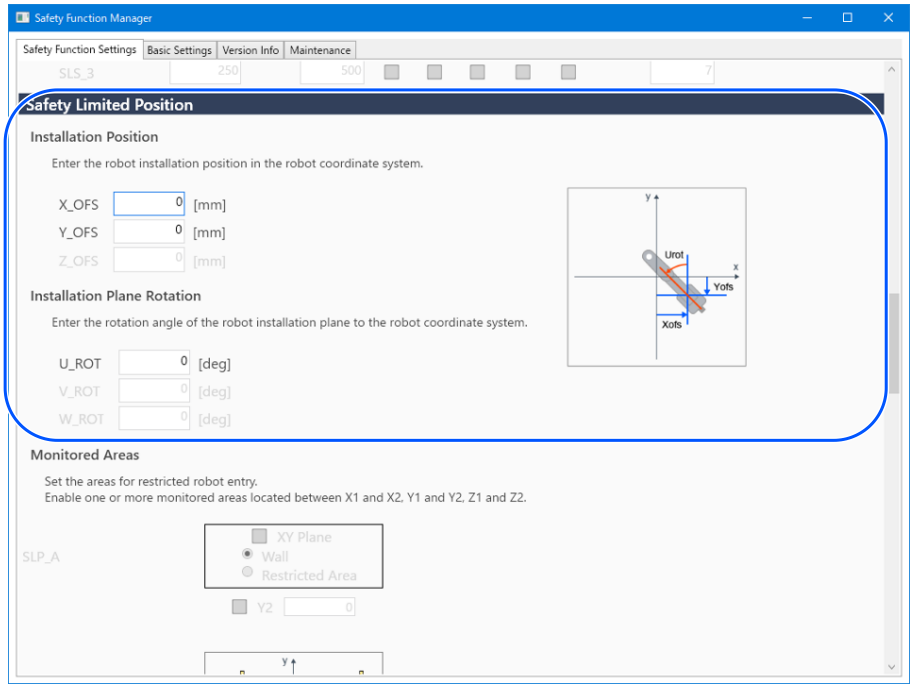
No	Name	Function	Notes
A	Maximum Speed (mm/s)	Setting for Maximum Speed [mm/sec] in each limit	Make this setting based on the speeds that can be obtained with the SF_PeakSpeedS command and SF_RealSpeedS command.
B	Delay Time (msec)	Setting for Delay Time [ms] in each limit	-
C	Monitored Joints	Settings for Monitored Joints in each limit	Be sure to set up at least one joint.
C.1	J2	Setting for whether to monitor J2 (shoulder) speed	-
C.2	J3	Setting for whether to monitor J3 (elbow) speed	This can only be set for a 6-Axis robot.
C.3	J5	Setting for whether to monitor J5 (wrist) speed	This can only be set for a 6-Axis robot.
C.4	Hand	Setting for whether to monitor hand speed (TCP speed)	-
D	Joint rotation setting	Setting for joint speed monitoring in each limit	-
D.1	Joints	Setting for whether to monitor joint speed	-
D.2	Maximum Joint Speed [%]	Setting for Maximum Speed of joint axis rotation or vertical motion [%]	Set this as a percentage [%] of the maximum speed. Set this using the PeakSpeed command referring to the absolute obtainable peak speed value.

4.3.3 Robot Installation Position Settings for Safety Limited Position (SLP)

Set the robot installation position for using the Safety Limited Position (SLP) function. Set the following items:

- Installation Position
- Installation Plane Rotation

> **⚠ WARNING**
>
> Be sure to set the Installation Position and the Installation Plane Rotation in order for the Safety Limited Position to operate properly.



No	Name	Function	Notes
1. Installation Position		Set the robot offset position [mm].	
1.1	X_OFS	Setting for the offset position in the X direction	-
1.2	Y_OFS	Setting for the offset position in the Y direction	-
1.3	Z_OFS	Setting for the offset position in the Z direction	This can only be set for a 6-Axis robot.

No	Name	Function	Notes
2. Installation Plane Rotation		Set the robot offset angle [deg].	
2.1	U_ROT	Setting for the offset angle around the U axis	-
2.2	V_ROT	Setting for the offset angle around the V axis	This can only be set for a 6-Axis robot.
2.3	W_ROT	Setting for the offset angle around the W axis	This can only be set for a 6-Axis robot.

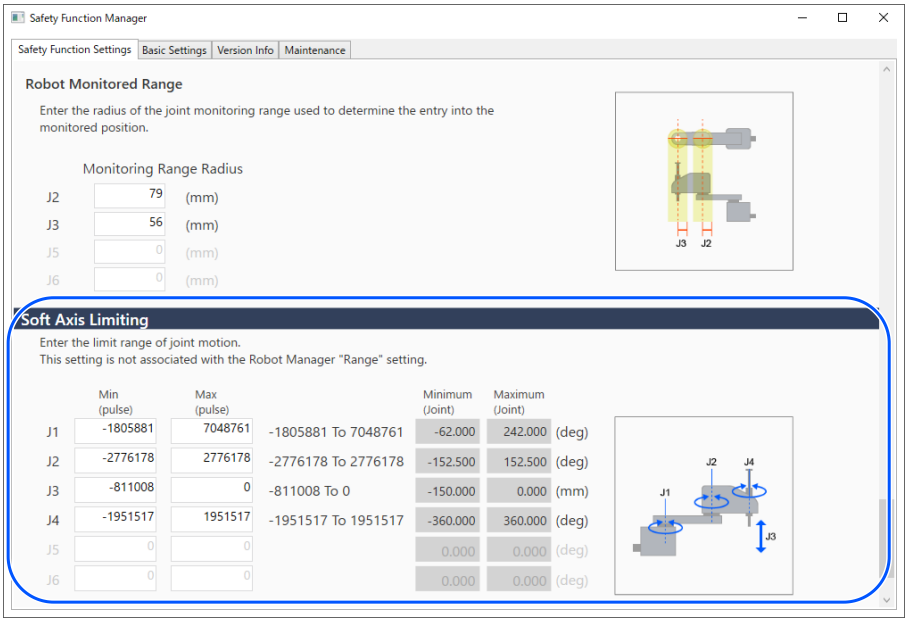
4.3.4 Setting Safety Limited Position (SLP)

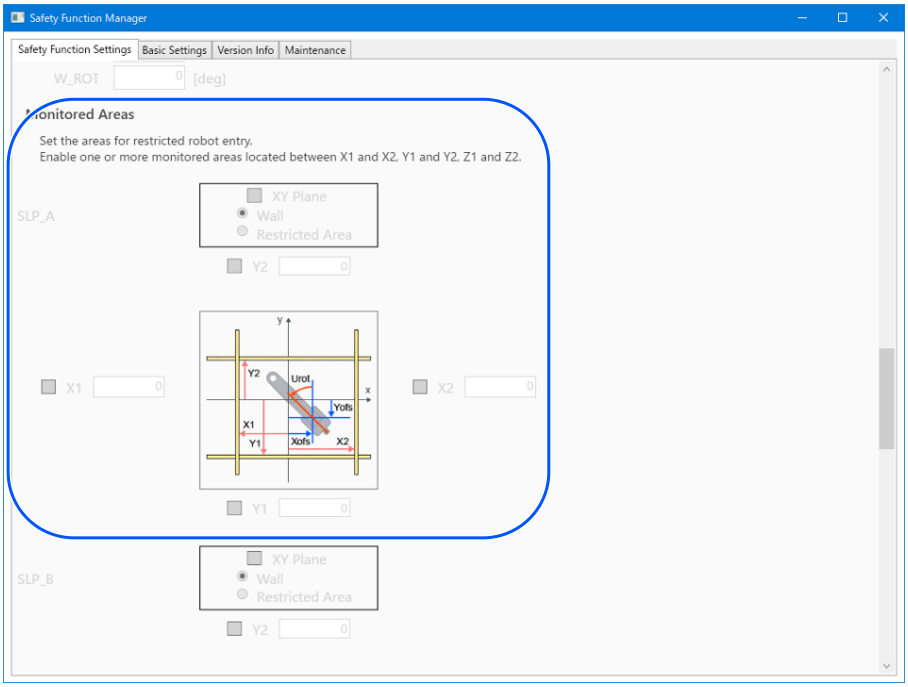
Perform settings to use the Safety Limited Position (SLP) function. Set the following items:

- Robot Monitored Range
- Monitored Areas

KEY POINTS

- SLP_A, SLP_B, and SLP_C can only be edited if they are assigned to safety inputs.
- This does not perform control to prevent entry into the monitored areas. Perform the following settings as necessary.
  - Set the XYZ limits (XYLim) so that the robot does not enter the monitored areas.
  - Set the entry detection area (Box) or the entry detection plane (Plane) considering the stopping distance around the monitored areas, and perform appropriate control when an entry is detected.
    For details on XYZ limits (XYLim), entry detection area (Box), and entry detection plane (Plane), refer to the following manual.
    "EPSON RC+ User's Guide", "SPEL+ Language Reference"
- For SCARA Manipulators, set the J3 axis monitoring radius to a value that encompasses the hand (end effector). This value is used to determine if the hand has entered the monitored areas.
- For 6-Axis Manipulators, set the J6 axis monitoring radius to a value that encompasses the hand (end effector). This value is used to determine if the hand has entered the monitored areas.





No	Name	Function	Notes
1. Robot Monitored Range		Set the safety monitoring radius [mm] for each joint.	
1.1	J2	Setting for the monitoring radius for J2 axis	-
1.2	J3	Setting for the monitoring radius for J3 axis	-
1.3	J5	Setting for the monitoring radius for J5 axis	This can only be set for a 6-Axis robot.
1.4	J6	Setting for the monitoring radius for J6 axis	This can only be set for a 6-Axis robot.
2	SLP_A	SLP_A-related settings	-
3	SLP_B	SLP_B-related settings	-
4	SLP_C	SLP_C-related settings	-

No	Name	Function	Notes
A	XY plane settings	Setting for XY plane in each function	-
A.1	Enable setting	Setting for whether to execute monitoring of the XY plane	-
A.2	Range selection	Selection of setting range - Wall - Restricted Area	This can only be set if "A.1 Enable setting" is enabled.
B	Enable XY plane range	Setting for whether to execute monitoring in each XY direction	This can only be set if "A.1 Enable setting" is enabled.
B.1	X1	Setting for whether to execute monitoring in the X1 direction	This can only be set when Wall is selected. Be sure to enable at least one location.
B.2	X2	Setting for whether to execute monitoring in the X2 direction	
B.3	Y1	Setting for whether to execute monitoring in the Y1 direction	
B.4	Y2	Setting for whether to execute monitoring in the Y2 direction	
C	XY plane range input	Setting for monitoring range in the XY direction	This can only be set if "A.1 Enable setting" is enabled.
C.1	X1	Setting for range in the X1 direction	Set X2 to a value greater than X1.
C.2	X2	Setting for range in the X2 direction	
C.3	Y1	Setting for range in the Y1 direction	
C.4	Y2	Setting for range in the Y2 direction	
D	Setting for the Z direction	Setting for monitoring in the Z direction	
D.1	Enable setting	Setting for whether to execute monitoring in the Z direction	Only Wall (floor, ceiling) can be set for the Z direction.
E	Enable Z direction range	Setting for whether to execute monitoring in the Z direction	This can only be set if "D.1 Enable setting" is enabled.
E.1	Z1	Setting for whether to execute monitoring in the Z1 direction	
E.2	Z2	Setting for whether to execute monitoring in the Z2 direction	
F	Z direction range input	Setting for monitoring range in the Z direction	
F.1	Z1	Setting for range in the Z1 direction	Set this to a value smaller than the robot position.
F.2	Z2	Setting for range in the Z2 direction	

Difference between a "Wall" and a "Restricted Area"

- Wall
  The upper and lower limits of the robot's operating area are set, and if the robot moves from inside the set area to outside,

then Safe Torque OFF (STO) is executed, putting the Robot Controller in the emergency stop status. Please set the monitoring range considering the stopping distance. For the stopping distance, refer to the following manual.
"Manipulator Manual - Appendix B. Stopping Time and Stopping Distance at Emergency Stop, Appendix C: Stopping Time and Stopping Distance When Safeguard Is Open"
Example of use: Preventing collisions with safety barriers
Refer to the following section for details.
Monitoring Areas for a SCARA Manipulator
Monitoring Areas for a 6-Axis Manipulator
For a SCARA Manipulator, 15 patterns, (a) through (o) can specified for the restricted range on the XY plane, which correspond to Walls.
For a 6-Axis Manipulator, there are a total of 18 patterns, including three patterns, (q) through (s) for the monitored position in the Z direction, in addition to those specified for the restricted range on the XY plane, which correspond to Walls.

- Restricted Area
  A prohibited area is set within the robot's operating area, and if the robot moves from outside the set area to inside, then Safe Torque OFF (STO) is executed, putting the Robot Controller in the emergency stop status. Please set the monitored areas considering the stopping distance. For the stopping distance, refer to the following manual.
  "Manipulator Manual - Appendix B. Stopping Time and Stopping Distance at Emergency Stop, Appendix C: Stopping Time and Stopping Distance When Safeguard Is Open"
  Example of use: Preventing collisions with structures near the robot
  Refer to the following section for details.
  Monitoring Areas for a SCARA Manipulator
  Monitoring Areas for a 6-Axis Manipulator
  Pattern (p) corresponds to the Restricted Area.

4.3.5 Setting Soft Axis Limiting

Perform settings to use the Soft Axis Limiting function.

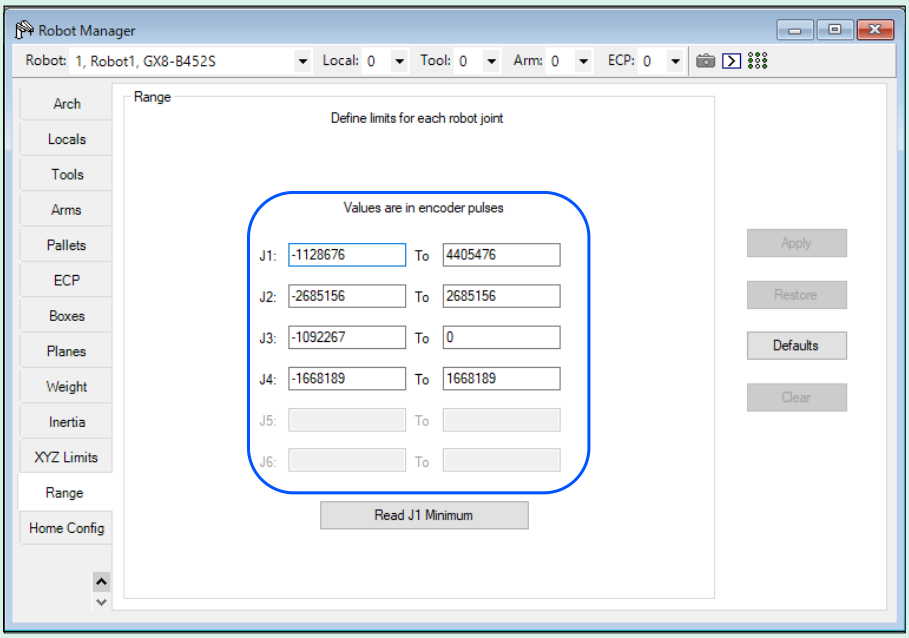
The setting range of Soft Axis Limiting is displayed to the right of the Soft Axis Limiting setting value. This setting range varies depending on the robot model.

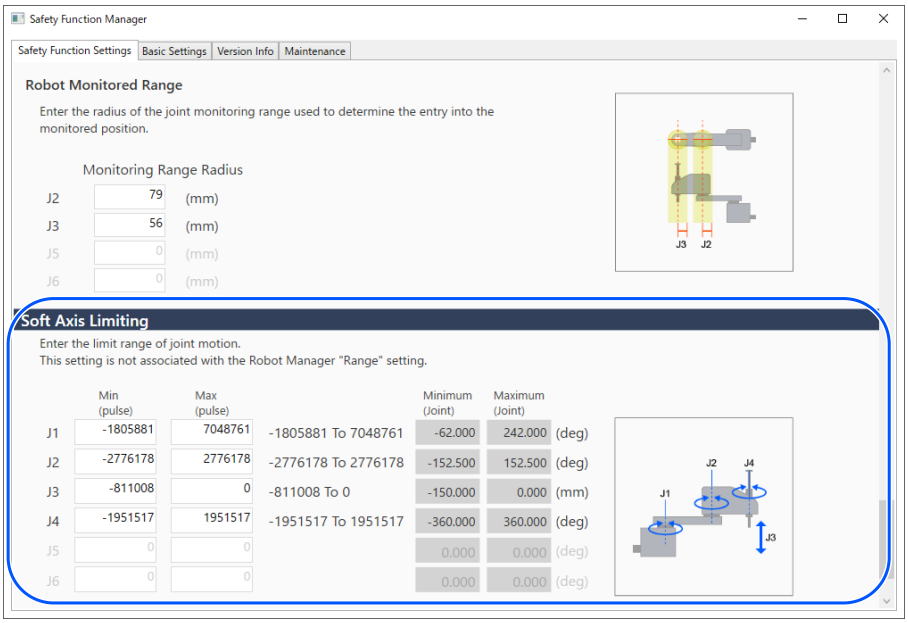
⚠ WARNING

The operating range set in Safety Function Manager is not linked to the setting parameters set in the "Tool Settings" section of the "EPSON RC+ User's Guide". Set the operating range referring to the following.

KEY POINTS

- The Soft Axis Limiting function is always enabled, except in TEACH mode.
- If any axis moves out of the motion range, Safe Torque OFF (STO) is executed, putting the Robot in the emergency stop status.
- The [Soft Axis Limiting] setting set in Safety Function Manager and the [Range] set in EPSON RC+ can be set separately. We recommend setting [Range] to values equal to or narrower than those of [Soft Axis Limiting].





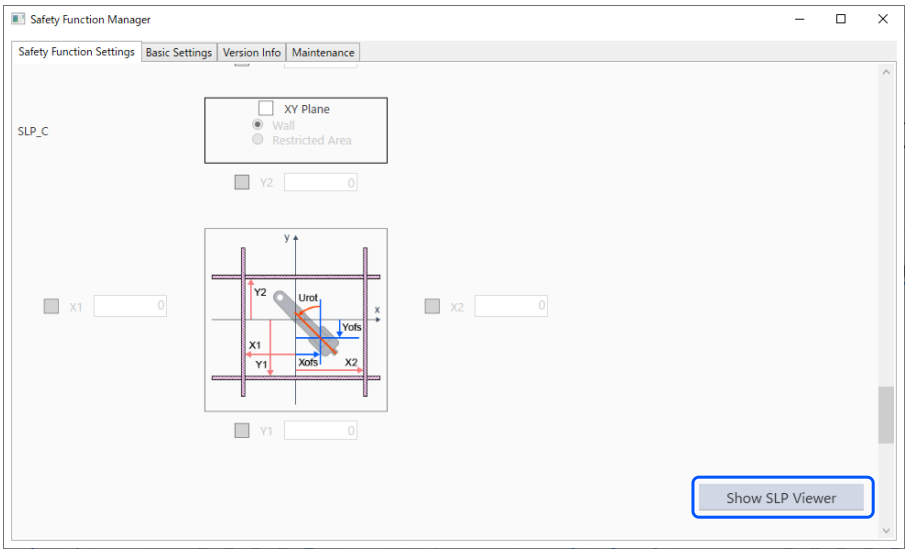
No	Name	Function	Notes
1. Soft Axis Limiting		Set the movement range monitoring value for each joint.	
5.1	J1	Set the movement range monitoring value for each joint.	-
5.2	J2	Setting for the operating range monitoring value for J2 axis	-
5.3	J3	Setting for the operating range monitoring value for J3 axis	-
5.4	J4	Setting for the operating range monitoring value for J4 axis	-
5.5	J5	Setting for the operating range monitoring value for J5 axis	This can only be set for a 6-Axis robot.
5.6	J6	Setting for the operating range monitoring value for J6 axis	This can only be set for a 6-Axis robot.

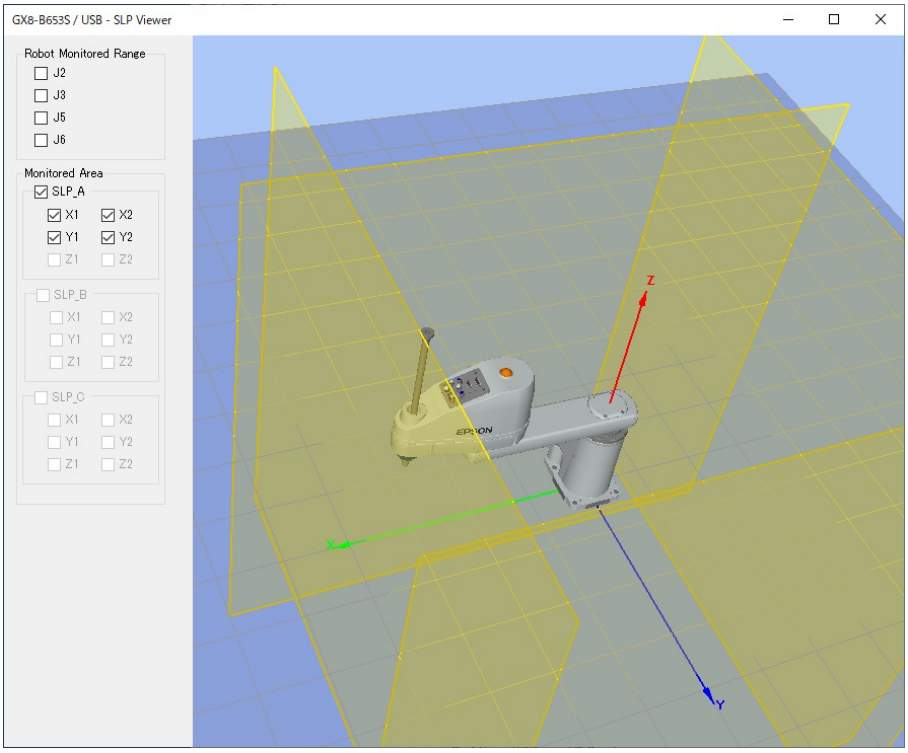
No	Name	Function	Notes
A	Minimum (pulse)	Setting for the minimum value of the limit range	-
B	Maximum (pulse)	Setting for the maximum value of the limit range	-
C	-	Display of minimum Acceptable Range	-
D	-	Display of maximum Acceptable Range	-
E	Minimum (joint)	Display of minimum Acceptable Range	0 [pulse] is displayed as 0 [°].
F	Maximum (joint)	Display of maximum Acceptable Range	0 [pulse] is displayed as 0 [°].

4.3.6 SLP Viewer

This allows you create a 3D model to visualize the Monitored Areas and Robot Monitored Range edited in Safety Function Manager to check settings.

SLP Viewer is started by clicking the [Start SLP Viewer] button.
With SLP Viewer running, click the [Start SLP Viewer] button to update the display.





No	Name	Function	Notes
1	3D model display section	Visualization of the Safety Restricted Area and Robot Monitored Range	There is no collision detection function.
2	Operation panel of the Robot Monitored Range	Select the monitoring area of the robot axis to be visualized	-
3	Operation panel of the Safety Restricted Area	Select the safety area to be visualized	-

Moving robot joints

Drag the joints of the robot to move each joint of the robot. Selected joints are displayed in blue.

Changing viewpoint

Drag the 3D model display screen with the left mouse button to rotate the viewpoint.
Drag the 3D model display screen with the right mouse button to move the viewpoint up, down, left, or right.

Zooming in or out

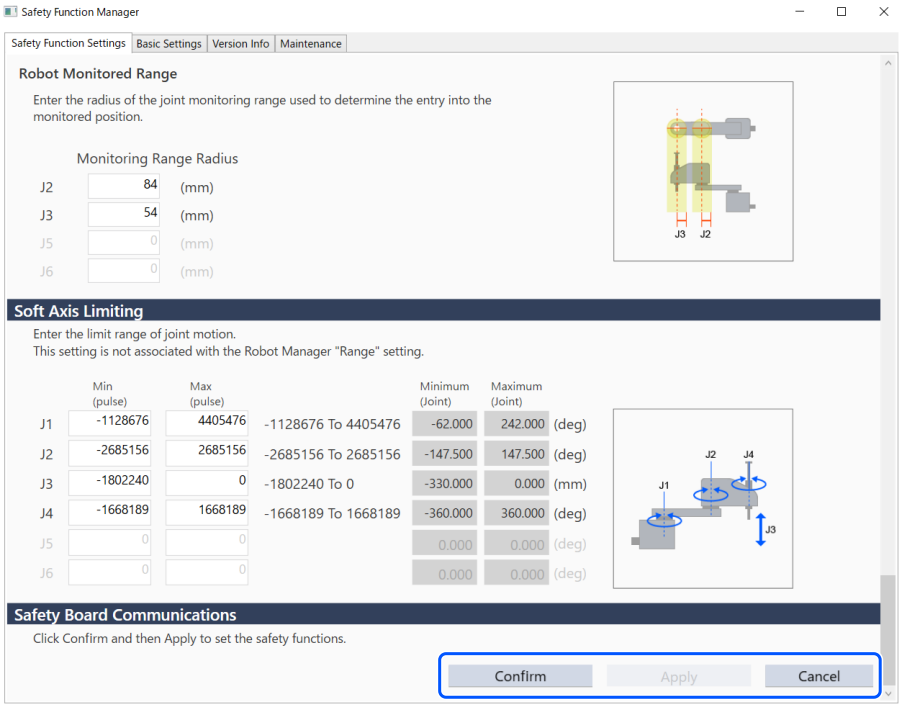
Move the scroll wheel to zoom in or out on the 3D display.

KEY POINTS

- The Monitored Areas and Robot Monitored Range displayed in SLP Viewer are the values being edited in Safety Function Manager. The setting values may differ from those of the safety board.
- The robot posture displayed when SLP Viewer is started reflects the actual posture of the robot.
- The SLP Viewer is not linked to the actual robot motion.

4.3.7 Applying Safety Function Parameters

Apply the safety function parameters you changed to the safety board.



No	Name	Function	Notes
1	Confirm	Send the safety function parameters to the safety board and display response values from the safety board	Edit the necessary items before selecting this.
2	Apply	Apply the safety function parameters to the safety board	Make sure there are no abnormalities in the response values before selecting this.
3	Cancelling	Cancel changes	Clicking [Cancel] after clicking [Confirm] will cancel the changes and restart the Robot Controller.

4.4 Making Dry Run Settings

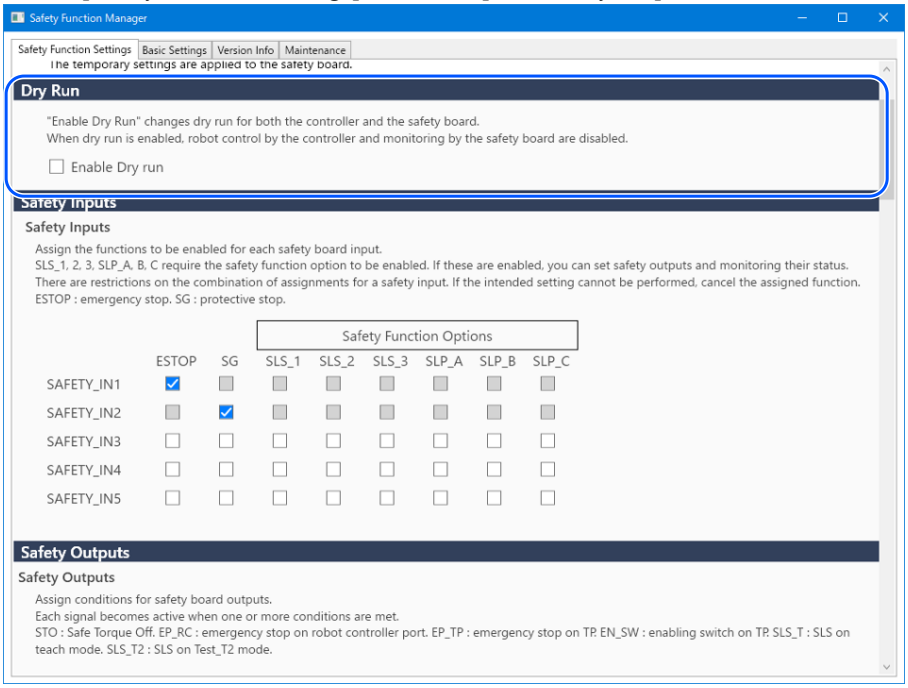
When dry run is enabled, the Robot Controller can be executed without connecting it to a Manipulator.

Safety Function Manager provides dry run settings for both the Robot Controller and the safety board.
When switching between enabling and disabling dry run, the relationship between robot operation and the operation of safety functions by the safety board is as follows:

Dry Run Settings	Robot Operation	Safety Functions
Enabled	Stopped	Stopped
Disabled	Operating*	Operating

*: Be careful of the robot's operations.

How to set dry run
On the [Safety Function Settings] tab, select [Enable Dry run].



KEY POINTS

- Safety function parameters cannot be changed until dry run is disabled. However, the set values of the safety function parameters are retained.
- Dry run cannot be set with EPSON RC+ for a Robot Controller equipped with safety functions.

4.5 Outputting the Safety Function Parameters to Text

To output the configured safety function parameters to the Robot Controller as text, implement the SPEL program as shown in the example below.

```
Function main
        Integer fileNum, i, j

        fileNum = FreeFile
        WOpen "c:\EpsonRC70\SFParam.csv" As #fileNum

        ' Outputs parameters acquired by the SF_GetParam$ function as text
        Print #fileNum, "index,value"
        For i = 1 To 7
        Print #fileNum, Str$(i) + "," + SF_GetParam$(i)
        Next i

        ' Outputs parameters acquired by the SF_GetParam function as text
        Print #fileNum, "index,value"
        For j = 1 To 174
        Print #fileNum, Str$(j) + "," + Str$(SF_GetParam(j))
        Next j

        Close #fileNum
Fend
```

KEY POINTS

For details on the SF_GetParam$ function, which returns safety function parameters, and the SF_GetParam function (index corresponding to each safety function parameter), refer to the following manual.
"EPSON RC+ Language Reference"

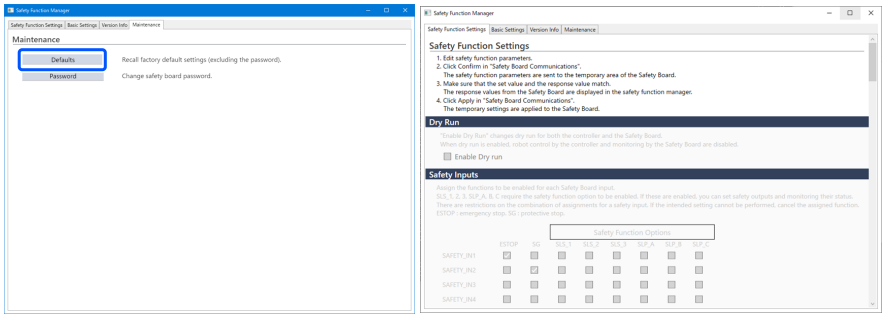
4.6 Safety Board Maintenance

You can restore the safety function parameters to their factory defaults and change the password for the Safety Board.

4.6.1 Restoring Factory Default Settings

This function restores the safety function parameters set on the safety board to their factory default settings.

1. On the [Maintenance] screen, select [Defaults] to display the Safety Function Settings screen with default values added.



2. Use [Confirm] or [Apply] to set factory set Safety Function parameters for the Safety Board.

KEY POINTS

This function does not change the password. To change the password, refer to the following section.
Changing the Password

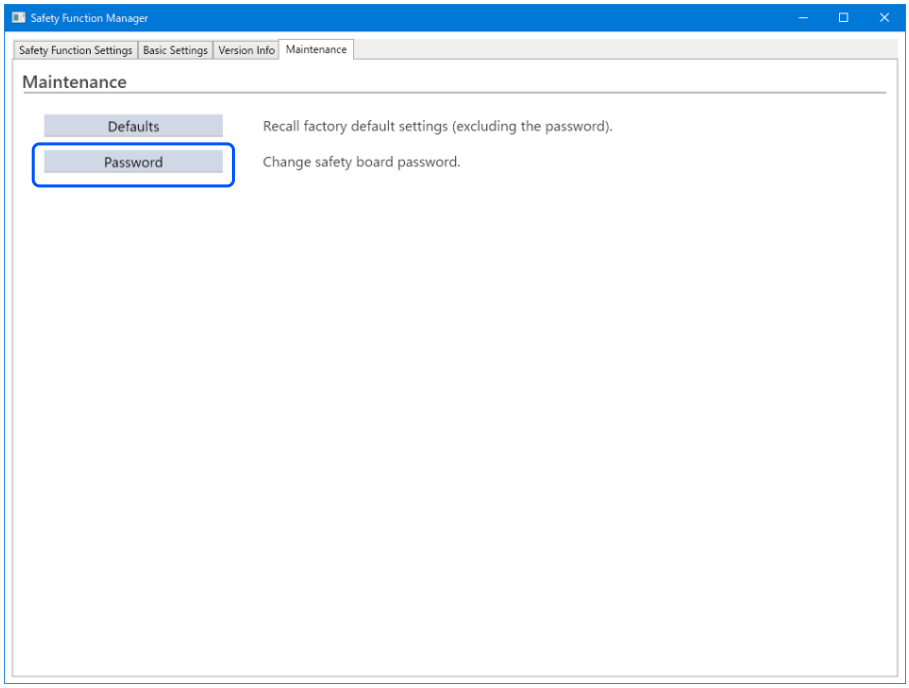
4.6.2 Changing the Password

This function changes the password on the safety board.

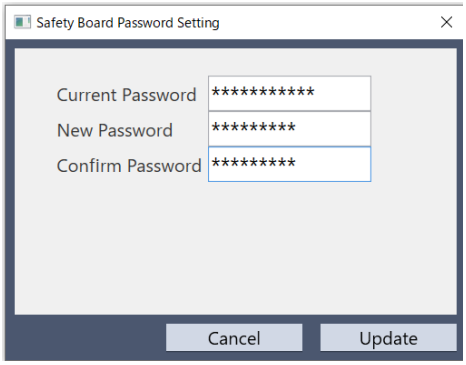
KEY POINTS

- The password must be changed by the safety manager.

1. On the [Maintenance] screen, select [Password].



2. Enter the current password in [Current Password] and the new password you want to set in [New password] and [Confirm Password], and then click [Update].
   The Robot Controller is restarted.



KEY POINTS

The password must be eight characters or longer, but no more than 15 characters long. The characters that can be used are as follows:
Half-width uppercase alphabetic characters: A to Z
Half-width lowercase alphabetic characters: a to z
Half-width numbers: 0 to 9
Half-width symbols: (space) ! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [ ] ^ _ { | } ~

3. After the Robot Controller has restarted, start Safety Function Manager.

KEY POINTS

- If an incorrect password is entered three times, Safety Function Manager shuts down and the Robot Controller is restarted. At this time, the settings are not changed.
- The password is always required when using Safety Function Manager. Please keep it in a safe place so that you do not forget it.
- If you need to reset the password, contact your safety manager or the supplier.

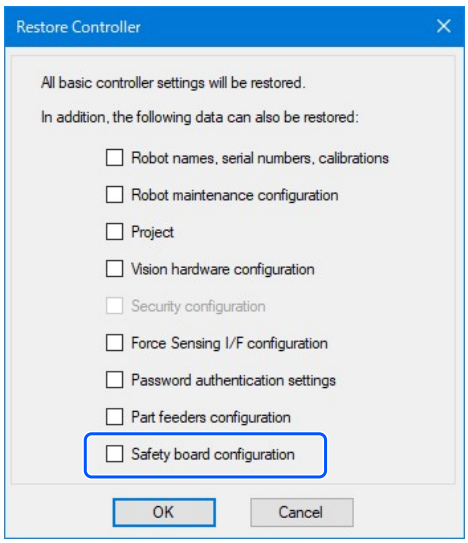
4.6.3 Restoring Saved (Backed-up) Settings

Restoration procedure

A restoration can be performed using the [Restore Controller] in EPSON RC+.

> **⚠ CAUTION**
>
> Be sure to perform the restoration on the same Robot Controller for which the data backup was performed. Also, do not rewrite the contents of the backup data. Operation of the robot system cannot be guaranteed if a restoration is performed using the data of a different Robot Controller or with rewritten data.

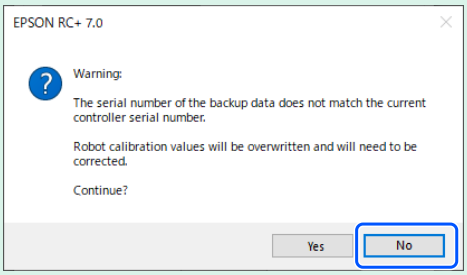
1. From the EPSON RC+ menu, select [Tools] - [Controller] to display the [Controller Tools] dialog box.
2. Click the [Restore Controller…] button to display the [Browse For Folder] dialog box.
3. Specify the folder where the backup data is stored.
   B_RC700-E_Serial number_Date and time the backup was performed
   Example: B_RC700-E_12345_2011-04-03_092941
4. Click the [OK] button and select [Safety board configuration].
   For other selection items, refer to the following manual.
   "EPSON RC+ User's Guide"



5. Click the [OK] button, and restore the settings of the safety function.

KEY POINTS

- Restore backup data saved in the backup of Robot Controller settings on the same system.
  If you try to restore information from a different system, the following warning dialog box appears.



  Except in special cases such as replacing a Robot Controller, click the [No] button.

- Restoring backup data from a system with safety function options enabled to a system with safety function options disabled does not set the option functions.

4.7 How to Reset the Robot When It Stopped due to a Safety Function

If the robot was stopped due to a safety function, it must be reset to a status where it can operate again. Refer to the "How to reset" sections below and reset the robot.

- If the robot stopped due to a safety input: **Example of Using Safety Input Functions**
- If the robot stopped due to Safety Limited Speed (SLS): **Example of Using Safety Limited Speed (SLS)**
- If the robot stopped due to Joint Angle Limit: **Example of Using Joint Angle Limit**
- If the robot stopped due to Safety Limited Position (SLP): **Example of Using Safety Limited Position (SLP)**
- If the robot stopped due to Soft Axis Limiting: **Example of Using Soft Axis Limiting**

5. Example of Using Safety Functions

This section describes how to use each safety function, showing a simple example.
For a detailed description of each function, refer to the Safety Function Manager screen.

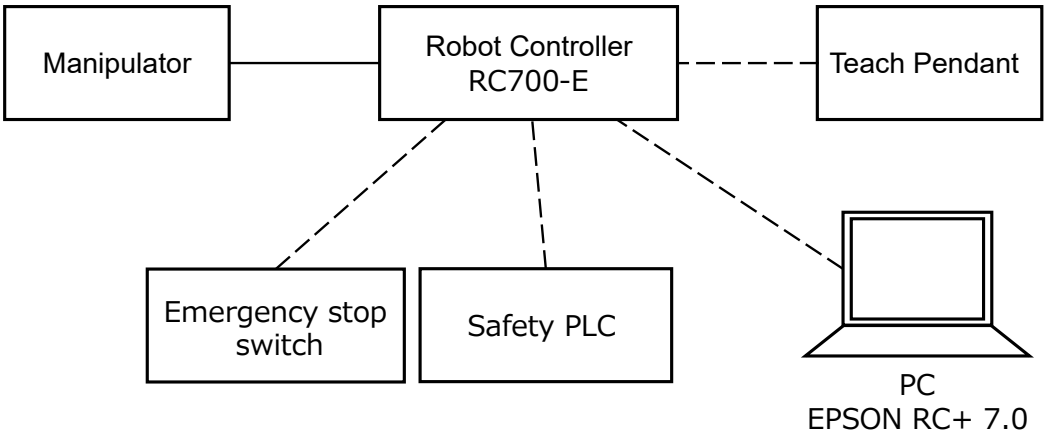
5.1 Environment Required to Check Operation

The following describes the environment required to check operation.

Equipment configuration and applications
Please prepare the following equipment and applications:

- Manipulator: GX-B Series, C-B Series
- Robot Controller: RC700-E
- Safety PLC
- For GX4-B/GX8-B: PC with EPSON RC+7.0 Ver.7.5.4 or later installed
  For GX10-B/GX20-B: PC with EPSON RC+7.0 Ver.7.5.4A or later installed
  For C4-B/C8-B/C12-B: PC with EPSON RC+7.0 Ver.7.5.4C or later installed
- Emergency stop switch
- Teach Pendant*
  *: Can be used when using the Safety Limited Position (SLP) and Soft Axis Limiting.

Equipment and wiring methods



For the specific connection methods, refer to the following manual.
"Robot Controller RC700-E Manual"

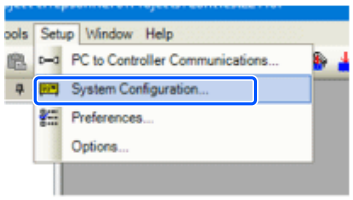
5.2 Example of Using Safety Input Functions

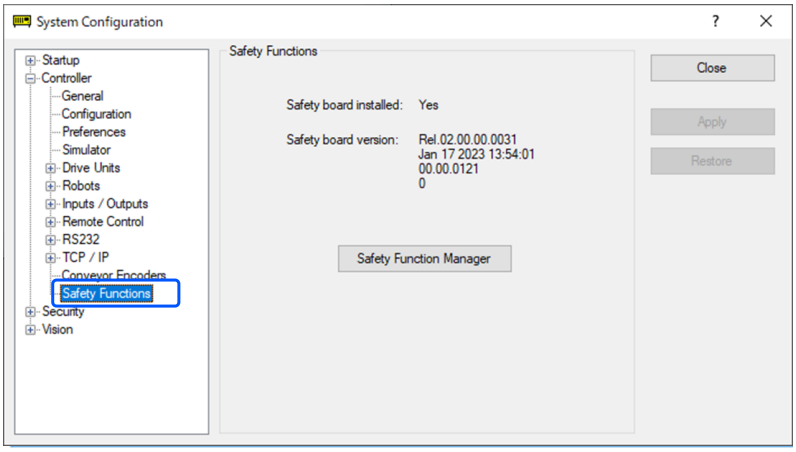
The following describes an example of using safety inputs.
In this example, an Emergency Stop (ESTOP) function is assigned to SAFETY_IN1, an emergency stop switch is connected to the SAFETY_IN1 port, and the emergency stop switch is operated to confirm the safety input.

How to set

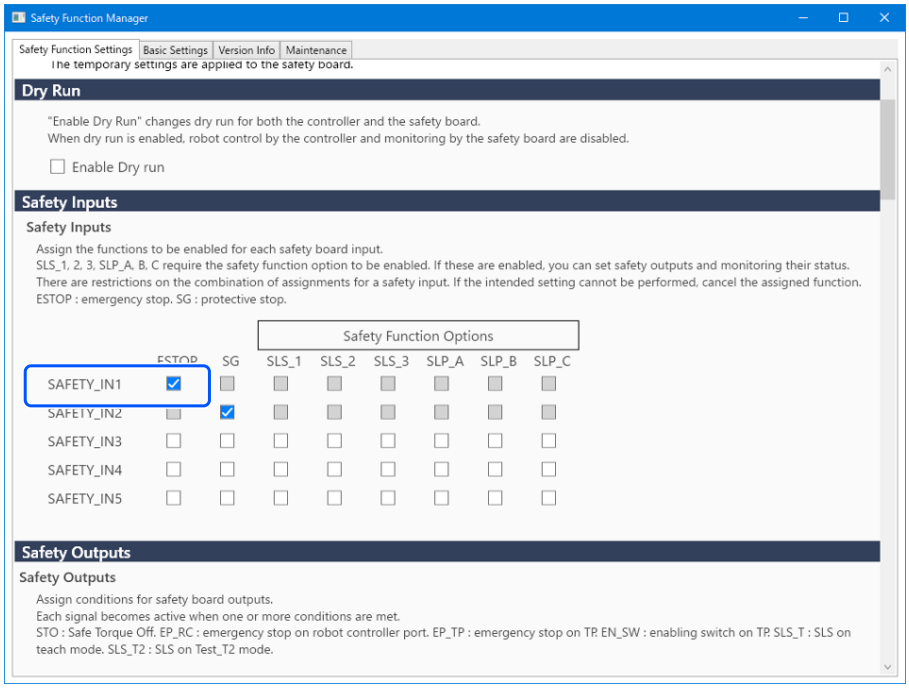
Follow the procedure below to set the safety function parameters.

1. In EPSON RC+, select [Setup] - [System Configuration], and then start Safety Function Manager under [Controller] - [Safety Functions].





2. For [SAFETY_IN1], select [ESTOP].

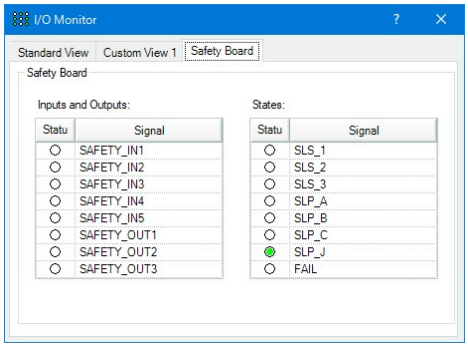


3. Apply settings.

How to check operation

Follow the procedure below to check the operation.

1. In EPSON RC+, select [Tools] - [I/O Monitor], and then select [Safety Board].

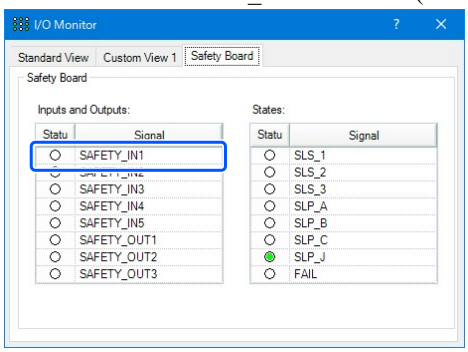


2. Press the emergency stop switch connected to SAFETY_IN1 to enable the emergency stop function.

KEY POINTS

As the safety inputs use negative logic, the Low level (0 V) is the ON status.

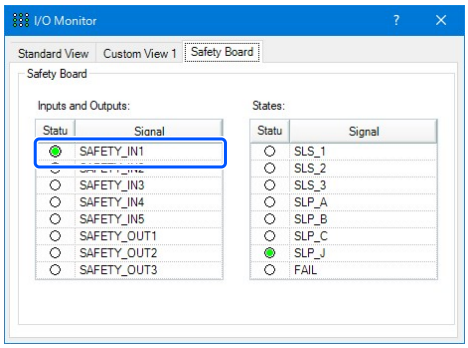
3. Confirm that SAFETY_IN1 turns ON (white).



4. Confirm that the [EStop] displayed in the lower right corner of EPSON RC+ lights up.

5. Release the emergency stop switch connected to SAFETY_IN1 to disable the emergency stop function.

6. Confirm that SAFETY_IN1 turns OFF (green).



How to reset

Follow the procedure below to reset the emergency stop status.

1. Release the emergency stop switch.

2. In EPSON RC+, select [Robot Manager] - [Control Panel], and then perform the error reset operation.

3. Confirm that the [EStop] displayed in the lower right corner of EPSON RC+ turns off.

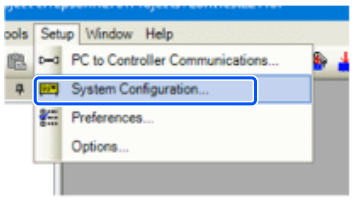
5.3 Example of Using Safety Output Functions

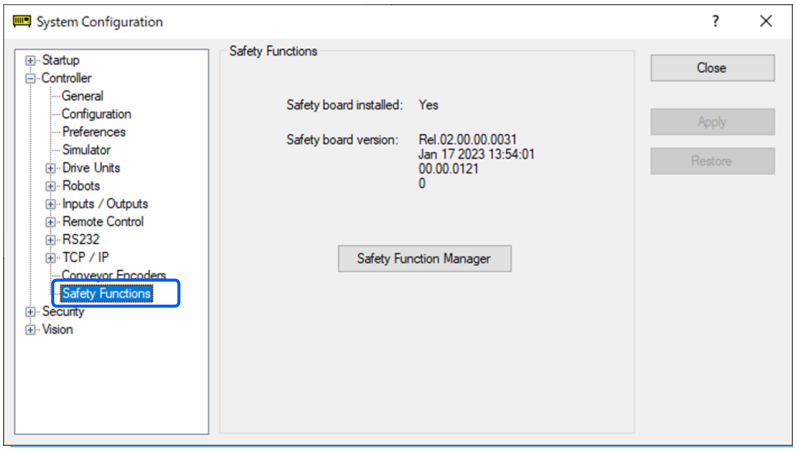
The following describes an example of using safety outputs.
In this example, the Safe Torque OFF (STO) function is assigned to SAFETY_OUT1. By operating the emergency stop switch used to check the safety input, the safety output is confirmed by the status of the SAFETY_OUT1 display on the Safety Board tab in the I/O monitor.

How to set

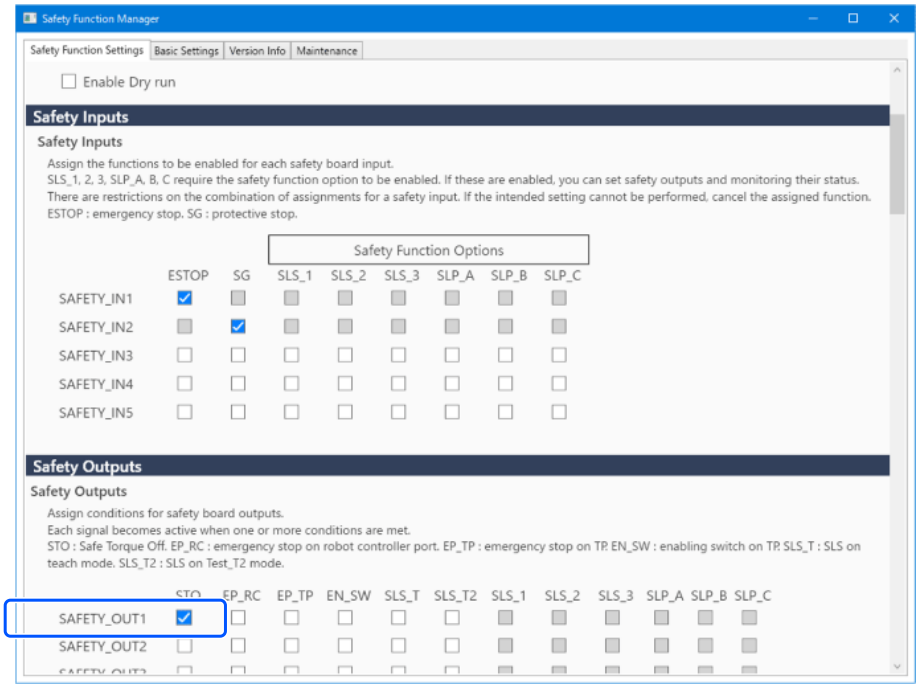
Follow the procedure below to set the safety function parameters.

1. In EPSON RC+, select [Setup] - [System Configuration], and then start Safety Function Manager under [Controller] - [Safety Functions].





2. For [SAFETY_OUT1], select [STO].



3. Apply settings.

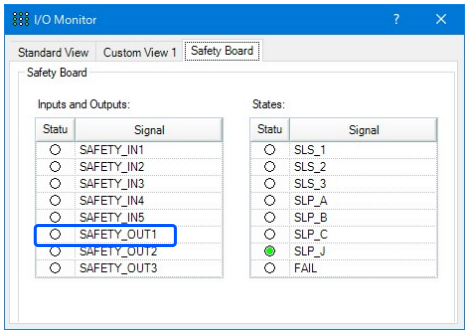
How to check operation

Follow the procedure below to check the operation.

1. Press the emergency stop switch.

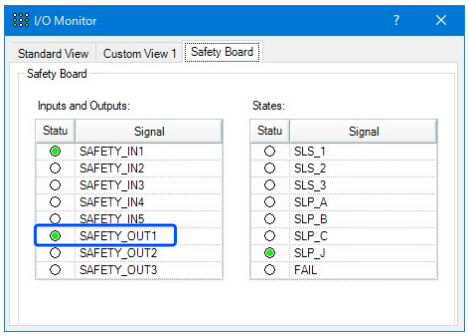
2. Confirm that the [EStop] displayed in the lower right corner of EPSON RC+ lights up.

3. In EPSON RC+, select [Tools] - [I/O Monitor], and then select the [Safety Board] tab, and confirm that SAFETY_OUT1 is ON (white).



4. Release the emergency stop switch.

5. Confirm that SAFETY_OUT1 turns OFF (green).



How to reset

Follow the procedure below to reset the emergency stop status.

1. Release the emergency stop switch.

2. In EPSON RC+, select [Robot Manager] - [Control Panel], and then perform the error reset operation.

3. Confirm that the [EStop] displayed in the lower right corner of EPSON RC+ turns off.

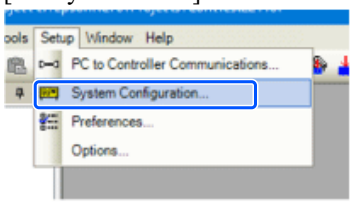
5.4 Example of Using Safety Limited Speed (SLS)

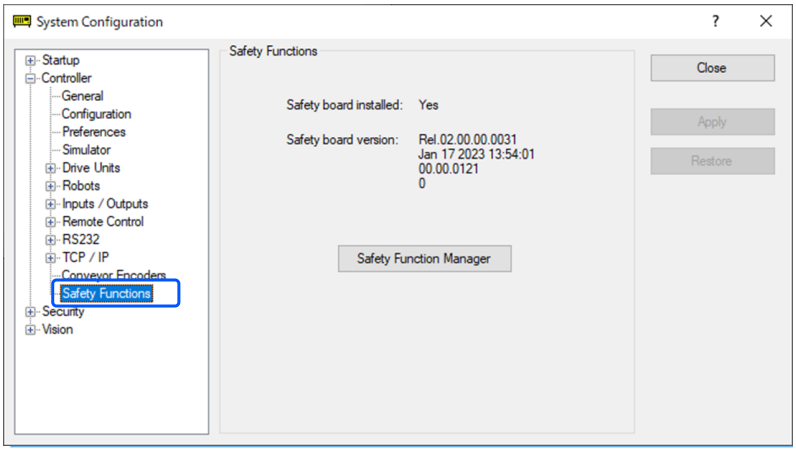
The following describes an example of using the Maximum Speed of Safety Limited Speed (SLS).
In this example, SLS_1 is assigned to SAFETY_IN3 and the Maximum Speed of SLS_1 is set to 1000 [mm/sec].

How to set

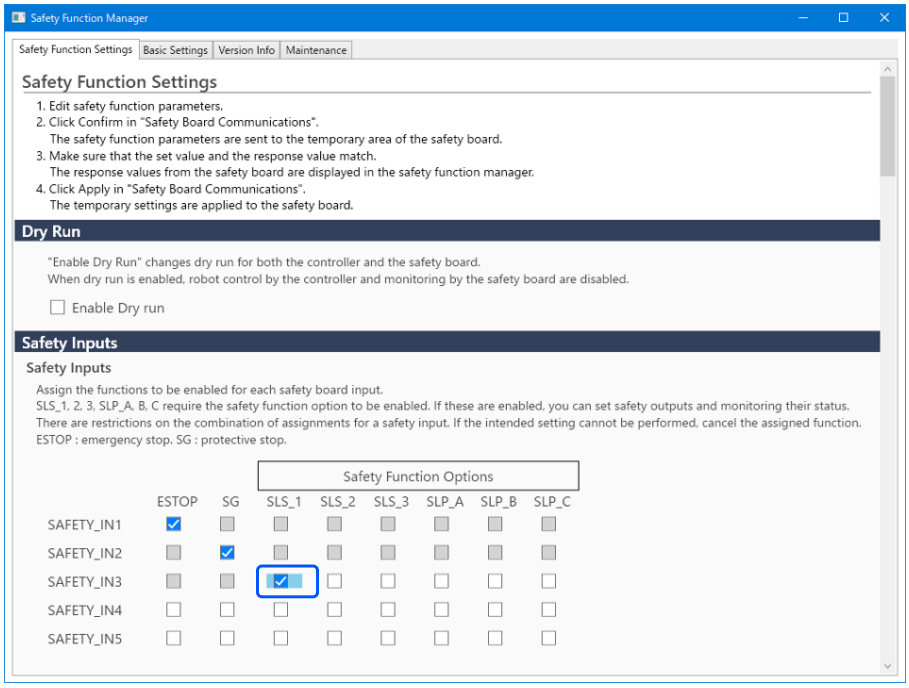
Follow the procedure below to set the safety function parameters.

1. In EPSON RC+, select [Setup] - [System Configuration], and then start Safety Function Manager under [Controller] - [Safety Functions].





2. For [SAFETY_IN3], select [SLS_1].

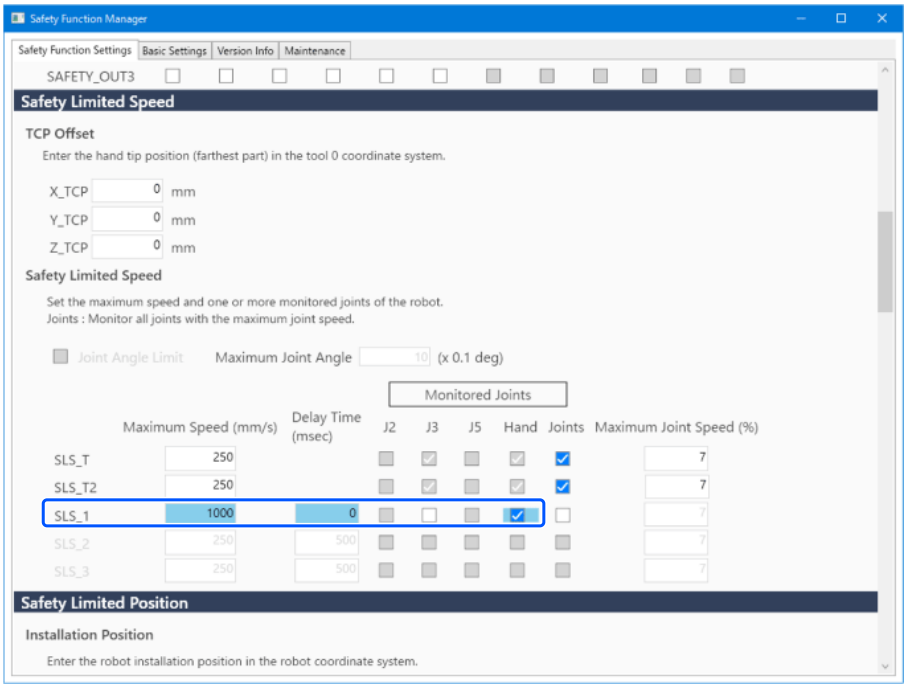


3. For the TCP offset, enter [X_TCP:0mm], [Y_TCP:0mm], [Z_TCP:0mm].

KEY POINTS

In this example, confirmation is performed without the hand attached. If 0 mm is entered for all the TCP Offset, a warning message will be displayed when you click the [Confirm] button. However, you can continue as-is.

4. For [SLS_1], enter 1000 for [Maximum Speed], 0 for [Delay Time], and select [Hand].



5. Apply settings.

How to check operation

Follow the procedure below to check the operation.

1. Turn SAFETY_IN3 ON (0V) to enable the speed monitoring function.
2. In EPSON RC+, operate the robot at a speed of 500 mm/sec.

   Sample program to operate at 500 mm/sec:

```
Function SLS_Test_500
    SF_LimitSpeedS SLS_1, 500      'Sets the speed limit to 500 mm/s when SLS_1 is enablec
    SF_LimitSpeedSEnable SLS_1, On 'Enables speed control when SLS_1 is enabled.
        Motor On
    Power Low
    Go P1              'Moves in PTP mode to the operation start position (P1).
    Power High
    Speed 100
    Accel 100, 100
    SF_PeakSpeedSClear 'Clears the peak speed value.
    Go P2
    SF_PeakSpeedS      'Displays the peak speed value.
    Motor Off
Fend
```

> **KEY POINTS**
>
> The safety functions do not operate because the operating speed is less than the Maximum Speed (1000 mm/sec).

3. In EPSON RC+, change the speed to 1500 mm/sec and then operate the robot.

Sample program to operate at 1500 mm/sec:

```
Function SLS_Test_1500
        SF_LimitSpeedS SLS_1, 1500     'Sets the limit speed to 1500 mm/s when SLS_1 is er
    SF_LimitSpeedSEnable SLS_1, On 'Enables speed control when SLS_1 is enabled.
    Motor On
    Power Low
    Go P1              'Moves in PTP mode to the operation start position (P1).
    Power High
    Speed 100
    Accel 100, 100
    SF_PeakSpeedSClear 'Clears the peak speed value.
    Go P2
    SF_PeakSpeedS      'Displays the peak speed value.
    Motor Off
Fend
```

4. Confirm that an emergency stop occurs and the robot operation stops.

How to reset

Follow the procedure below to reset the emergency stop status.

1. Release the emergency stop switch.
2. In EPSON RC+, select [Robot Manager] - [Control Panel], and then perform the error reset operation.
3. Confirm that the [EStop] displayed in the lower right corner of EPSON RC+ turns off.

5.5 Example of Using Joint Angle Limit

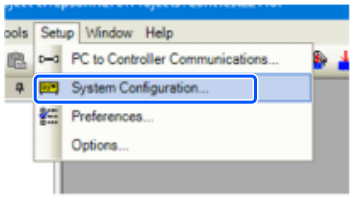
The following describes how to use Joint Angle Limit using SLS_1.
In this example, SLS_1 is assigned to SAFETY_IN3 to enable the Joint Angle Limit. Set the Maximum Joint Angle to 15 deg, and the SLS_1 Maximum Speed to 1000[mm/sec]. Confirm that the Manipulator continues to operate as long as it does not violate the Maximum Joint Angle, and that any violation of Joint Angle Limit results in an emergency stop.

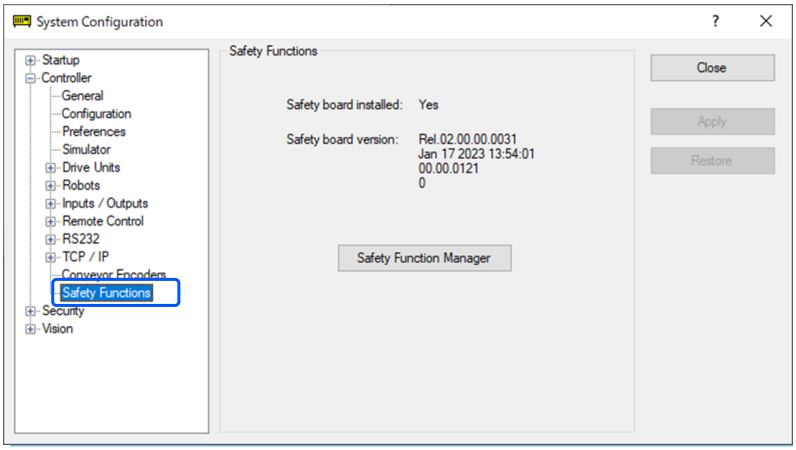
KEY POINTS

For details on the Joint Angle Limit, refer to the following section.
Joint Angle Limit

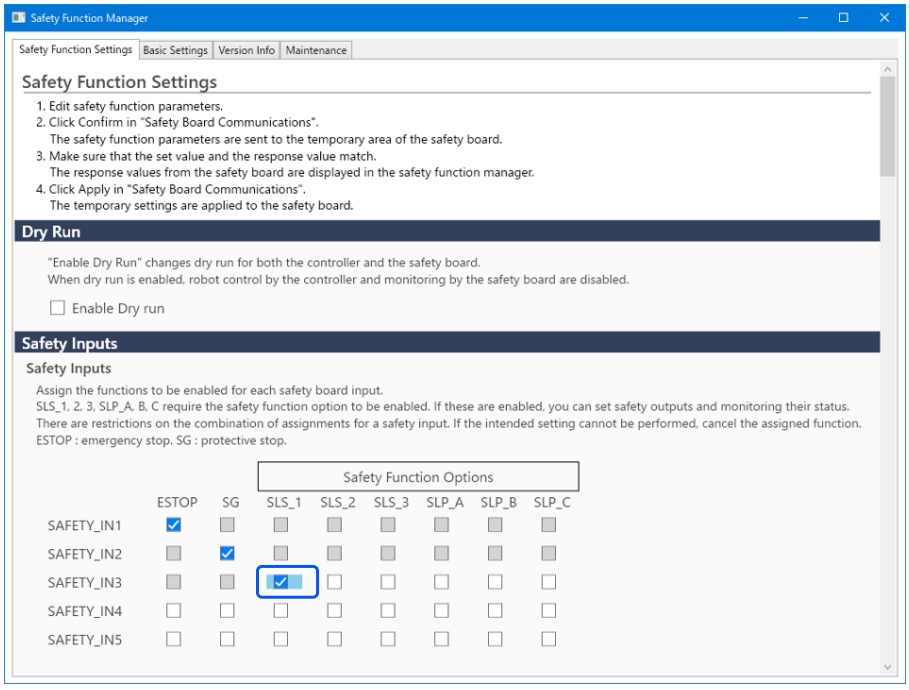
How to set
Follow the procedure below to set the safety function parameters.

1. In EPSON RC+, select [Setup] - [System Configuration], and then start Safety Function Manager under [Controller] - [Safety Functions].





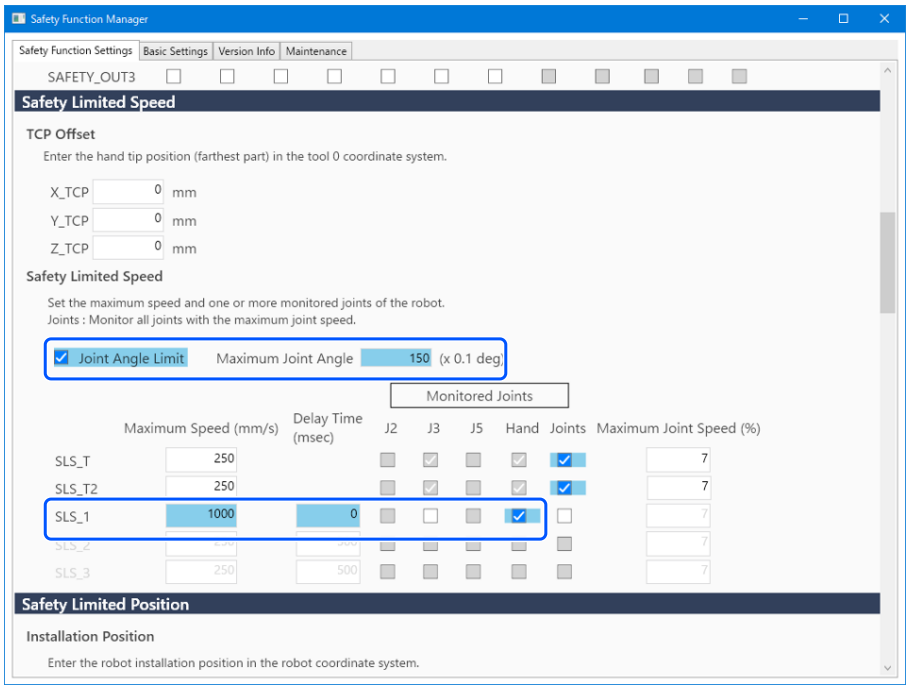
2. For [SAFETY_IN3], select [SLS_1].



3. Select the [Joint Angle Limit].
   When the [Joint Angle Limit] is selected, the [SLS_1] delay time is fixed to 0.

4. Enter 150 for [Maximum Joint Angle], and 1000 for [Maximum Speed] in [SLS_1].

5. Apply settings.



How to check operation

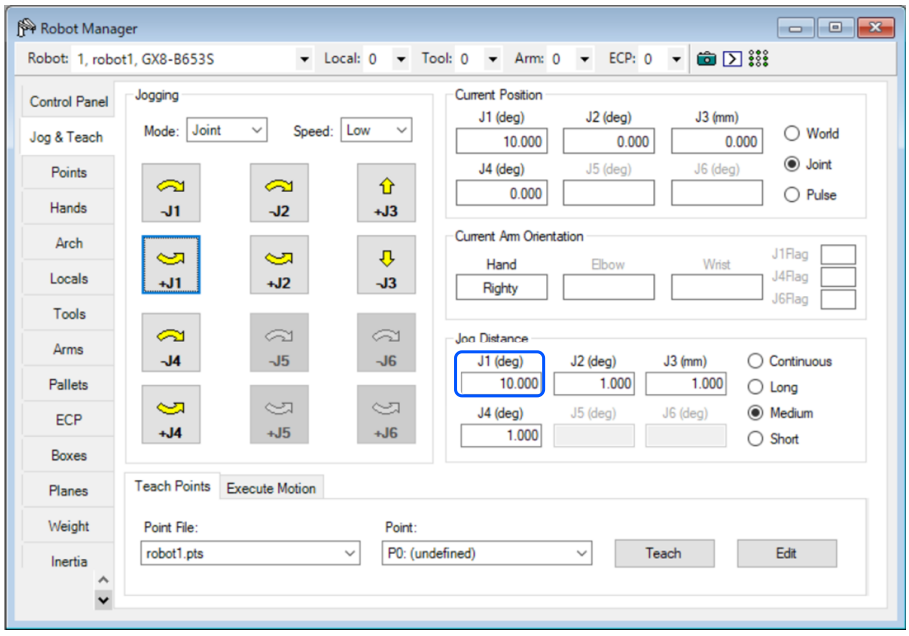
Follow the procedure below to check the operation.

1. Turn SAFETY_IN3 ON (0V) to enable the Joint Angle Limit.

2. In EPSON RC+, select [Tools] - [Robot Manager] - [Control Panel], and then turn the mode on.

3. In EPSON RC+, select [Tools] - [Robot Manager] - [Jog & Teach], and then set [Jog Distance] for J1 axis to 10 deg.

4. Click [+J1] to rotate 10 deg at low speed.

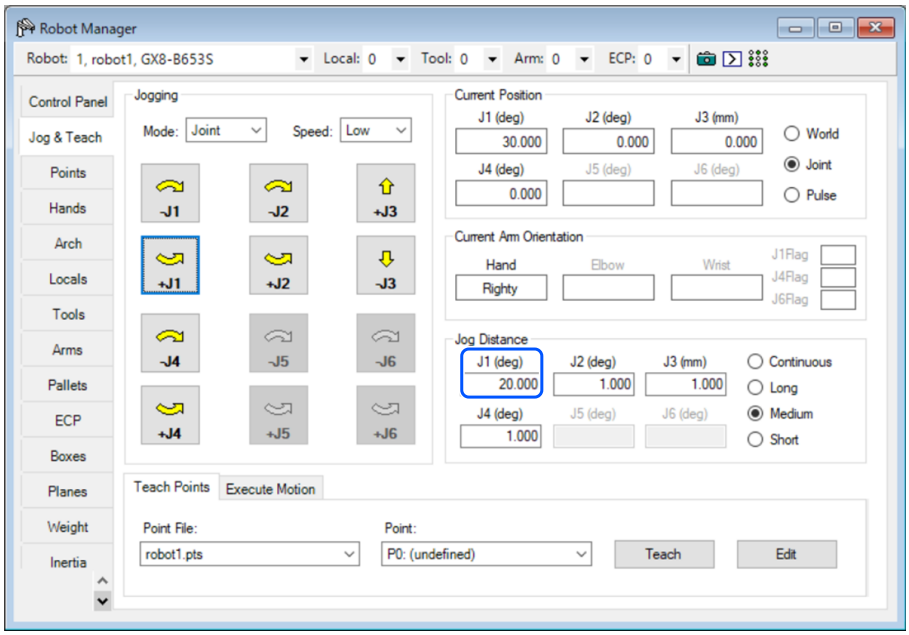


KEY POINTS

As the jog distance (angle) is equal to or less than the limit angle (15 deg), the motor stays on without triggering the Safety Function.

5. Set [Jog Distance] for the J1 axis to 20 deg.

6. Click [+J1] to rotate 20 deg at low speed.



7. Confirm that an emergency stop occurs and the robot operation stops.

How to reset

Follow the procedure below to reset the emergency stop status.

1. In EPSON RC+, select [Robot Manager] - [Control Panel], and then perform the error reset operation.

2. Confirm that the [EStop] displayed in the lower right corner of EPSON RC+ turns off.

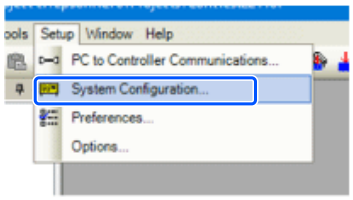
5.6 Example of Using Safety Limited Position (SLP)

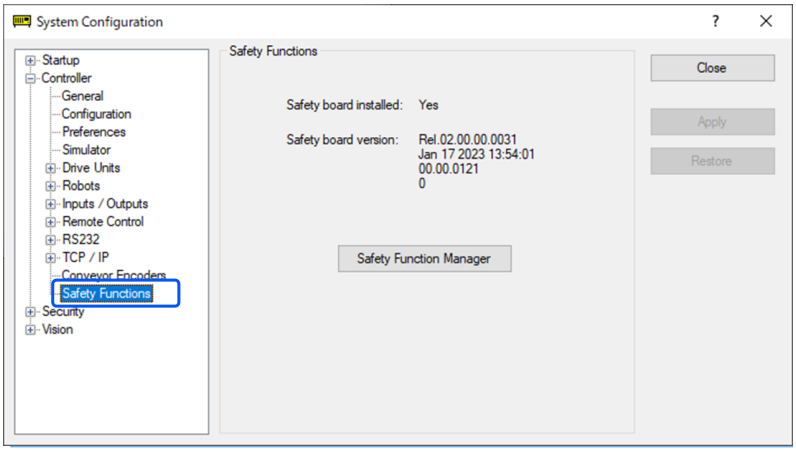
The following describes an example of using Safety Limited Position (SLP). In this example, SLP_A is assigned to SAFETY_IN3 to confirm that an emergency stop occurs when the robot enters the restricted area. This example uses a GX8-B653S as the SCARA Manipulator and a C4-B901S as an the 6-Axis Manipulator.

5.6.1 Safety Limited Position (SLP) Settings for a SCARA Manipulator

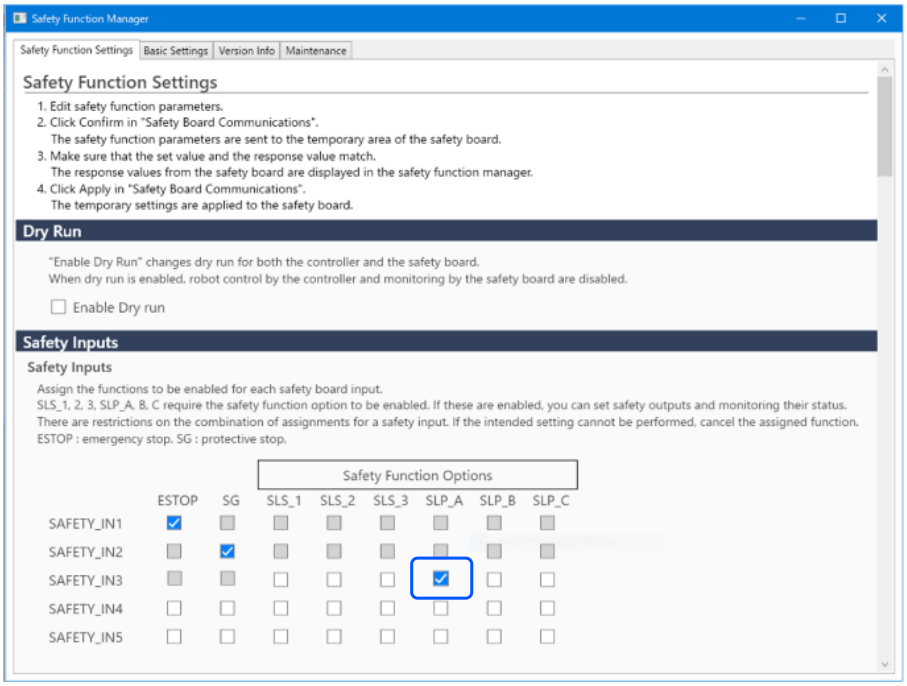
Follow the procedure below to set the safety function parameters for the Safety Board.

1. In EPSON RC+, select [Setup] - [System Configuration], and then start Safety Function Manager under [Controller] - [Safety Functions].

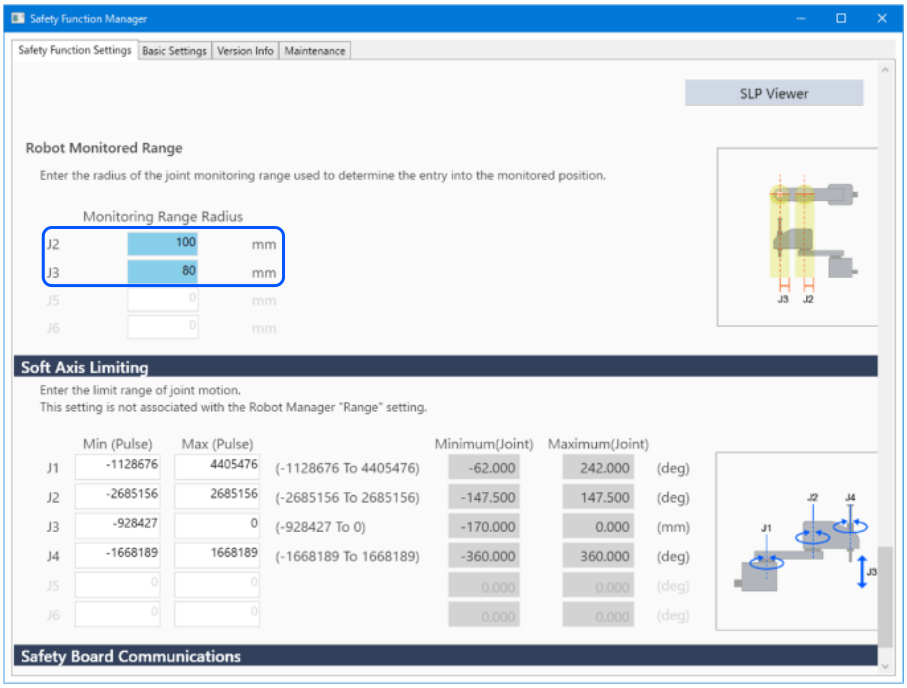




2. For [SAFETY_IN3], select [SLP_A].

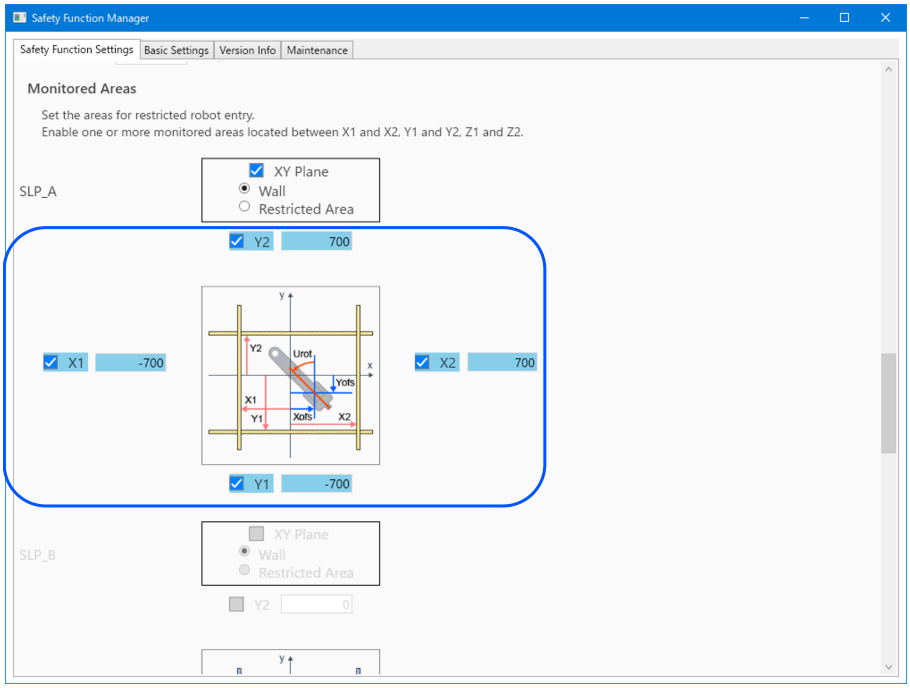


3. In [Robot Monitored Range], enter 100 (mm) for [J2] and 80 (mm) for [J3].

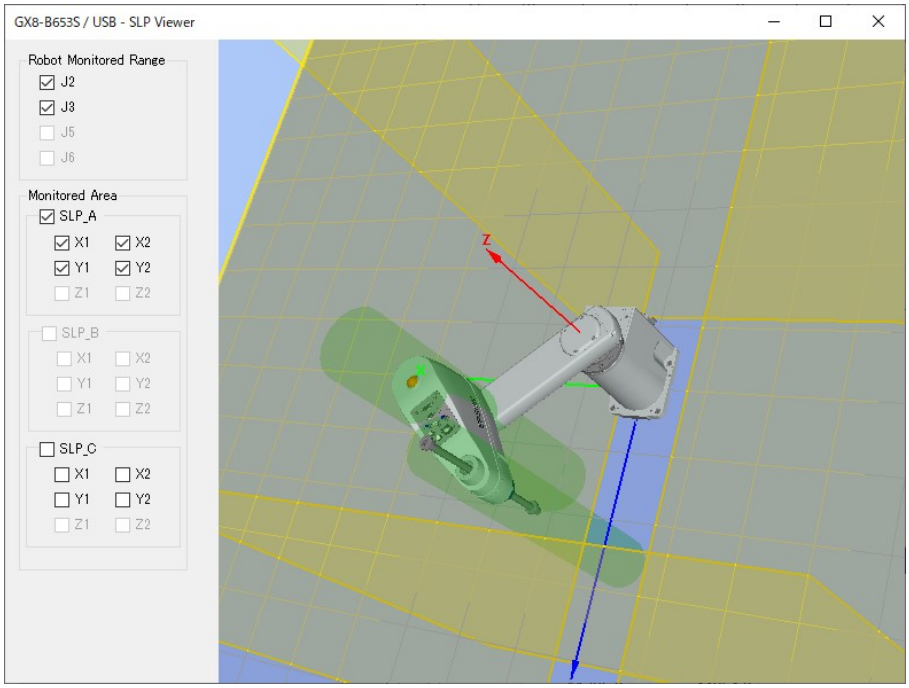


4. Select the XY Plane in SLP_A, and then select [Wall].

5. Enable the checkboxes for [X1], [X2], [Y1], and [Y2], then enter -700 (mm) for [X1], 700 (mm) for [X2], -700 (mm) for [Y1], and 700 (mm) for [Y2] as the positions of each Wall.



6. Check the set range in SLP Viewer.

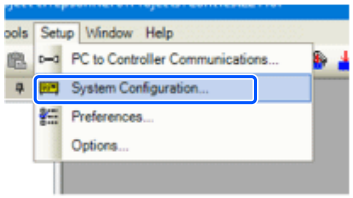


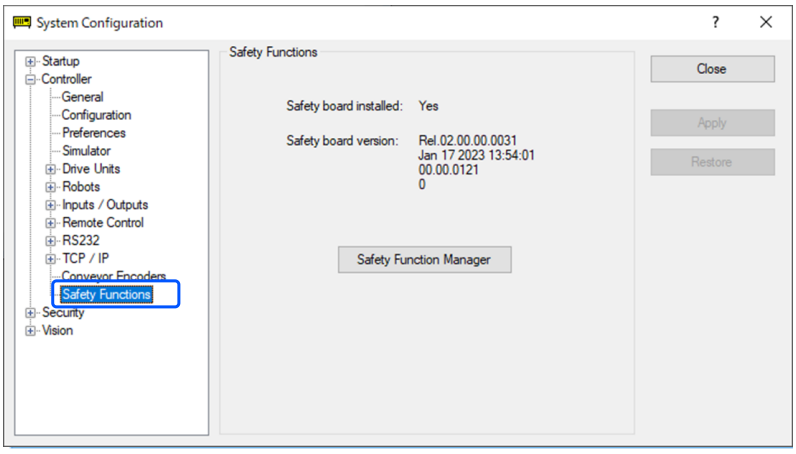
7. Apply settings.

5.6.2 Safety Limited Position (SLP) Settings for a 6-Axis Manipulator

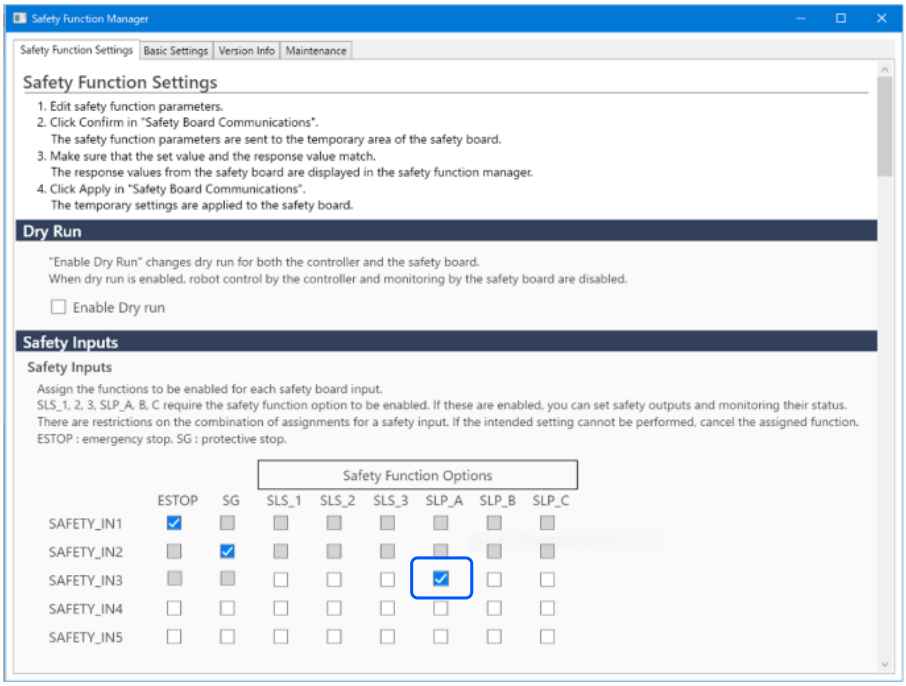
Follow the procedure below to set the safety function parameters for the Safety Board.

1. In EPSON RC+, select [Setup] - [System Configuration], and then start Safety Function Manager under [Controller] - [Safety Functions].

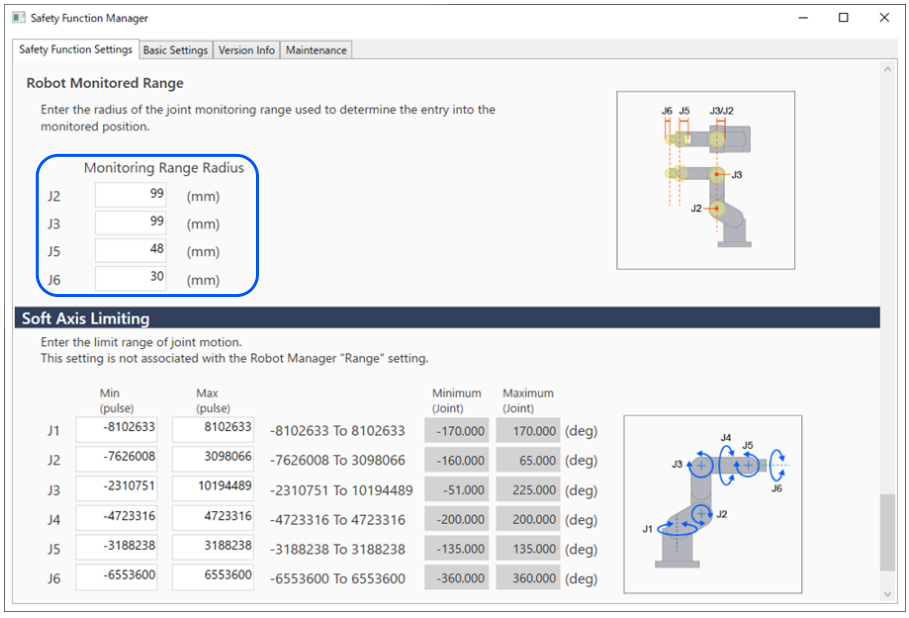




2. For [SAFETY_IN3], select [SLP_A].

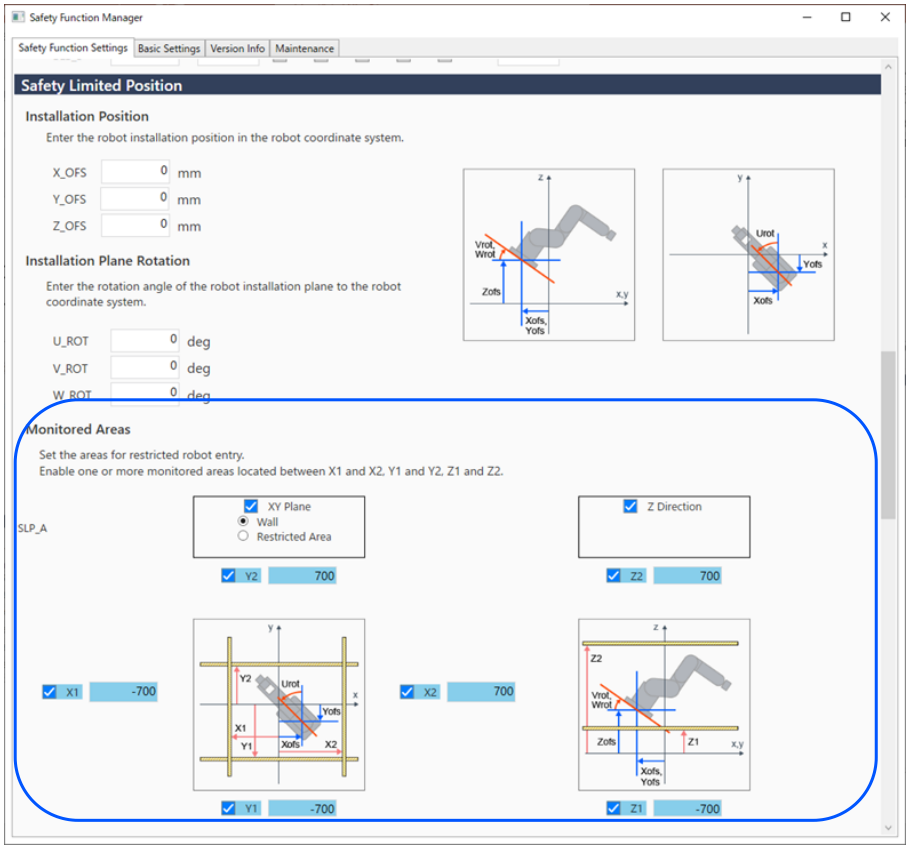


3. In [Robot Monitored Range], enter 99 (mm) for [J2], 99 (mm) for [J3], 48 (mm) for [J5], and 30 (mm) for [J6].

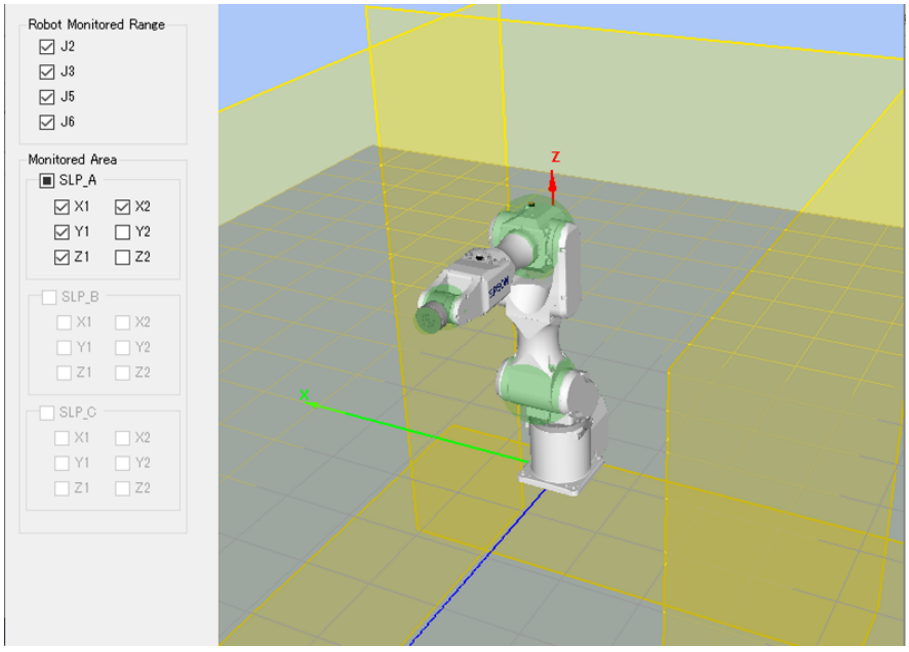


4. Select the XY Plane in SLP_A, and then select [Wall]. Select the Z Direction as well.

5. Enable the checkboxes for [X1], [X2], [Y1], and [Y2], then enter -700 (mm) for [X1], 700 (mm) for [X2], -700 (mm) for [Y1], and 700 (mm) for [Y2] as the positions of each Wall. Enable the checkboxes for [Z1] and [Z2], then enter -700 (mm) for [Z1], and 700 (mm) for [Z2] as the positions of each Wall.



6. Check the set range in SLP Viewer.

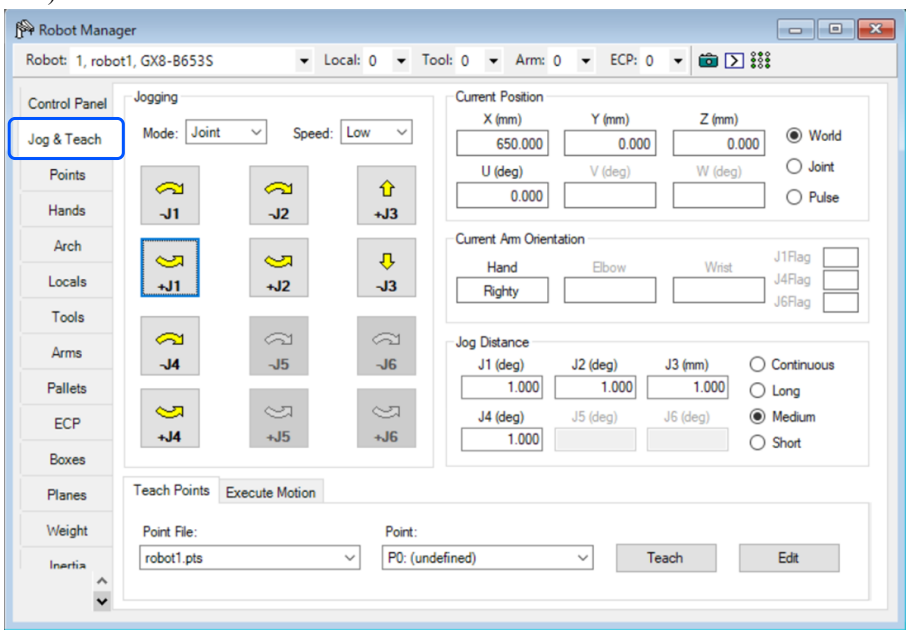


7. Apply settings.

5.6.3 Confirming the Operation of the Safety Limited Position (SLP)

Follow the procedure below to check the operation.

1. Turn [SAFETY_IN3] ON (0V) to enable the Safety Limited Position.
2. In EPSON RC+, select [Tools] - [Robot Manager] - [Jog & Teach], and then move the robot to outside the wall (restricted area).



3. Confirm that an emergency stop occurs and the robot operation stops.

How to reset

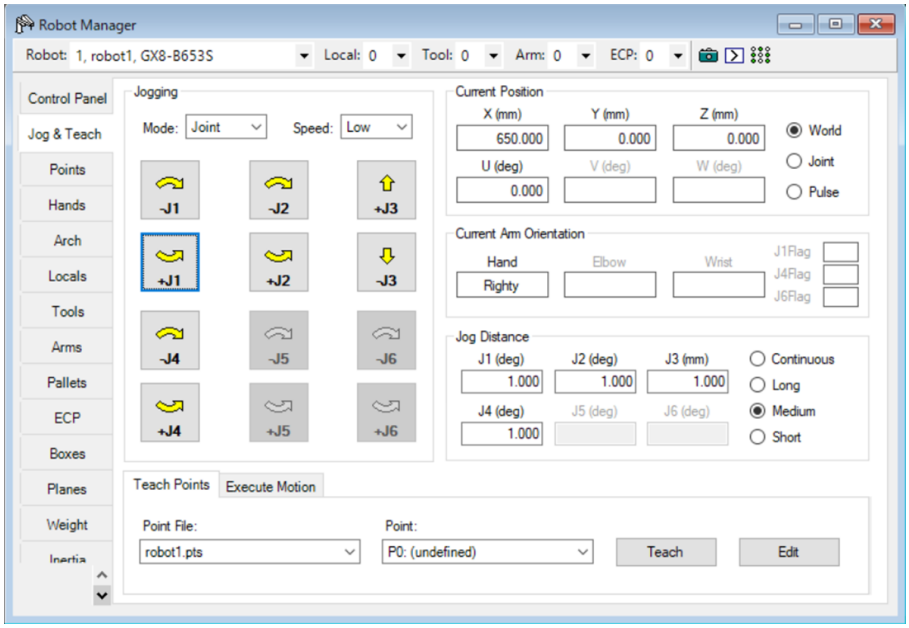
The following three methods can be used to reset an emergency stop.

- Method using safety inputs
- Method using the motor brake release
- Method using the Teach Pendant

Method using safety inputs

1. Set [SAFETY_IN3] to the OFF status (24 V) to disable Safety Limited Position.
2. In EPSON RC+, select [Tools] - [Robot Manager] - [Control Panel], and then perform the error reset operation.
3. Confirm that the [EStop] displayed in the lower right corner of EPSON RC+ turns off.
4. In EPSON RC+, select [Robot Manager] - [Control Panel], and then click the [MOTOR ON] button.

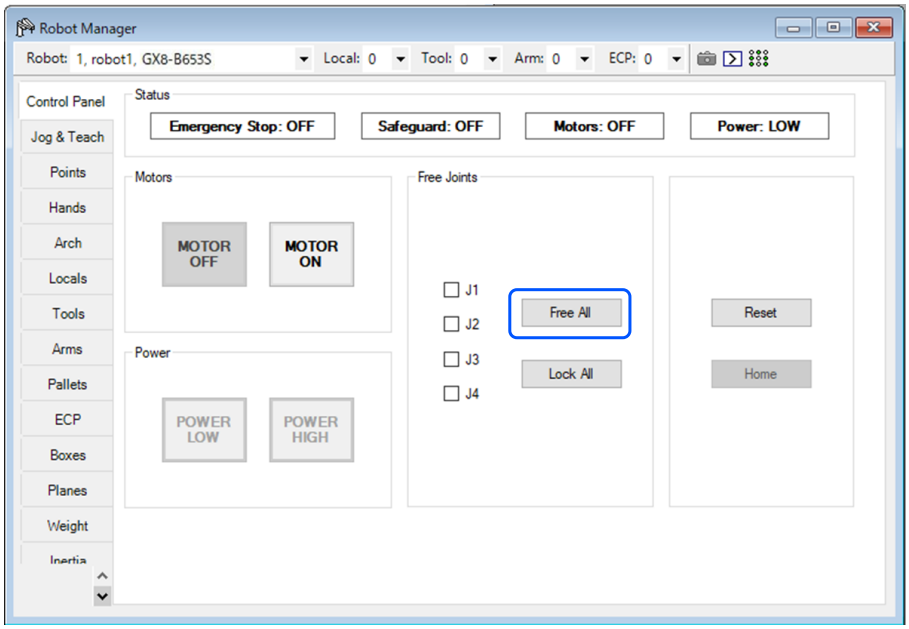
5. In EPSON RC+, select [Tools] - [Robot Manager] - [Jog & Teach], and then move the robot to inside the wall (outside the restricted area).



Method using the motor brake release

How to Reset a SCARA Manipulator

1. In the EPSON RC+ control panel, under [Free Joints], click the [Free All] button to release the motor brake on each axis.



2. Move the robot by hand to outside the restricted area.

3. In EPSON RC+, select [Robot Manager] - [Control Panel], and then perform the error reset operation.

4. Confirm that the [EStop] displayed in the lower right corner of EPSON RC+ turns off.

How to Reset a 6-Axis Manipulator

One way is by using the brake release unit (option). For details, refer to the following manual.
"Manipulator Manual – Safety - How to Move Arms with the Electromagnetic Brake"

Method using the Teach Pendant

1. Attach the Teach Pendant to the Robot Controller and set the Robot Controller to TEACH mode.

⚠ CAUTION

When in TEACH mode, Safety Limited Position is disabled. Be careful of the robot's operations.

2. Operate the Teach Pendant to move the robot to outside the restricted area.

3. Change to AUTO mode and perform the error reset operation using the Teach Pendant or EPSON RC+.

4. Use the Teach Pendant or EPSON RC+ to confirm that [EStop] is turned off.

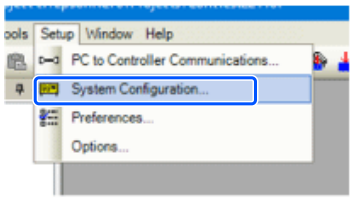
5.7 Example of Using Soft Axis Limiting

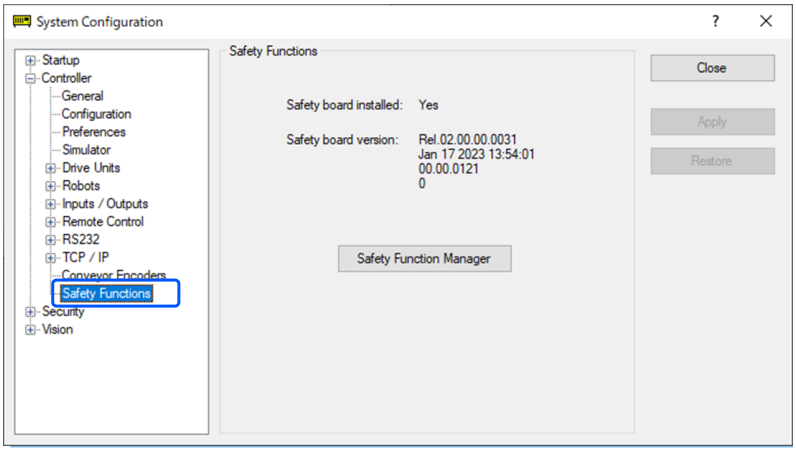
The following describes an example of using the Soft Axis Limiting. This example uses a SCARA Manipulator as the robot. Note that the same procedure applies when using a 6-Axis Manipulator.
This example confirms that if the J1 axis moves outside the limit range, the robot enters the emergency stop status.

How to set

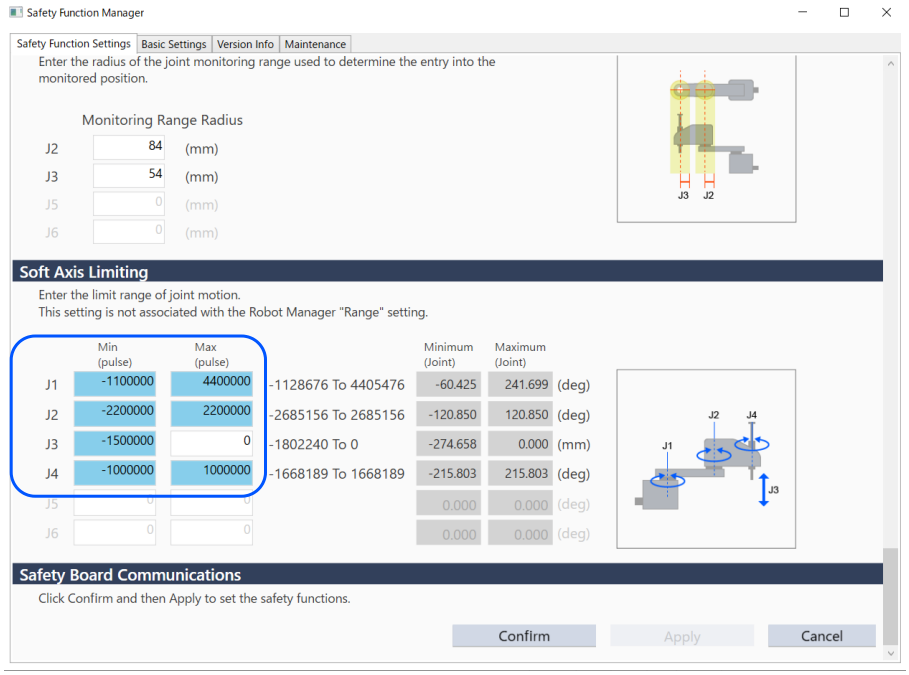
Follow the procedure below to set the safety function parameters.

1. In EPSON RC+, select [Setup] - [System Configuration], and then start Safety Function Manager under [Controller] - [Safety Functions].





2. Enter a limit range value of each joint [J1] to [J4] set using Soft Axis Limiting as follows:
   Min [pulse]
   J1:-1100000, J2:-2200000, J3:-1500000, J4:-1000000
   Max [pulse]
   J1:4400000, J2:2200000, J3:0, J4:1000000

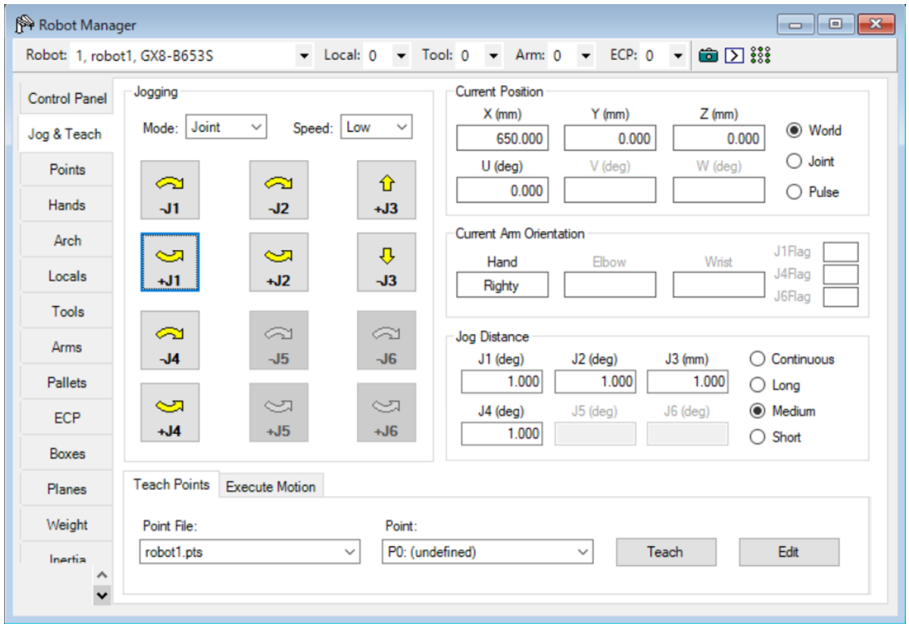


3. Apply settings.

How to check operation

Follow the procedure below to check the operation.

1. In EPSON RC+, select [Tools] - [Robot Manager] - [Jog & Teach], and then move the J1 axis to outside the limit range.



2. Confirm that an emergency stop occurs and the robot operation stops.

How to reset

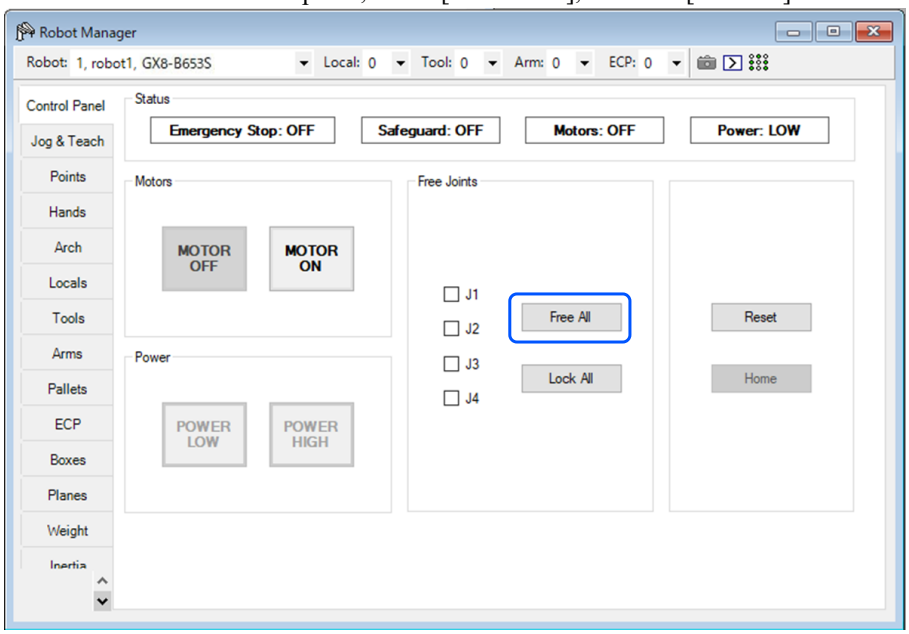
The following two procedures can reset the emergency stop status.

- Method using the motor brake release
- Method using the Teach Pendant

Method using the motor brake release

How to Reset a SCARA Manipulator

1. In the EPSON RC+ control panel, under [Free Joints], click the [Free All] button to release the motor brake on each axis.



2. Move the robot by hand to inside the operating range.

3. In EPSON RC+, perform the error reset operation.

4. Confirm that the emergency stop state is reset.

How to Reset a 6-Axis Manipulator

Use the brake release unit (option) or the Brake command of the software. For details, refer to the following manual.
"Manipulator Manual – Safety - How to Move Arms with the Electromagnetic Brake"

Method using the Teach Pendant

1. Attach the Teach Pendant to the Robot Controller and set the Robot Controller to TEACH mode.

> ⚠ CAUTION
>
> When in TEACH mode, Soft Axis Limiting is disabled. Be careful of the robot's operations.

2. Operate the Teach Pendant to move the robot to inside the operating range.
3. Change to AUTO mode and perform the error reset operation.